

# People's Health Matters

## Community Health and Humanities Seminar Speaker Series

### MATHEMATICAL MODELLING TO SUPPORT THE PUBLIC HEALTH RESPONSE TO THE COVID-19 PANDEMIC: perspectives from Newfoundland and Labrador



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@amy\_hurford

Amy Hurford, MSc, PhD, is a mathematical biologist who studies evolutionary epidemiology. During the pandemic, she applied her disease modelling expertise to explore the potential impacts of different public health responses to COVID-19 in Atlantic Canada. She has been a frequent contributor on local news media and was recently awarded the Dean of Science Distinguished Teaching Award.

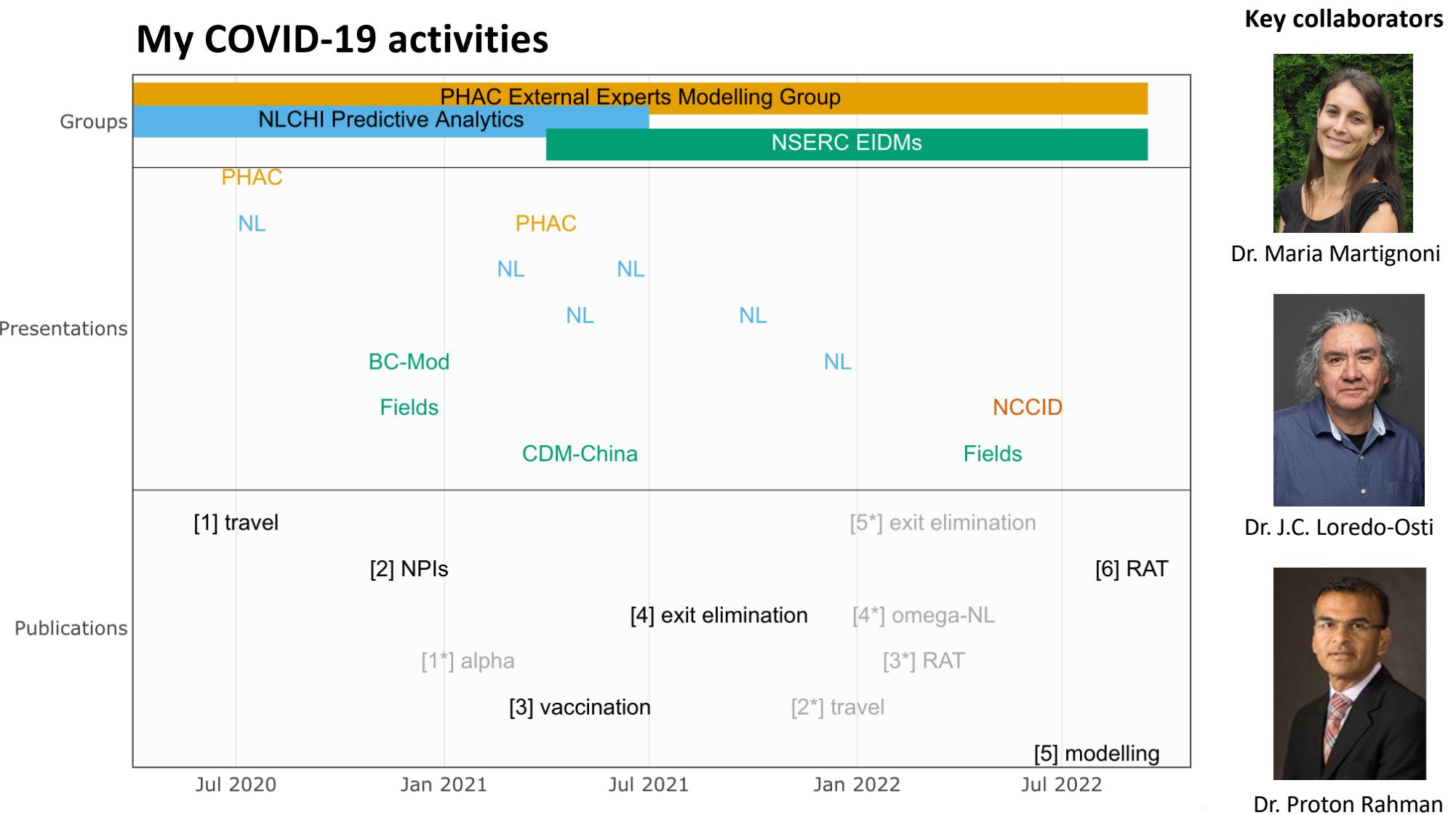
# Outline

## Background

1. Impact of travel restrictions
2. Recommendations for implementing travel restrictions
3. Modelling for regions with no community cases
4. Modelling for regions with community cases
5. Prioritizing rotational workers for vaccination
6. Recording the K-12 RAT results

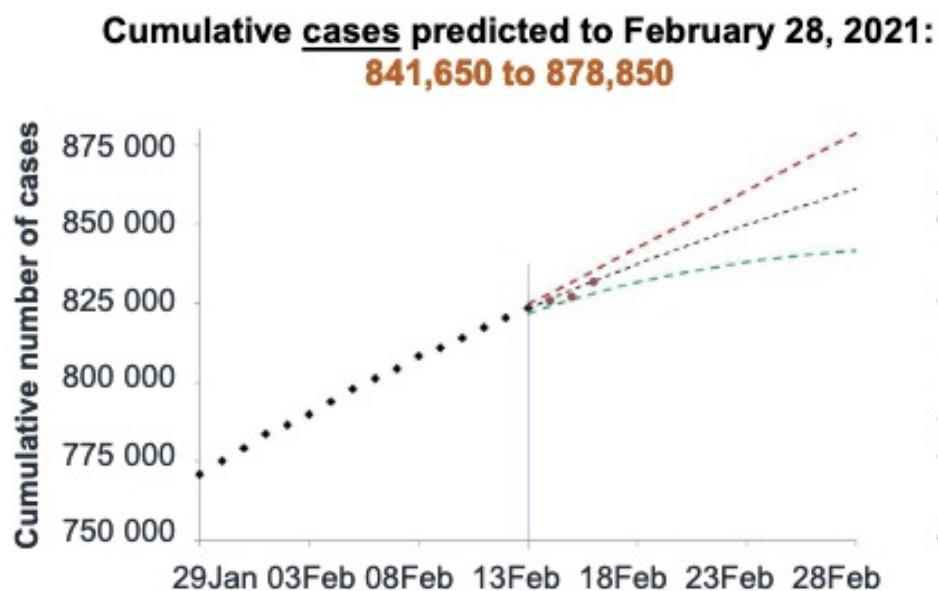
## Conclusion

# My COVID-19 activities



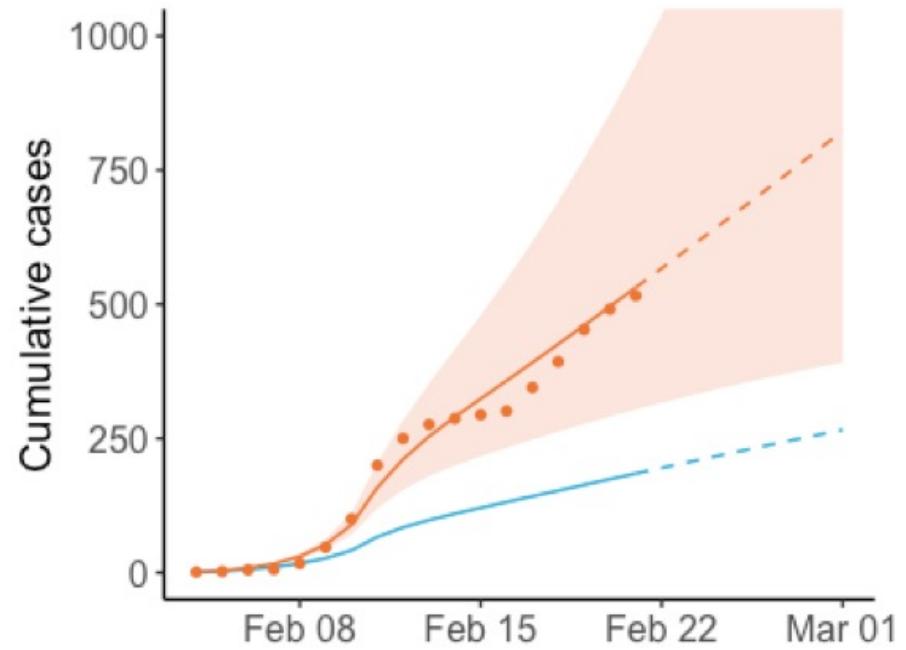
# What do we mean “modelling”?

## Statistical model



Update on COVID-19 in Canada: Epidemiology and Modelling. PHAC. Slides. Feb 19.  
<https://www.canada.ca/content/dam/phac-aspc/documents/services/diseases-maladies/coronavirus-disease-covid-19/epidemiological-economic-research-data/update-covid-19-canada-epidemiology-modelling-20210219-en.pdf>

## Mechanistic model



# Statistical vs. mechanistic model

## Generalized-Richard's model

$$\frac{dC(t)}{dt} = r\{C(t)\}^p \left[ 1 - \left\{ \frac{C(t)}{K} \right\}^\alpha \right]$$

- $C(t)$  cumulative cases at time  $t$
- $r$  initial growth rate
- $k$  maximum value of  $C(t)$
- $p \in [0,1]$  affects growth profile
- $\alpha > 0$  deviation from the symmetry of the standard logistic curve

Smith et al. 2021. The performance of phenomenological models in providing near-term Canadian case projections in the midst of the COVID-19 pandemic: March – April, 2020. *Epidemics*

mac-theobio / McMasterPandemic Public

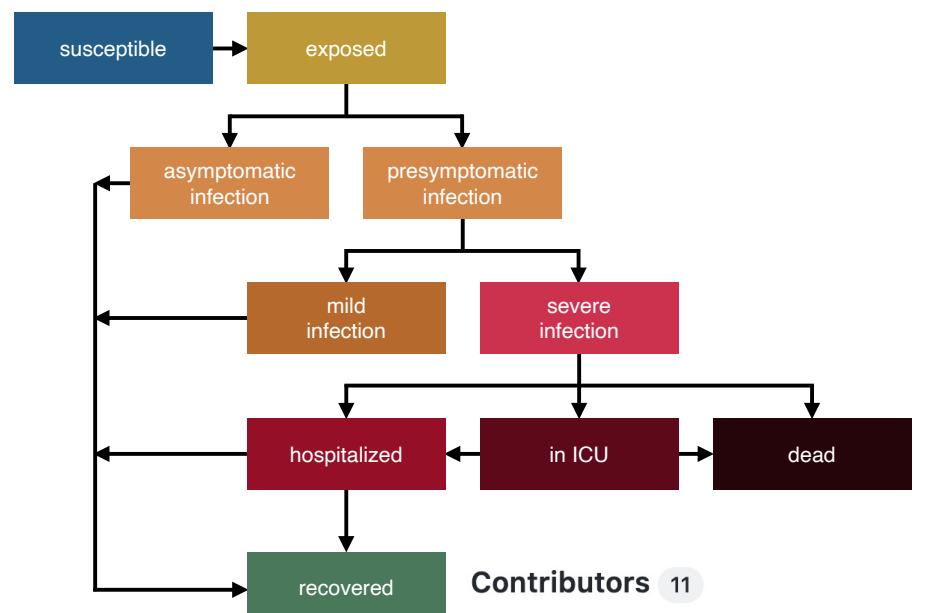
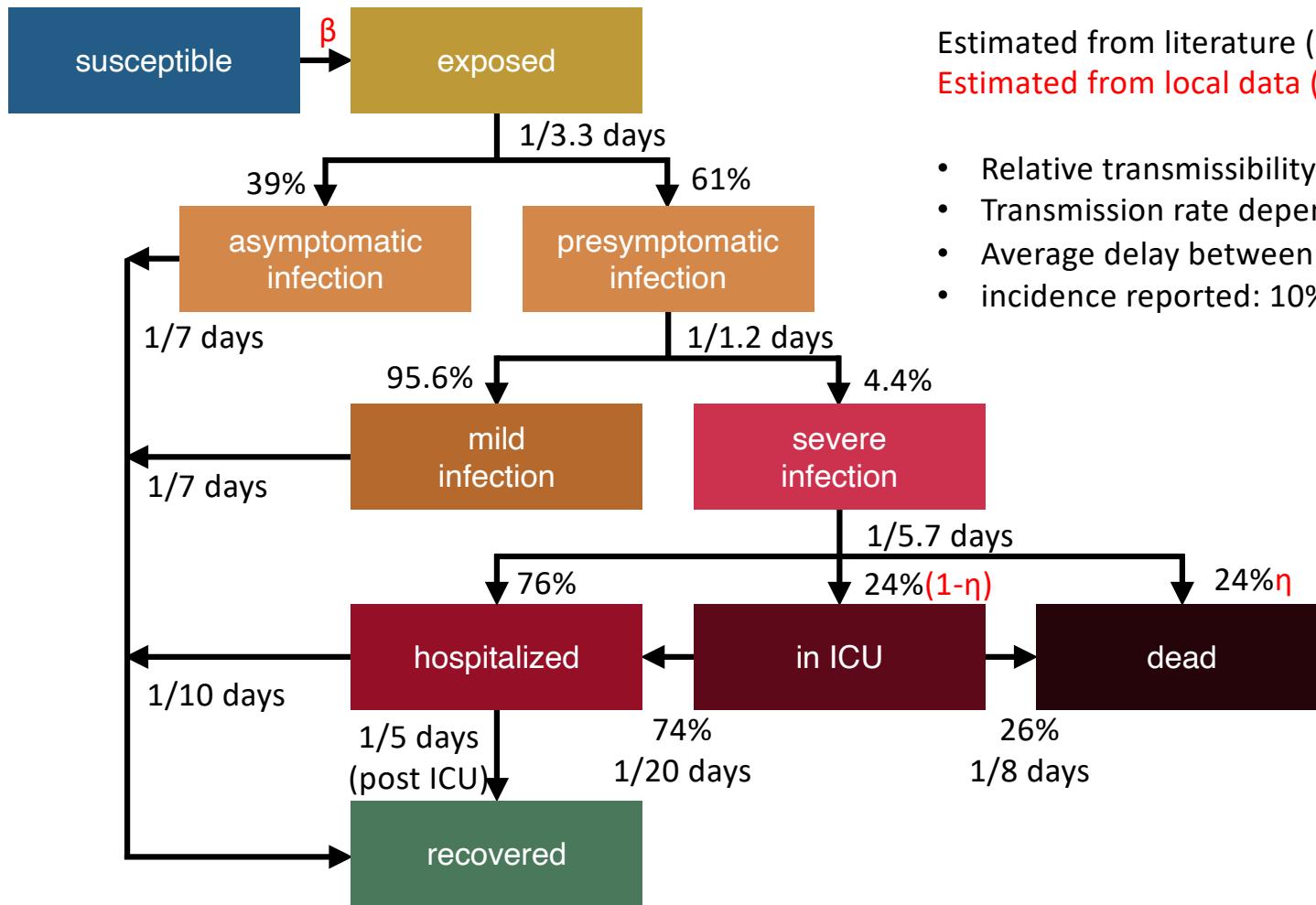


Diagram by Irena Papst



# PHAC parameter defaults



Estimated from literature (not region-specific)

Estimated from local data (region-specific)

- Relative transmissibility of asymptomatic: 67%
- Transmission rate depends on NPIs and population size
- Average delay between incidence and test report: 8 days
- incidence reported: 10%

# Mechanistic models are purposefully approximations

“All models are wrong but some are useful”

– Dr. George Box

“Statistics is a science of approximation but nevertheless an educated one”

– Dr. Veeresh Gadag

“As more parameters are added, the uncertainty builds up, and the error could increase to the point at which predictions become useless.” Saltelli et al. 2020.

Five ways to ensure that models serve society: a manifesto. Nature

# 1. Impact of travel restrictions

[4] On 29 April 2020 the CMOH issued Special Measures Order (Amendment No. 11), to take effect on 4 May 2020, limiting entry to residents of Newfoundland and Labrador, asymptomatic workers and those in extenuating circumstances. On 5 May 2020 the CMOH issued Special Measures Order (Travel Exemption Order), expanding those circumstances when entry into the province would be permitted. As neither Order served as an outright ban on all travel, I will henceforth collectively refer to these two special measures as the “travel restriction”.



IN THE SUPREME COURT OF NEWFOUNDLAND AND LABRADOR  
GENERAL DIVISION

Citation: *Taylor v. Newfoundland and Labrador*, 2020 NLSC 125  
Date: September 17, 2020  
Docket: 202001G2342

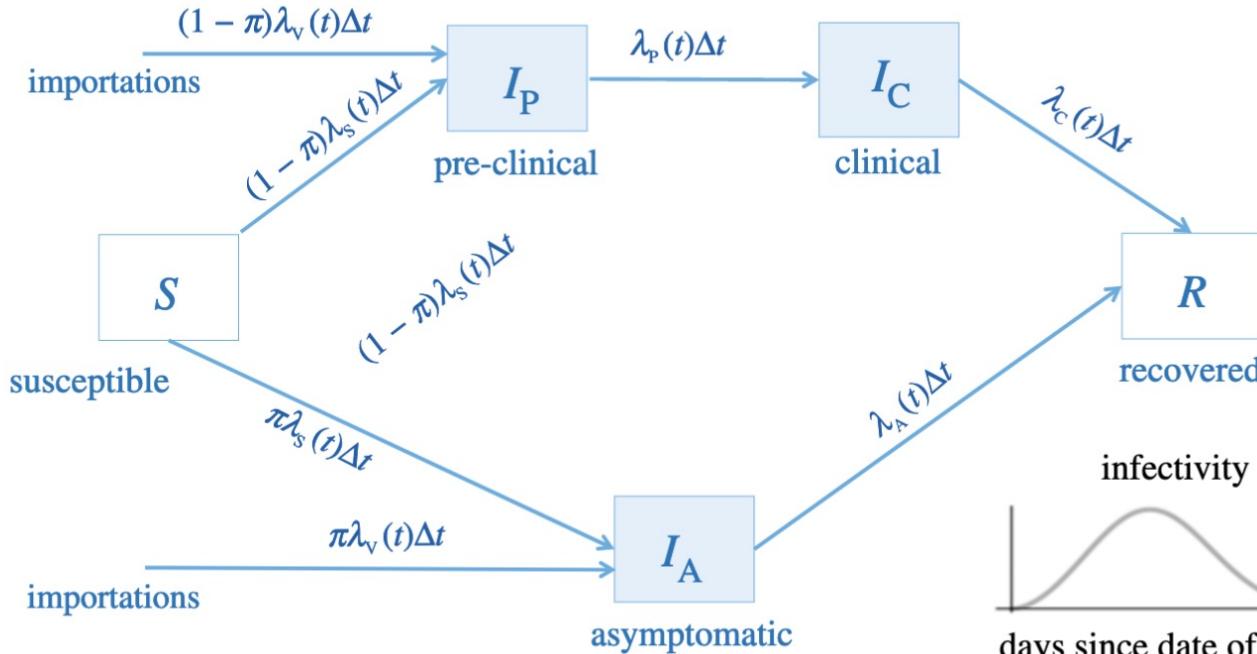


Photo credit: Government of Newfoundland and Labrador

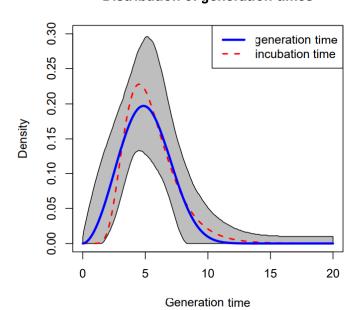
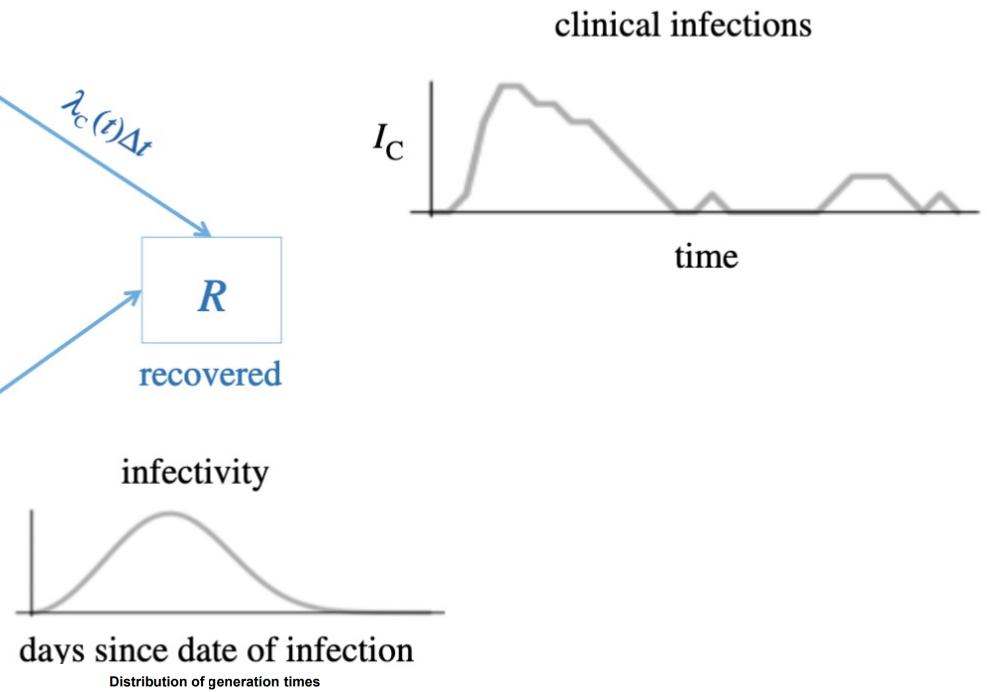
**[1] Travel** Hurford, A., P. Rahman, and J. C. Loredo-Osti. 2021. Modelling the impact of travel restrictions on COVID-19 cases in Newfoundland and Labrador. *R. Soc. Open Sci.* 8: 202266.

- the mean number of COVID-19 cases is reduced by 92%
- the likelihood of very large outbreaks is reduced
- more time: estimated ~6 months to 259 more cases (vs. 2.5 months without restrictions)

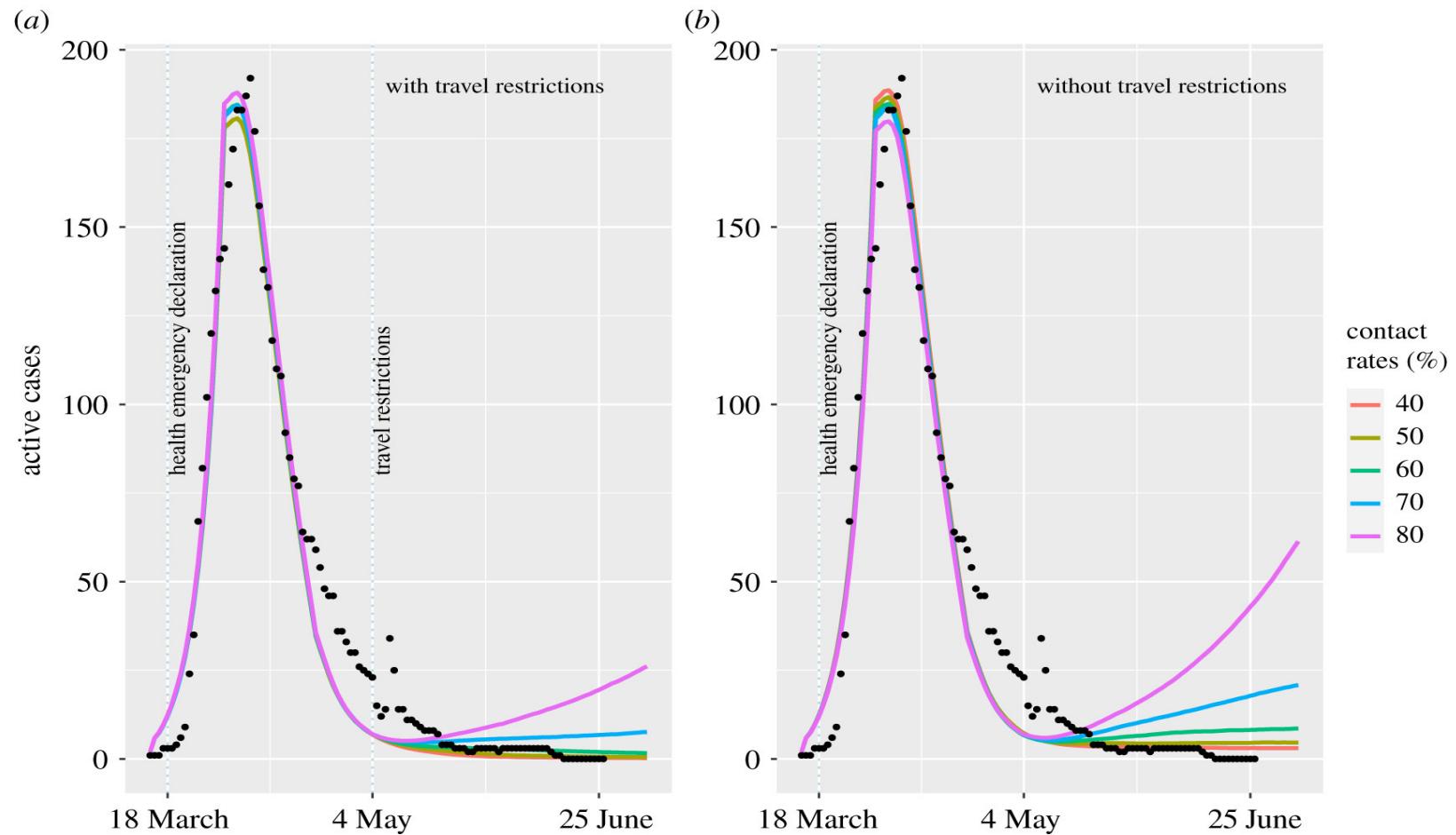
**3** infected individuals arrive and fail to self-isolation per month



[1] **Travel** Hurford, A., P. Rahman, and J. C. Loredo-Osti. 2021. Modelling the impact of travel restrictions on COVID-19 cases in Newfoundland and Labrador. *R. Soc. Open Sci.* 8: 202266.



Ferretti et al. 2020. Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing.



**[1] Travel** Hurford, A., P. Rahman, and J. C. Loredo-Osti. 2021. Modelling the impact of travel restrictions on COVID-19 cases in Newfoundland and Labrador. *R. Soc. Open Sci.* 8: 202266.

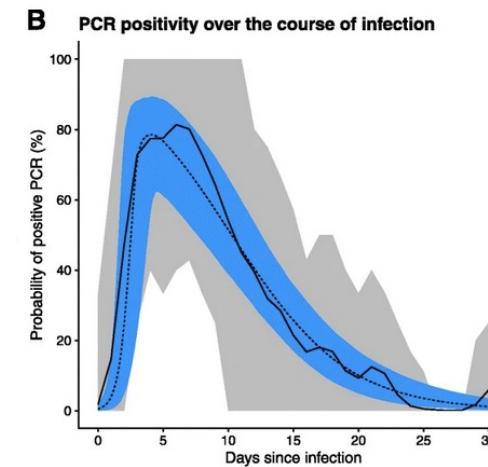
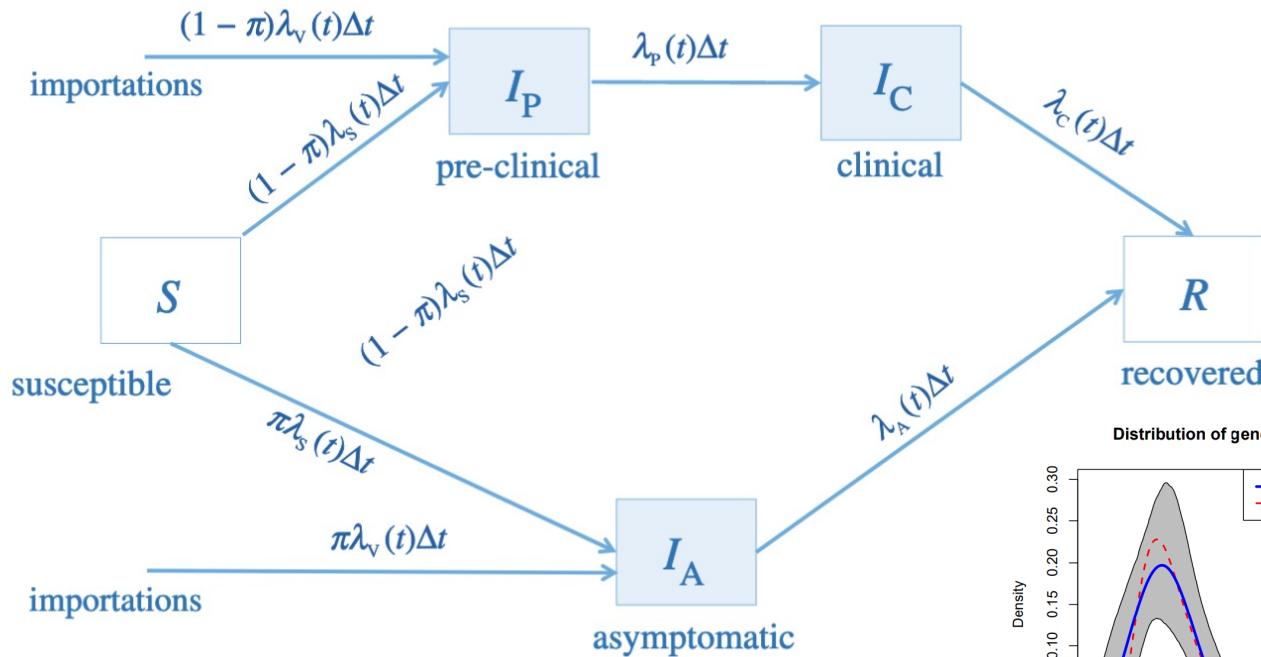
**Table 3.** Predicted total number of clinical COVID-19 cases in the nine weeks subsequent to 4 May 2020 with and without the implementation of travel restrictions. The prediction intervals represent the simulated 0.025 and 0.975 quantiles.

percentage reduction in the contact rate relative to pre-pandemic levels	predicted clinical COVID-19 cases over nine weeks			
	travel restrictions	no travel restrictions	magnitude greater without restrictions	percentage reduction with restrictions
<b>40%</b>				
mean	1.2	13.6	11.0	91.2%
median	0	12		
95% prediction intervals	[0,9]	[2,35]		
<b>50%</b>				
mean	1.5	18.1	12.0	91.7%
median	0	15		
95% prediction intervals	[0,11]	[3,53]		
<b>60%</b>				
mean	2.1	27.8	13.5	92.4%
median	0	23		
95% prediction intervals	[0,17]	[3,79]		
<b>70%</b>				
mean	3.7	47.9	13.0	92.3%
median	0	35		
95% prediction intervals	[0,33]	[3,159]		
		mean = 12.4	mean = 91.9%	

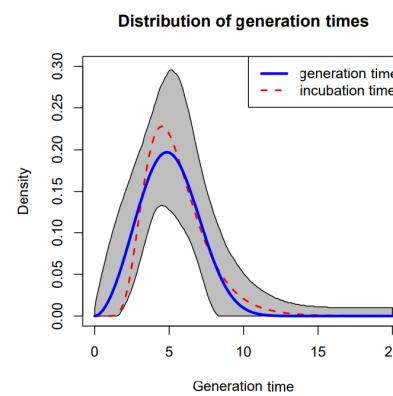
**[1] Travel** Hurford, A., P. Rahman, and J. C. Loredo-Osti. 2021. Modelling the impact of travel restrictions on COVID-19 cases in Newfoundland and Labrador. *R. Soc. Open Sci.* 8: 202266.

# Estimating the rate of community infections from travellers

? infected individuals arrive and fail to self-isolation per month

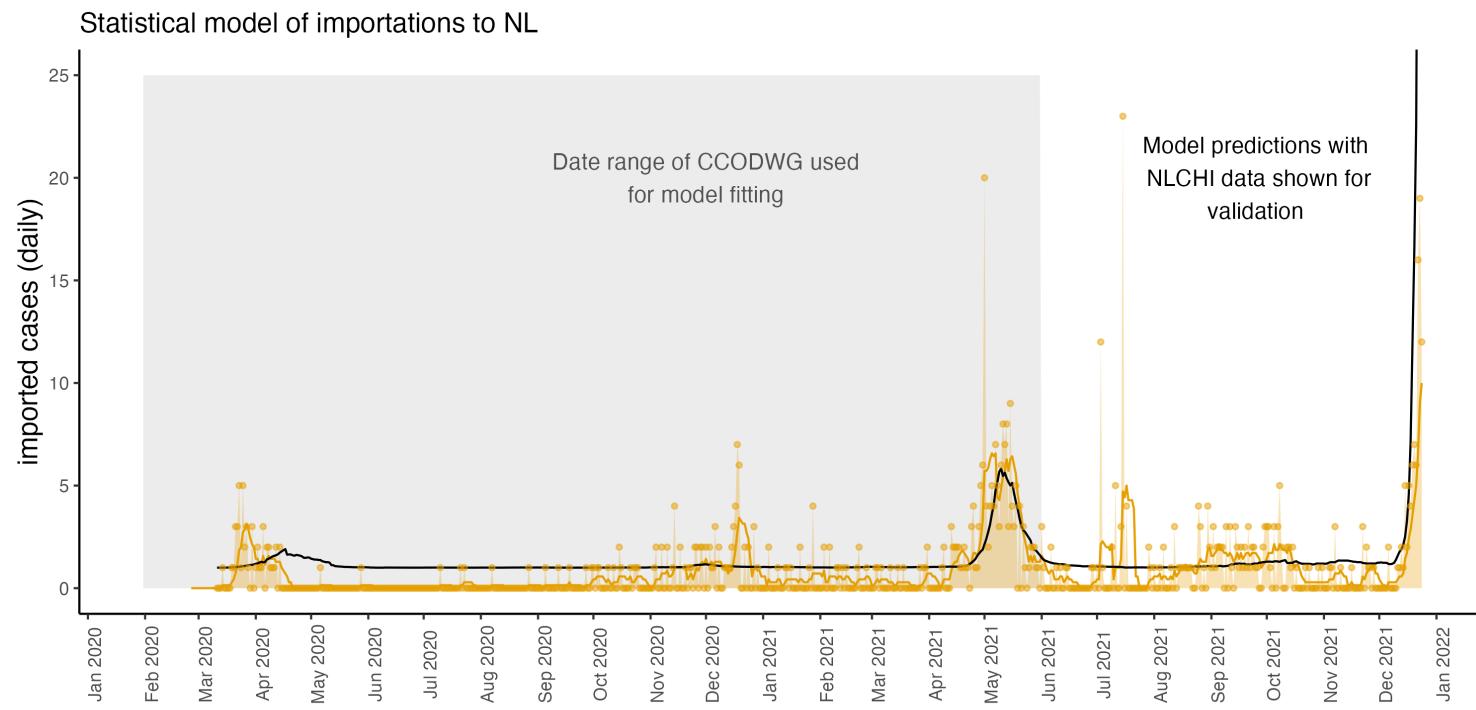


Hellewell, J., et al. BMC Med 19, 106 (2021).  
<https://doi.org/10.1186/s12916-021-01982-x>



Ferretti et al. 2020. Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing.

# Estimating the rate of community infections from travellers

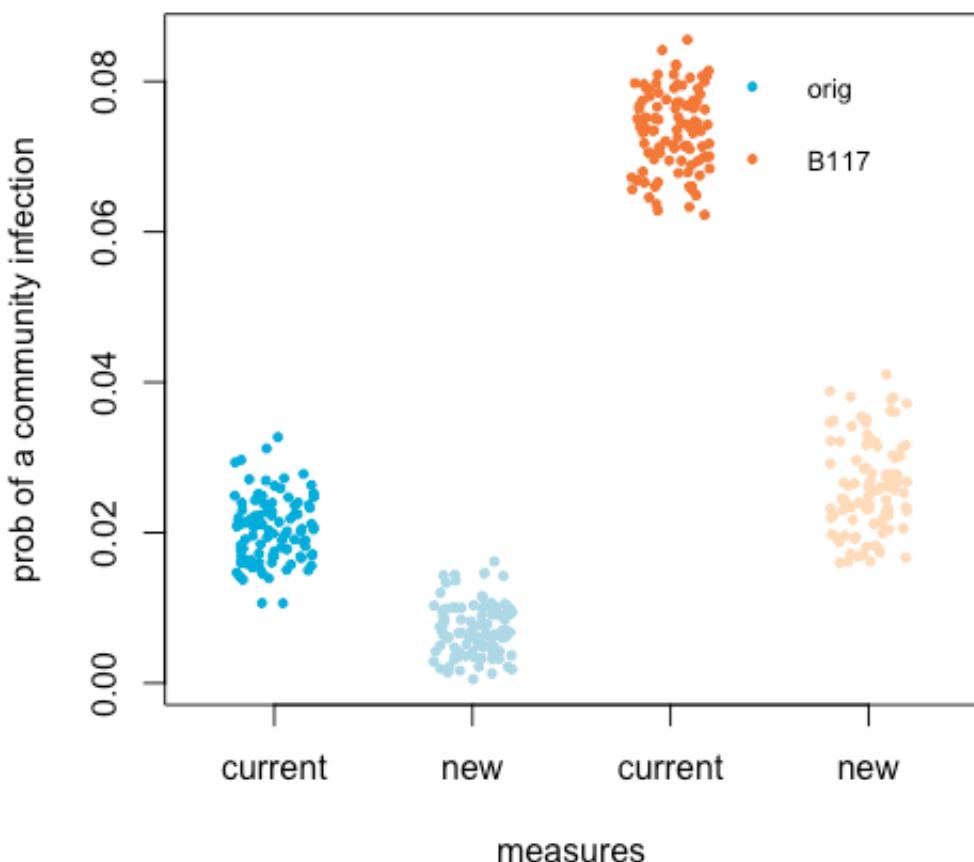


The daily number of imported cases to NL (reported by NLCHI for March 15, 2020-December 24, 2021) is reliably predicted as 0.105 times the number of active cases per 10,000 population in NS.

**[5] Modelling.** Hurford et al. Pandemic modelling for regions implementing an elimination strategy. Under review at the Journal of Theoretical Biology

# Estimating the rate of community infections from travellers

Rotational workers



## Assumptions

- Daily compliance (worker to community): 86%
- Infection probability of family members: 0.1 (original), 0.5 (B117)
- Household sizes based on 2016 NL census

## Current

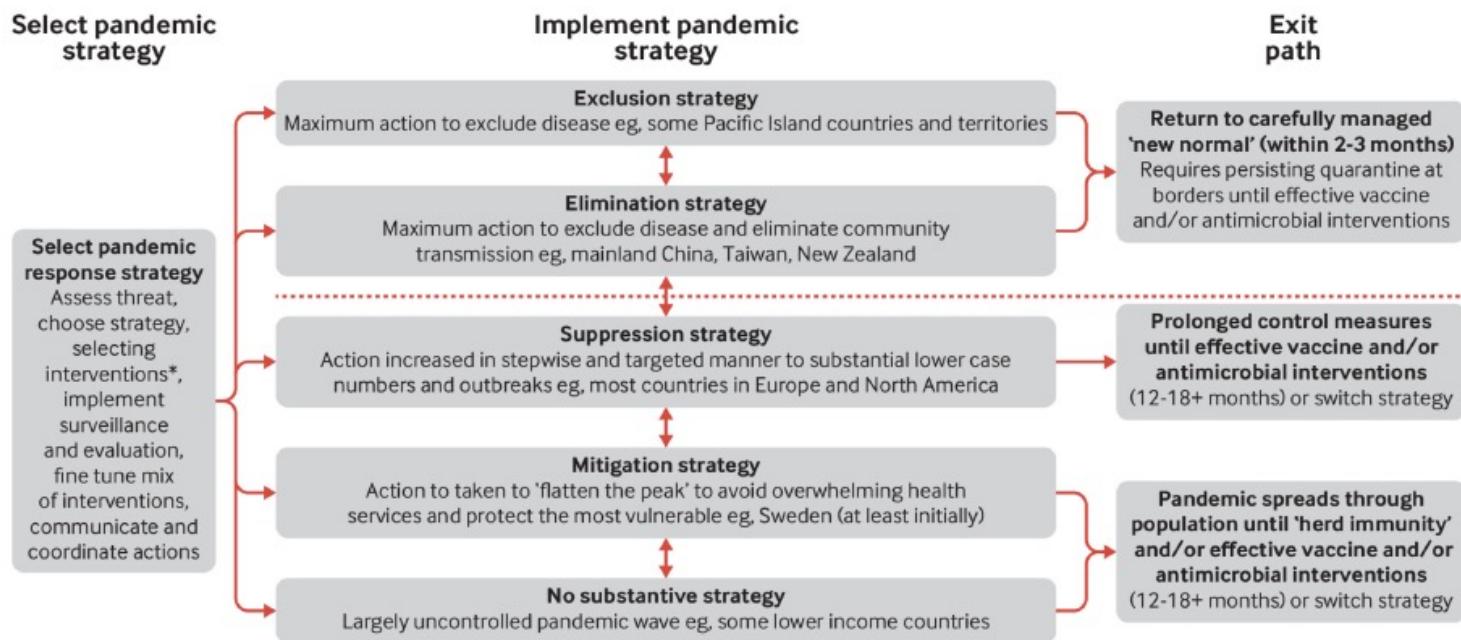
- Isolate away from family
- Test on Day 7, if negative exit isolation

## New

- Test on Day 1 and 7
- Testing assumed to improve compliance with isolation away from family (reduces infection probability of family by 80%)

## 2. Recommendations for implementing travel restrictions

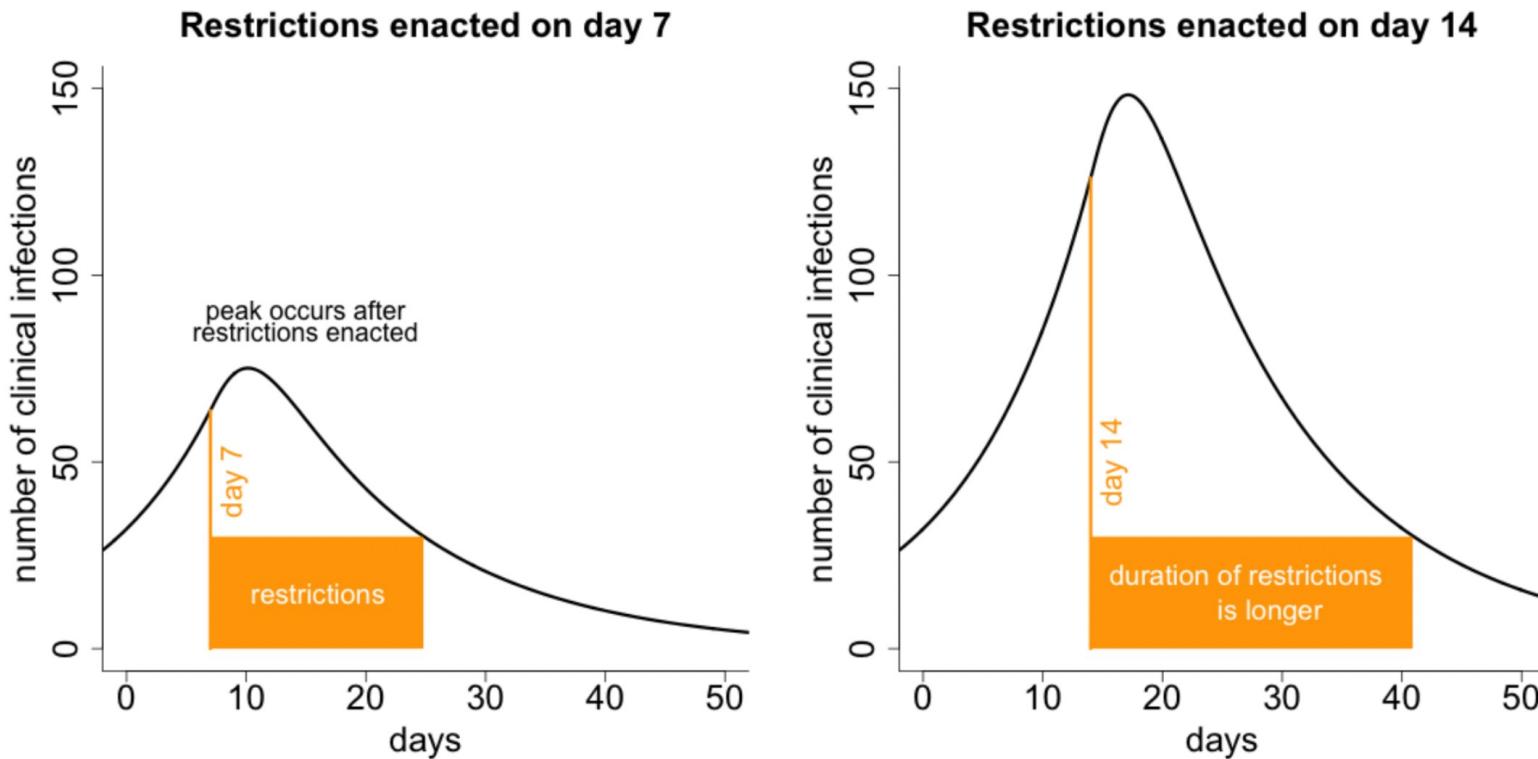
- Travel restrictions + strong NPIs given community cases is the basis of an elimination strategy
- The argument for travel restrictions depends on regional factors and variants



\* **Pandemic interventions:** Border controls to "keep it out"; testing, contact tracing, case isolation and contact quarantine to "stamp it out"; improved hygiene behaviours and use of masks; physical distancing; movement restrictions; combinations including "lockdown"; vaccines; antimicrobials  
NB. There are multiple other interventions to reduce harm, including protecting vulnerable populations, reorienting health services, social and economic support

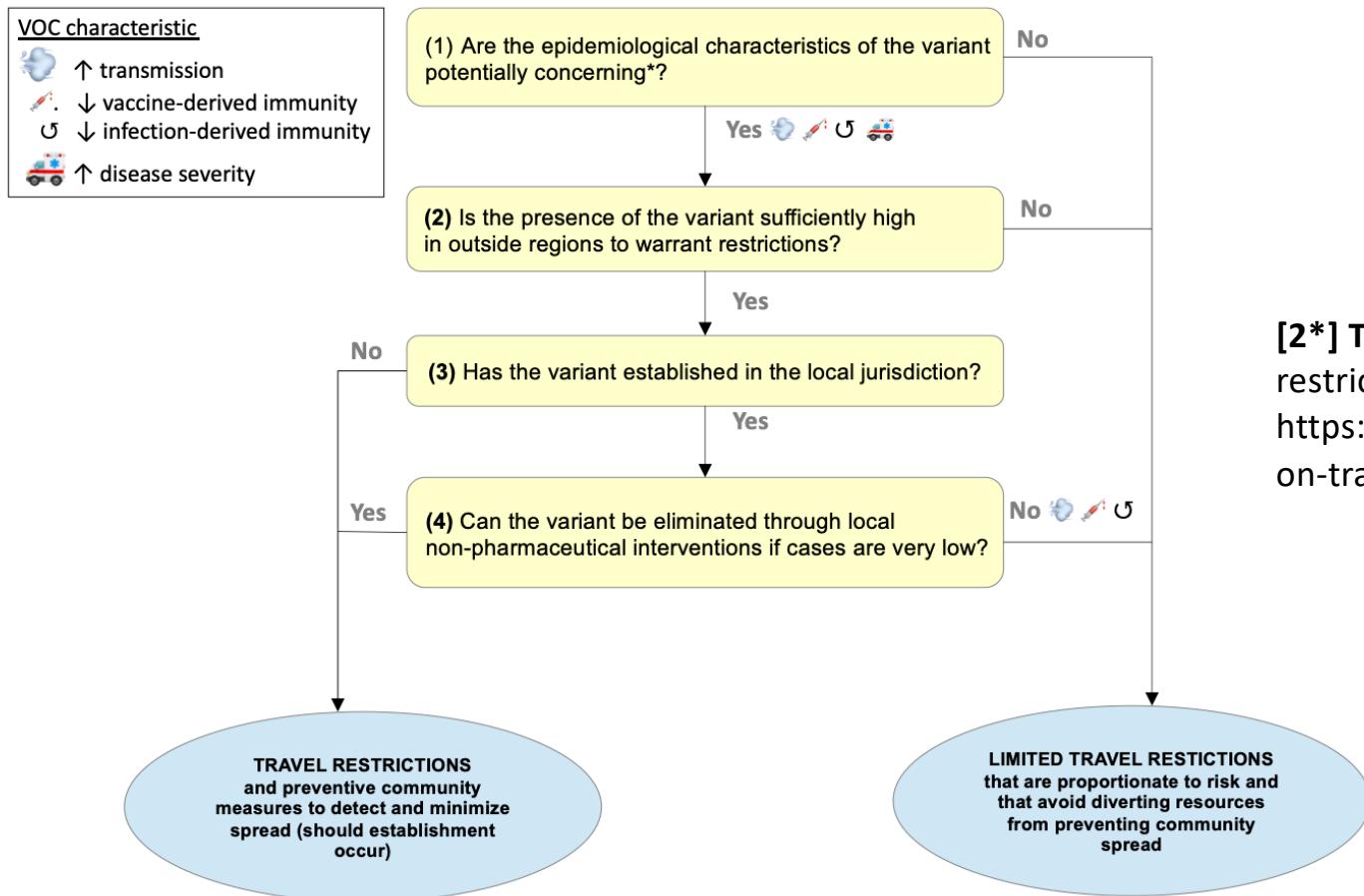
Baker et al. 2020. Elimination could be the optimal response strategy for covid-19 and other emerging pandemic diseases

# Under an elimination strategy: Don't wait, re-escalate



[2] NPIs. Hurford, A. and J. Watmough. 2021. Don't wait, re-escalate: Delayed action results in longer duration of COVID-19 restrictions. Fields Institute Communications. Springer.

# Travel restrictions + NPIs + regional considerations + variants

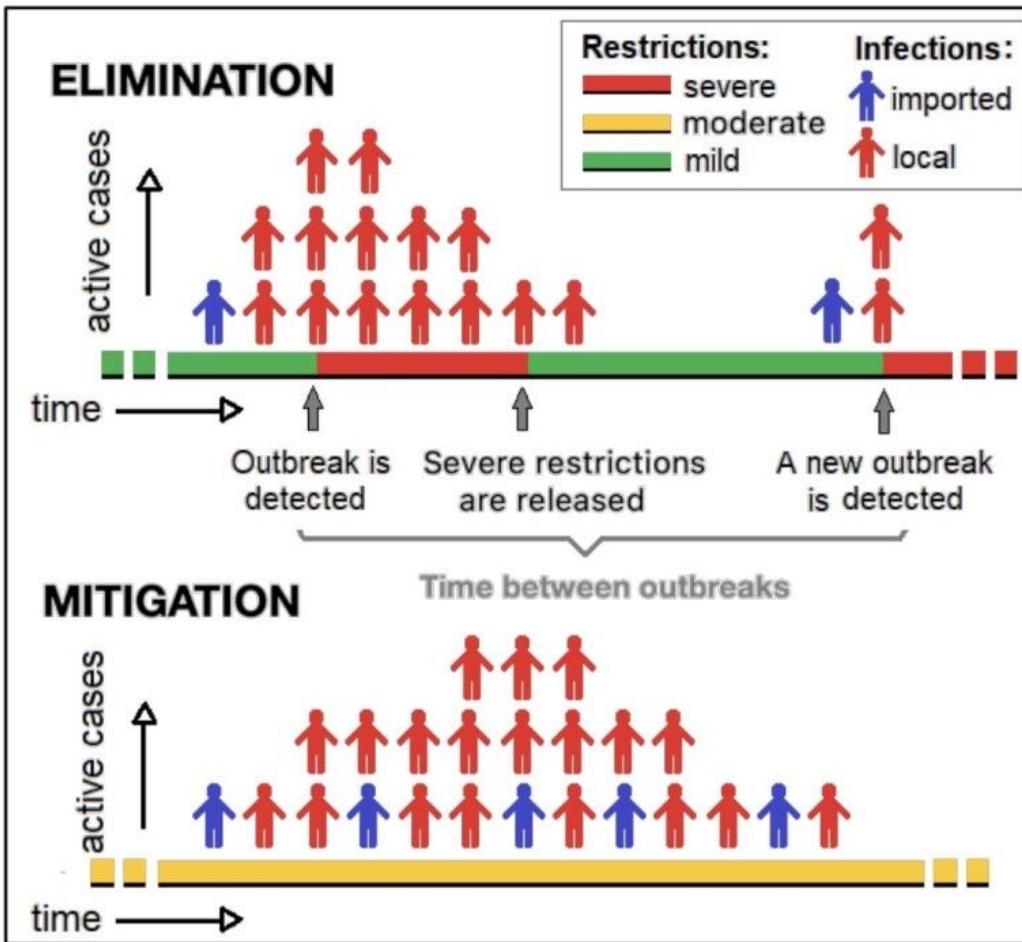


[2\*] **Travel.** Hurford et al. 2021. Travel restrictions and the Omicron variant.  
<https://canmod.net/static/assets/omicron-travel-final.pdf>

## **Box 2. Smaller jurisdictions and travel restrictions**

Smaller jurisdictions may have lower capacities, lower travel volumes, and geographical and social characteristics that reduce the transmission rate. All of these features favour the implementation of travel restrictions (Figure 1).

[2\*] **Travel.** Hurford et al. 2021. Travel restrictions and the Omicron variant. <https://canmod.net/static/assets/omicron-travel-final.pdf>



[5\*] **Exit elimination.** It's not realistic to eliminate COVID-19 in Newfoundland and Labrador. Here's why. March 2022. Martignoni and Hurford. CBC NL. <https://www.cbc.ca/news/canada/newfoundland-labrador/covid-19-here-to-stay-1.6384033>

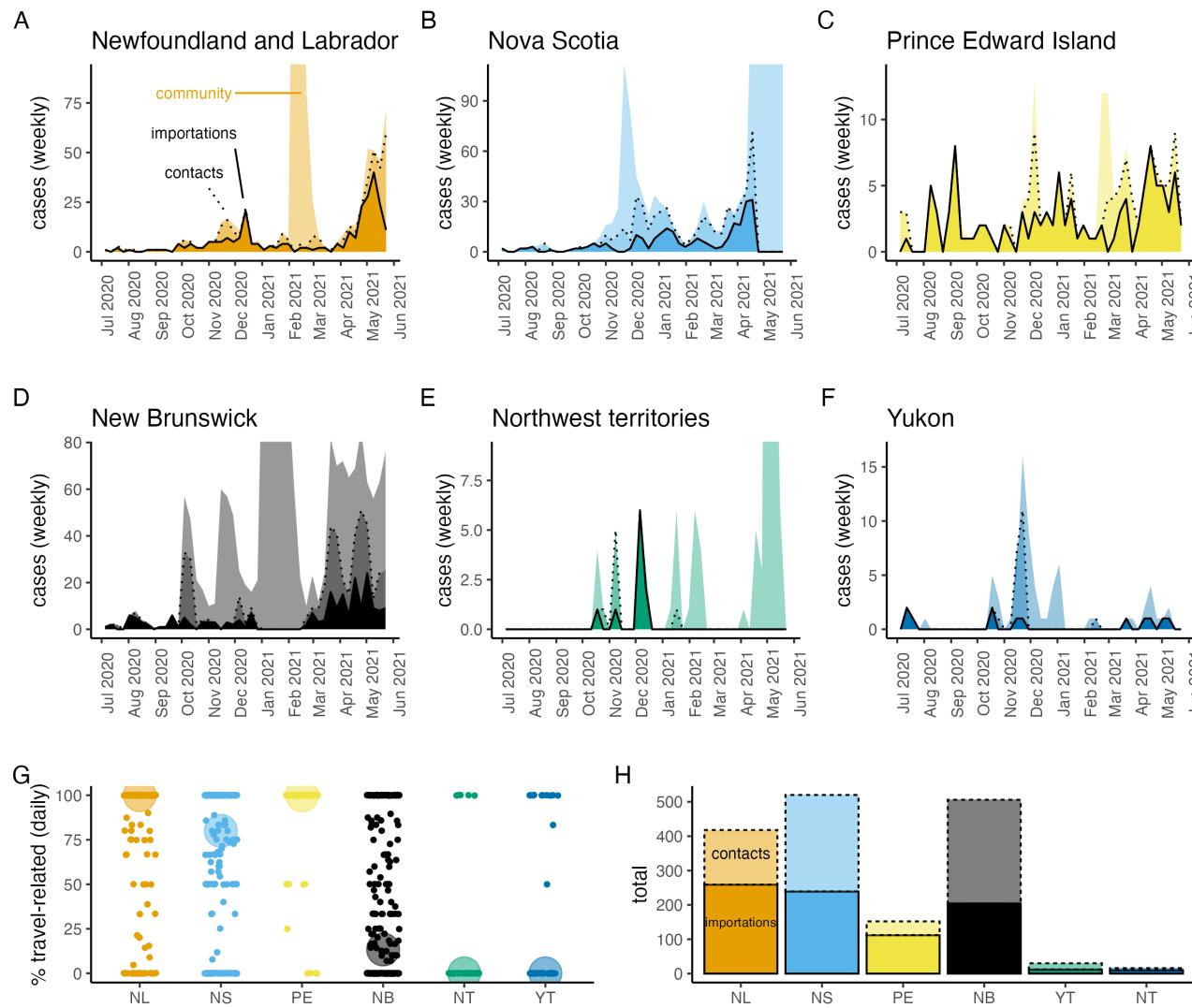
“I used to say that a criticism of travel restrictions is that they ‘delay the inevitable’; however, frequently when we think of what is ‘inevitable,’ we overlook evolution.” – Amy Hurford

***Covid-19: What went wrong after initial success in Laos?***  
BMJ 2022; 377:o994 by Andrew Silver

### 3. Modelling for regions with no community cases

- Distinguish between travel-related and community cases
- Model 1: Extend importation model to consider local vaccination and NPIs
- Model 2: Explore scenarios given establishment of community infections

**[5] Modelling.** Hurford et al. Pandemic modelling for regions implementing an elimination strategy. Under review at the Journal of Theoretical Biology



In Newfoundland and Labrador (NL), Nova Scotia, and Prince Edward Island the mean percentage of daily cases that were travel-related was 80% or greater (July 1, 2020 – May 31, 2021)

[5] **Modelling.** Hurford et al. Pandemic modelling for regions implementing an elimination strategy. Under review at the Journal of Theoretical Biology

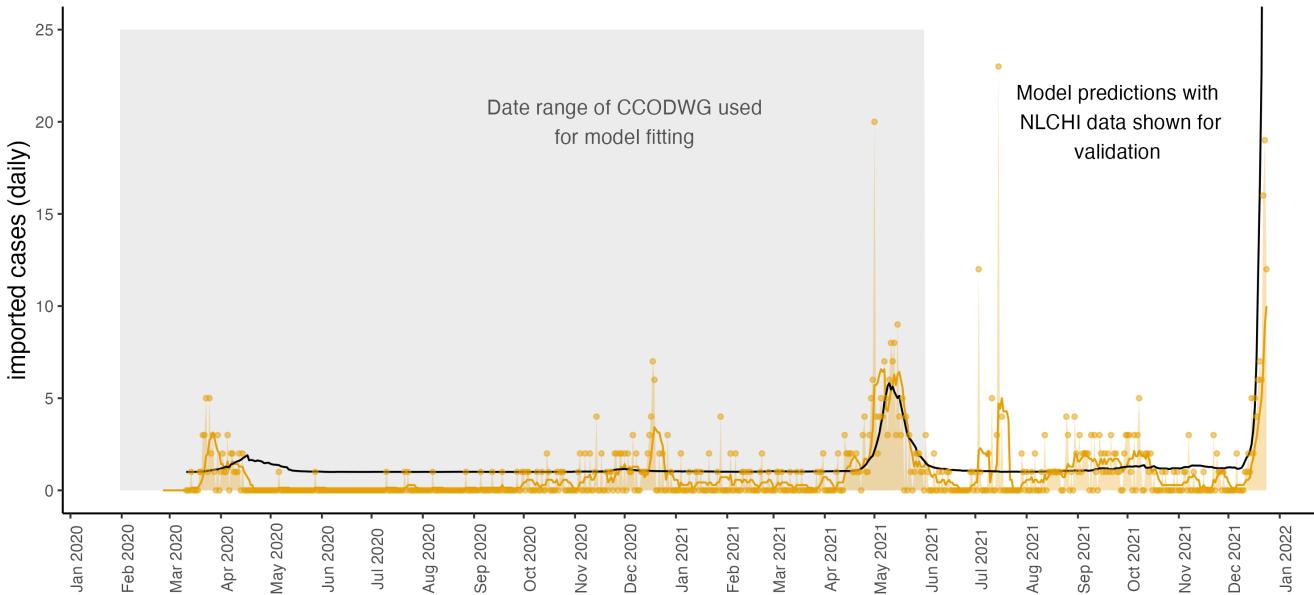
Your Responsibility		Travel	Formal Gatherings	Personal Gatherings	Businesses	Recreational Activities	Offices and Workplaces
<b>Transition</b>  June 15 to July 1	<ul style="list-style-type: none"> <li>Wear a non-medical mask in indoor public spaces.</li> <li>Physical distancing.</li> <li>If sick, stay home, get tested.</li> <li>Get both doses of COVID-19 vaccine.</li> </ul>	<ul style="list-style-type: none"> <li>Follow existing travel guidelines.</li> </ul>	<ul style="list-style-type: none"> <li>Outdoor gatherings up to 150 people.</li> <li>Community fireworks, parades and outdoor ceremonial events are permitted with physical distancing.</li> </ul>	<ul style="list-style-type: none"> <li>Outdoor personal gatherings up to 30 people.</li> <li>Indoor personal gatherings limited to Steady 20.</li> </ul>	<ul style="list-style-type: none"> <li>Follow existing business guidelines.</li> </ul>	<ul style="list-style-type: none"> <li>Outdoor sports tournaments permitted as part of Return to Play plans.</li> </ul>	<ul style="list-style-type: none"> <li>Begin gradual return to workplaces and offices.</li> </ul>
<b>Step 1</b>  As early as July 1  D1: 75% C/H: low	<ul style="list-style-type: none"> <li>Wear a non-medical mask in indoor public spaces.</li> <li>Physical distancing.</li> <li>If sick, stay home, get tested.</li> <li>Get both doses of COVID-19 vaccine.</li> </ul>	<ul style="list-style-type: none"> <li>Non-essential travel from within Canada permitted.</li> <li>Fully vaccinated Canadians have no testing or self-isolation requirements.</li> <li>Partially vaccinated Canadians must present a negative test result or self-isolate until receipt of a negative test result.</li> <li>Unvaccinated Canadians self-isolate for 14 days.</li> </ul>	<ul style="list-style-type: none"> <li>Outdoor gatherings up to 250 people.</li> <li>Indoor gatherings lesser of up to 200 people or 75 per cent capacity with physical distancing.</li> </ul>	<ul style="list-style-type: none"> <li>Outdoor personal gatherings up to 50 people.</li> <li>Indoor personal gatherings limited to Steady 20.</li> </ul>	<ul style="list-style-type: none"> <li>No capacity restrictions for retail stores with physical distancing.</li> <li>Restaurants and lounges can open at 75 per cent capacity, with physical distancing.</li> </ul>	<ul style="list-style-type: none"> <li>Outdoor sports tournaments permitted with COVID-19 protocols in place.</li> <li>Recreational and arts facilities follow the limits for formal gatherings.</li> </ul>	<ul style="list-style-type: none"> <li>Continued return to work.</li> <li>Workplaces can have small in-person meetings.</li> </ul>
<b>Step 2</b>  As early as August 15  D1: 80% D2: 50% C/H: low	<ul style="list-style-type: none"> <li>Wear a non-medical mask in indoor public spaces.</li> <li>Physical distancing.</li> <li>If sick, stay home, get tested.</li> <li>Get both doses of COVID-19 vaccine.</li> </ul>	<ul style="list-style-type: none"> <li>Fully and partially vaccinated Canadians have no testing or self-isolation requirements.</li> <li>Unvaccinated Canadians tested on day 7, 8 or 9, and self-isolate until receipt of a negative test result.</li> </ul>	<ul style="list-style-type: none"> <li>Outdoor gatherings up to 500 people.</li> <li>Indoor gatherings up to 350 people with physical distancing.</li> </ul>	<ul style="list-style-type: none"> <li>Limited to the number of people that can fit in the space with physical distancing.</li> </ul>	<ul style="list-style-type: none"> <li>No capacity restrictions at retail stores, restaurants and lounges.</li> <li>Dancing permitted.</li> </ul>	<ul style="list-style-type: none"> <li>Indoor and outdoor sports tournaments permitted with COVID-19 protocols.</li> <li>Recreational and arts facilities follow the limits for formal gatherings.</li> </ul>	<ul style="list-style-type: none"> <li>Continued return to work.</li> <li>Larger meetings and conferences can happen.</li> </ul>
<b>Step 3</b>  As early as September 15  D2: 80% C/H: low	<ul style="list-style-type: none"> <li>Mask guidance will be reviewed based on current evidence.</li> <li>Physical distancing.</li> <li>If sick, stay home, get tested.</li> <li>Get both doses of COVID-19 vaccine.</li> </ul>	<ul style="list-style-type: none"> <li>Fully and partially vaccinated Canadians have no testing or self-isolation requirements</li> <li>Unvaccinated Canadians self-isolate until receipt of a negative test result.</li> </ul>	<ul style="list-style-type: none"> <li>Outdoor gatherings have no capacity restrictions with physical distancing.</li> <li>Increased capacity at indoor gatherings to be determined.</li> </ul>	<ul style="list-style-type: none"> <li>Limited to the number of people that can fit in the space with physical distancing.</li> </ul>	<ul style="list-style-type: none"> <li>No capacity restrictions at retail stores, restaurants and lounges.</li> </ul>	<ul style="list-style-type: none"> <li>Indoor and outdoor sports tournaments permitted with COVID-19 protocols.</li> <li>Recreational and arts facilities follow the limits for formal gatherings.</li> </ul>	<ul style="list-style-type: none"> <li>Workplaces are back to normal with appropriate COVID-19 protocols in place, as required.</li> </ul>

**D1:** Percentage of people ages 12 years and older vaccinated with at least one dose of COVID-19 vaccine

**D2:** Percentage of people ages 12 years and older vaccinated with two doses of COVID-19 vaccine

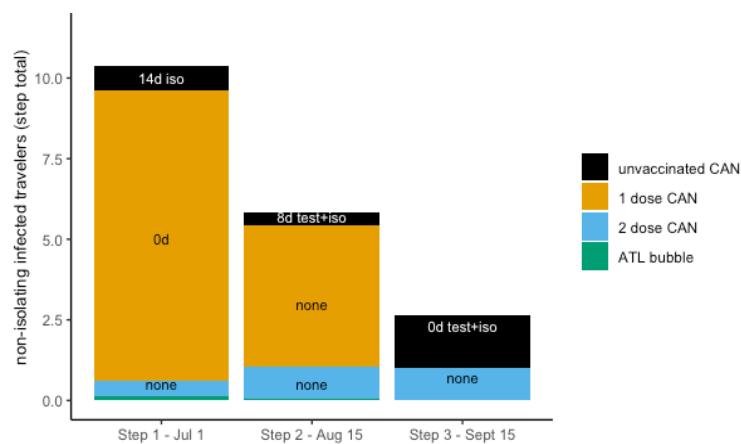
**C/H:** COVID-19 case counts and hospitalizations

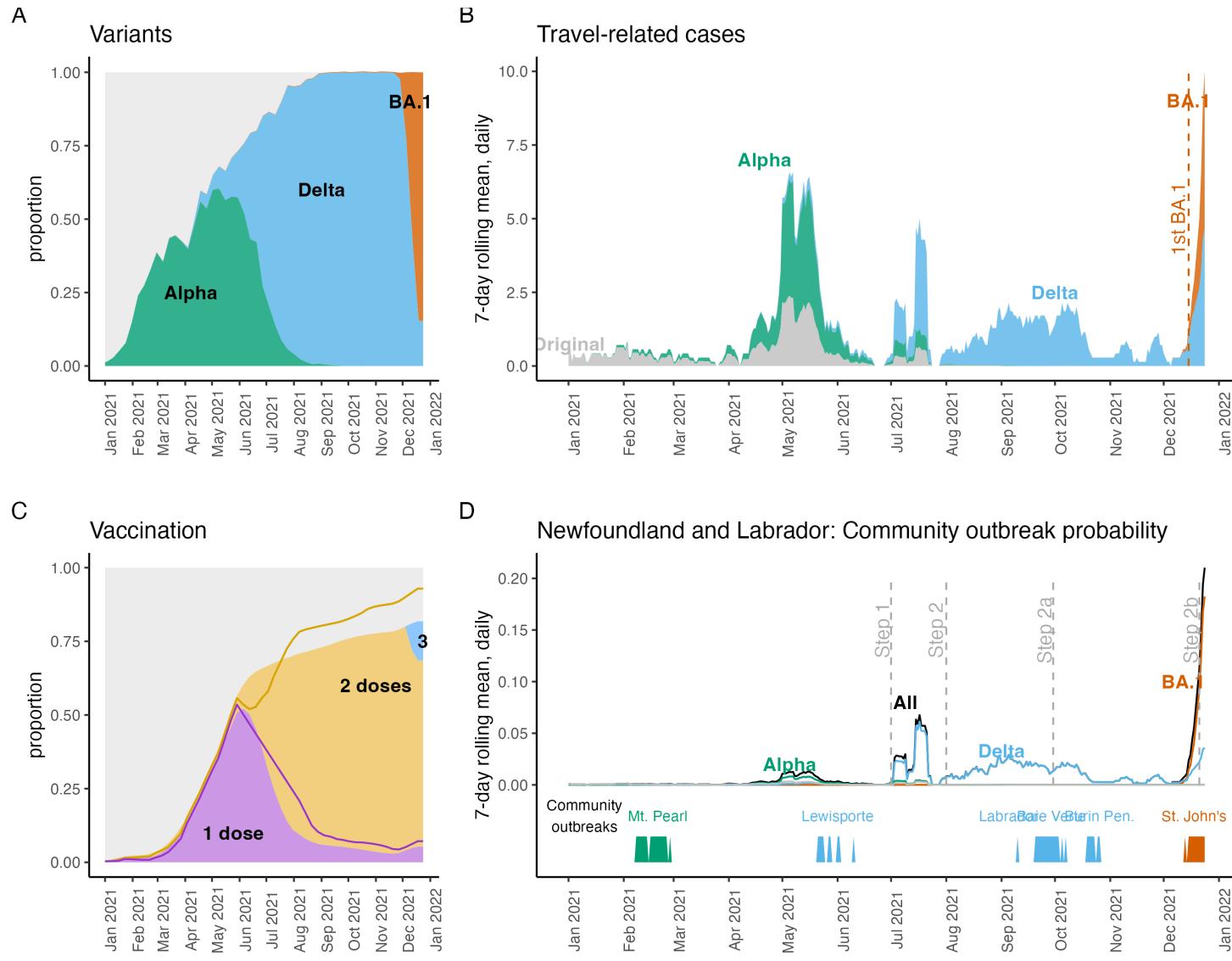
### Statistical model of importations to NL



The daily number of imported cases to NL (reported by NLCHI for March 15, 2020–December 24, 2021) is reliably predicted as 0.105 times the number of active cases per 10,000 population in NS.

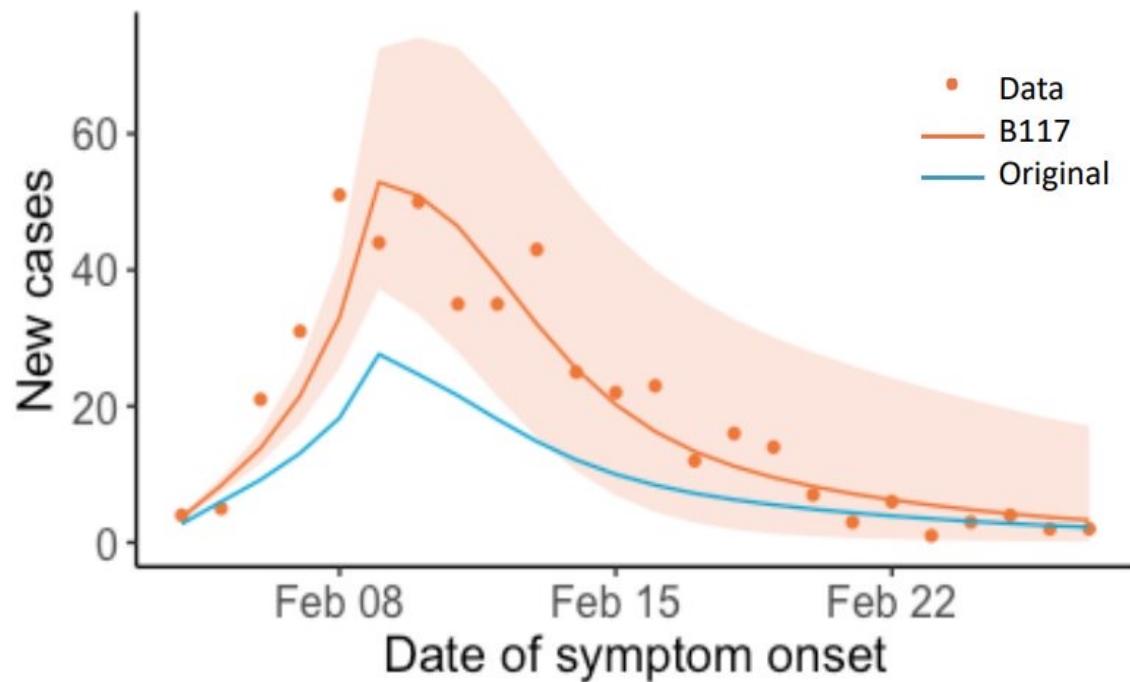
**[5] Modelling.** Hurford et al. Pandemic modelling for regions implementing an elimination strategy. Under review at the Journal of Theoretical Biology





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Pandemic modelling for regions  
implementing an elimination  
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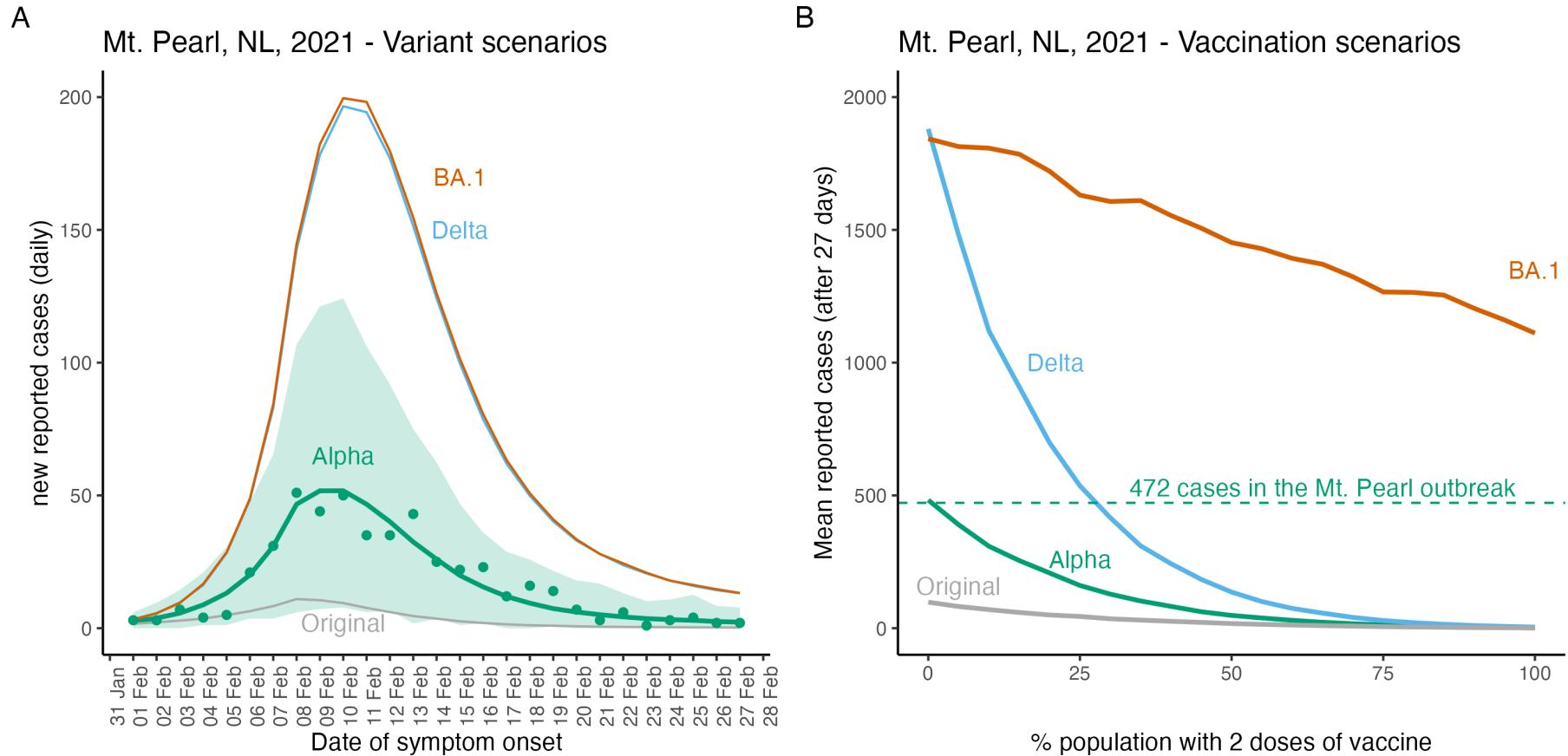
## Comparison of B117 vs. "original" SARS-CoV2 Outbreak



### Reproduction number

	B117	Original*
Before Feb 9	6.4	4.3
After Feb 9	0.6	0.4

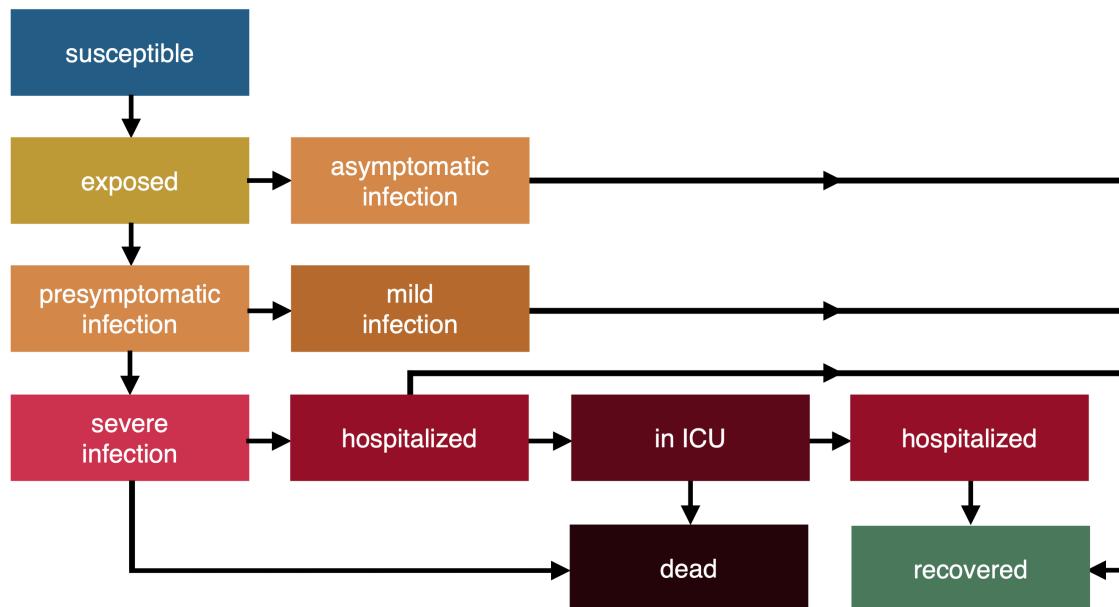
\* Inferred by assuming 50% greater  
for B117



[5] **Modelling.** Hurford et al. Pandemic modelling for regions implementing an elimination strategy. Under review at the Journal of Theoretical Biology

## 4. Modelling for regions with community cases

mac-theobio / McMasterPandemic Public

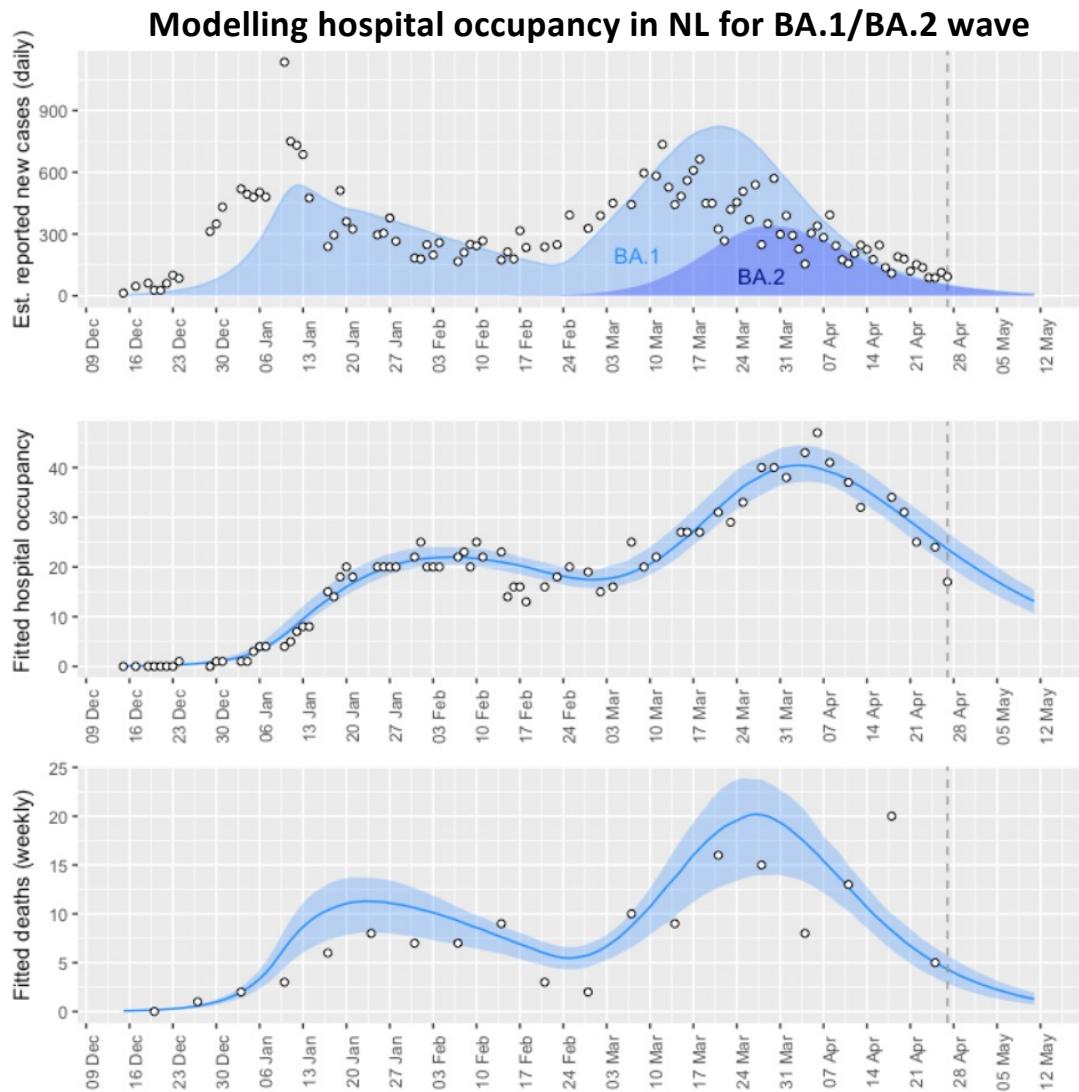


Contributors 11



Used by PHAC and Ontario Science Table

[4\*] omega-nl The Omicron wave in NL. Twitter & The telegram  
<https://rpubs.com/ahurford/883365>



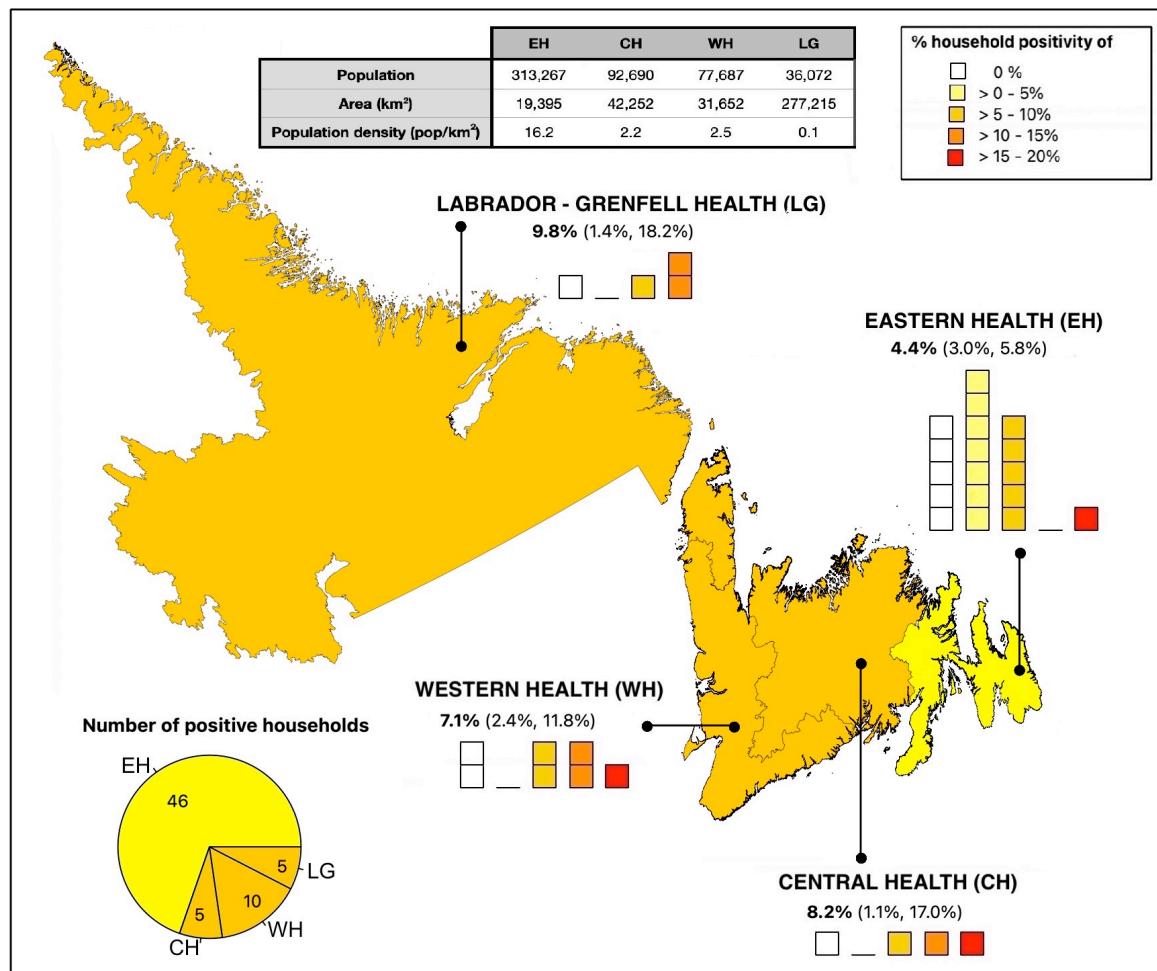
[4\*] **omega-nl** The Omicron wave in NL. Twitter & The telegram  
<https://rpubs.com/ahurford/883365>

## 5. Prioritizing rotational workers for vaccination

Group vaccinated	Vaccines needed	Reduction in hospital admissions	Reduction in ICU admissions
Rotational workers	6,000	42%	42%
> 75 years	43,300	24%	45%

**[3] Vaccination.** Maria M. Martignoni, Proton Rahman, Amy Hurford. Rotational worker vaccination provides indirect protection to vulnerable groups in regions with low COVID-19 prevalence. AIMS Mathematics, 2022, 7(3): 3988-4003. doi: 10.3934/math.2022220

## 6. Recording the K-12 RAT results



1 in 4.3 positive  
household reported in  
provincial case counts

[6.] RAT. Martignoni et al. Extensive SARS-CoV-2 testing reveals BA.1/BA.2 asymptomatic rates and underreporting in school children

## 6. NL K-12 return to school Rapid Antigen Testing

	Population size	Cumulative reported cases on January 15, 2022	Cumulative reported cases on Feb 12, 2022	% infected January 2022	% infected February 2022	Unreported cases per reported case
British Columbia	5,000,879	295,904 (5.92%)	339,736 (6.79%)	11.82	25.52	12.3
Alberta	4,262,635	439,320 (10.31%)	514,251 (12.06%)	16.78	31.79	8.6
Saskatchewan	1,132,505	98,699 (8.72%)	125,756 (11.10%)	11.53	22.28	4.5
Manitoba	1,342,153	107,838 (8.03%)	125,844 (9.38%)	16.26	28.05	8.7
Ontario	14,223,942	937,636 (6.59%)	1,070,455 (7.53%)	12.13	22.65	11.2
Quebec	8,501,833	806,920 (9.49%)	899,260 (10.58%)	9.73	20.32	9.7
New Brunswick	775,610	22,359 (2.88%)	32,610 (4.20%)	2.43	9.82	5.6
Nova Scotia	969,383	30,101 (3.11%)	42,230 (4.36%)	3.8	12.77	7.2
Prince Edward Island	154,331	4,118 (2.67%)	10,105 (6.55%)	1.52	7.21	1.5
Newfoundland and Labrador	510,550	12,406 (2.43%)	19,954 (3.91%)	2.1	8.18	4.1

[6.] RAT. Martignoni et al.  
Extensive SARS-CoV-2 testing  
reveals BA.1/BA.2  
asymptomatic rates and  
underreporting in school  
children

# Conclusion

## Mechanistic modelling: contributions to the pandemic response

1. Short-term forecasts
2. Counterfactual scenarios
3. Communication

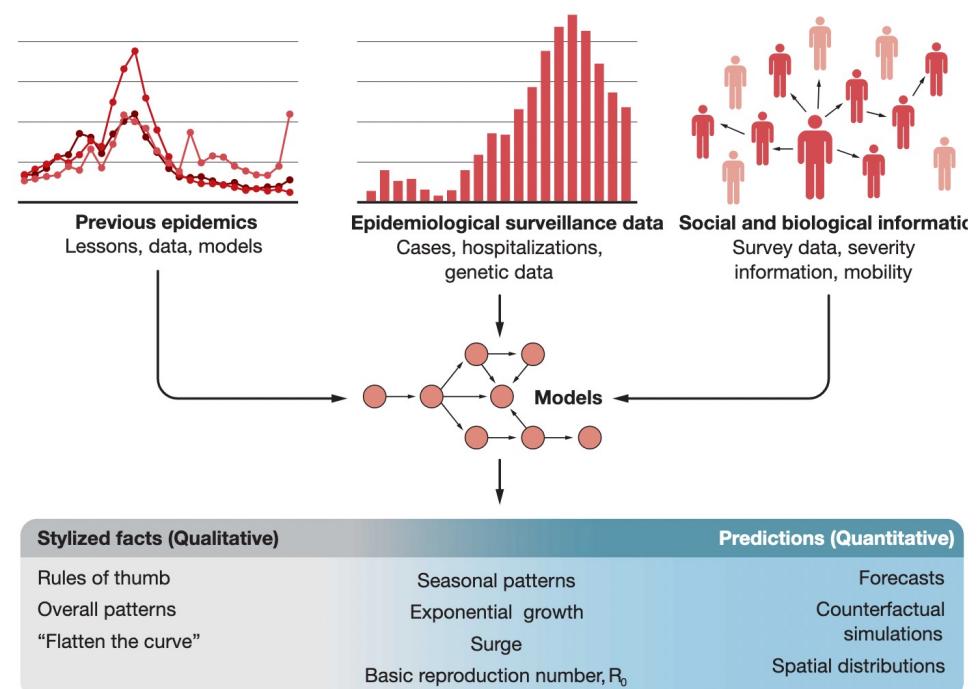


Diagram from Zelner and Eisenberg. 2022. Rapid response modelling of SARS-CoV-2 transmission. Science

# ACKNOWLEDGEMENTS

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Francis Anokye, MUNL

James Watmough, UNB

Sanjeev Sahara, UNB

Monica Cojocura, U Guelph

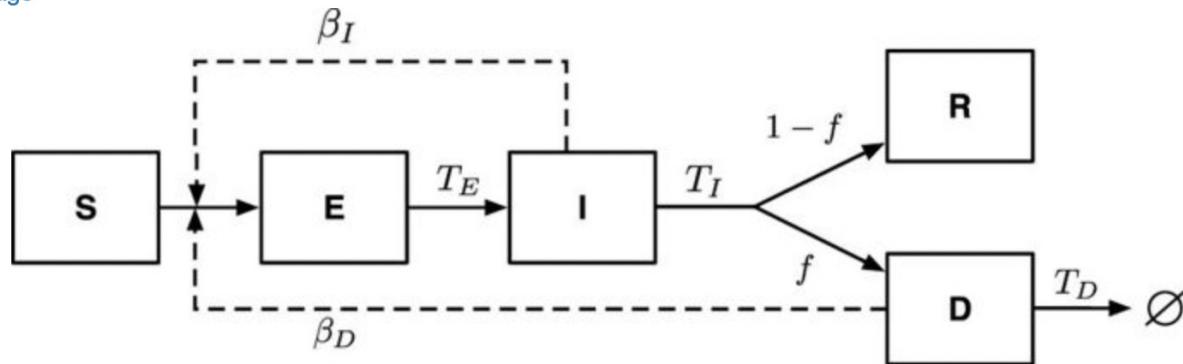
Troy Day, Queen's U

Lisa Kanary, Yukon U

Steve Walker



[Theobio main page](#)



# Ontario COVID-19 forecasts

#MacTheobio COVID Modelling Group

Irena Papst ([@irenapapst](#)), Ben Bolker ([@bolkerb](#)), Jonathan Dushoff ([@jd\\_mathbio](#)), David Earn ([@DavidJDEarn](#))

McMaster University, Hamilton, Ontario, Canada, L8S 4K1

Forecast date: 26 Jan 2022

Post last updated: 06 Feb 2022

## Context

Every few weeks, our group provides COVID-19 forecasts for the province of Ontario to the [Ontario Modelling Consensus Table](#) (MCT), a partner of the [Ontario Science Advisory Table](#) (SAT), which presents this information to the Health Coordination Table of the Ontario Ministry of Health.<sup>1</sup> Other modelling groups also provide forecasts to the MCT. After reviewing all forecasts provided, the MCT provides consensus projections to the SAT.

Our forecasts are based on a [compartmental epidemic model](#) implemented in our publicly available [McMasterPandemic](#) R package, and involve statistical fits to [Ontario's latest COVID-19 data](#).

## JURISDICTIONAL SCAN

### Jurisdictional Scan of Frameworks and Epidemiologic Indicators to Inform Public Health Measures during COVID-19

- For jurisdictions that provided thresholds, the lowest incidence thresholds to trigger additional PHMs and/or action ranged from <1 to 9 daily average cases per 100,000, 0.2 to 24.9 per 100,000 cumulative over 7 days, and <10-30 per 100,000 cumulative over 14 days.
- Across frameworks reviewed, the highest thresholds to trigger the most stringent public health measures, including ‘lockdown’ thresholds, were the most challenging to identify. Based on this scan, the highest thresholds varied greatly by jurisdiction, likely reflecting the overall decision-making context and/or goals in those jurisdictions. For example, the incidence per 100,000 thresholds range from ≥4 to ≥25 daily average cases, >0.4 to ≥300 cumulative over 7 days, and >100 to ≥150 cumulative over 14 days.

# **Special report: The simulations driving the world's response to COVID-19**

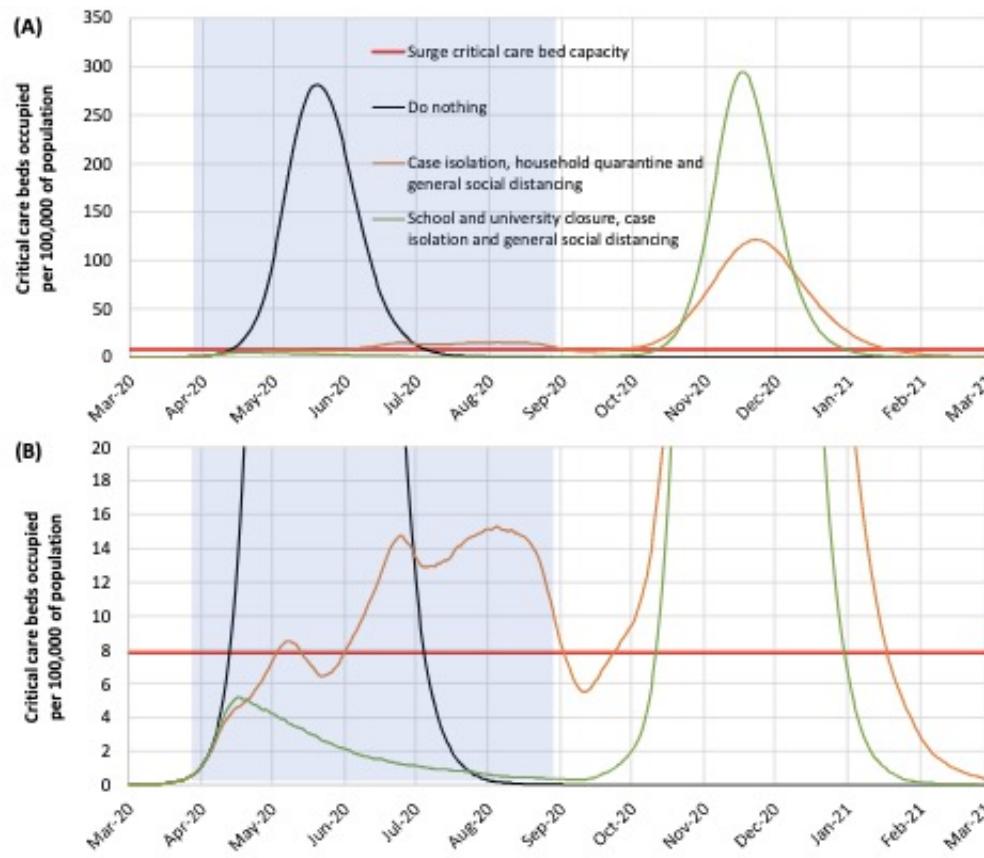
Adam 2020. Nature

On 26 March, Ferguson and his team released global projections of the impact of COVID-19 that uses the simpler equation-based SEIR approach

Had the United States taken no action against the virus:

- SEIR: 2.18 million deaths
- CovidSim ABM: 2.2 million deaths

“They give broadly similar overall numbers,” says epidemiologist Azra Ghani



Report 9 - Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand. WHO Collaborating Centre for Infectious Disease Modelling; MRC Centre for Global Infectious Disease Analysis; Abdul Latif Jameel Institute for Disease and Emergency Analytics; Imperial College London, UK

# **Simulating the pandemic: What COVID forecasters can learn from climate models**

Adam 2020. Nature

“There was a concern ... that these models the epidemiologists work with have an absurd number of parameters in them and they can’t possibly be right,” Peter Coveney, chemist and computer scientist, UCL

His team found 940 parameters in the CovidSim code, but whittled these down to the 19 that most affected the output.

Up to two-thirds of the differences in the model’s results could be put down to changes in just three key variables

# Critiqued coronavirus simulation gets thumbs up from code-checking efforts

Chawla 2020. *Nature*

Asked whether he'd learnt any lessons from the furore over his team's code, Ferguson emphasized to *Nature* how fast the work had to be done.

Ferguson: none of the criticisms of the code affects the mathematics or science of the simulation

← → ⌂ https://github.com/ahurford/NL-public-COVID-data 133% ⭐

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ahurford / NL-public-COVID-data Public

Code Issues Pull requests Actions Projects Wiki Security ...

main Go to file Add file Code

ahurford Update estimated.active.csv ... yesterday 16

AgeBreakDown... Add files via upload 8 days ago

NL\_prov\_stats.c... Rename Prov\_stats.csv to NL\_prov\_... 18 days ago

Prov\_Covid\_Dail... Add files via upload 8 days ago

README.md Update README.md 18 days ago

RHA\_DailyData... Add files via upload 8 days ago

estimated.activ... Update estimated.active.csv yesterday

About

No description, website, or topics provided.

Readme 0 stars 2 watching 0 forks

Releases

No releases published

A screenshot of a Twitter profile page for Amy Hurford (@amy\_hurford). The header shows a red banner with the text "Populations+ > Space.Temperature.Evolution" and "Hurford Lab". Below the banner is a circular profile picture of Amy jumping in a field. The sidebar on the left includes links for Home, Explore, Notifications, Messages, Bookmarks, Lists, and Profile (which is selected).

**Amy Hurford**  
@amy\_hurford  
1,174 Tweets

Mathematical biology. Quantitative training. COVID-19 modeller. Population dynamics. Expat kiwi. Basketball nut. (she/her)

[ahurford.github.io/website/#dr.-a...](https://ahurford.github.io/website/#dr.-a...) Joined February 2015

1,046 Following 1,077 Followers

## Research

I am a mathematical biologist. My research considers:

1. Public health responses to COVID-19 in Atlantic Canada;
2. Population dynamics with temperature dependence and explicit space; and
3. Evolutionary epidemiology.

For my publications, see [Google Scholar](#)

### Our COVID-19 research and outreach:

#### Talks and panel discussions

- **Endemicity: What's next?** Fields Institute panel discussion with Drs. Jane Heffernan and Steven Hoffman.
- **10 steps to modelling COVID-19 for science majors** A 50 minute talk.

#### Peer-reviewed publications

- **Newfoundland and Labrador's travel restrictions** decreased the number of COVID-19 cases in the province by 92%. Related interview with CBC On The Go is [here](#)
- **Don't wait, re-escalate:** using mathematics accessible to university students, we show that delayed restrictions need to have longer duration to achieve the same endpoint. Appears in



The Fields Institute for Research in Mathematical Sciences website. The header includes the Fields logo, navigation links for About Us, Sponsors and Partners, People and Contacts, Calendar, and FieldsLive. Below the header, there are dropdown menus for Activities, Centres, and Honours and Fellows. A main title "Mathematical Modelling of COVID-19" is displayed.

The Fields Institute, in partnership with [ARMS](#), [CRM](#), and [PIMS](#), and in collaboration with [PHAC](#), [VIDO-Intervac](#), and the [NRC](#), has formed the **Mathematical Modelling of COVID-19 Task Force** to undertake research relating to COVID-19.

Under the leadership of Fields Institute Director Kumar Murty, the task force will bring together Canadian mathematics institutes, national and international co-investigators, collaborators, and team members, to mobilize a network of infectious disease modellers who will assess transmission risk, predict outbreak trajectories, and evaluate the effectiveness of COVID-19 countermeasures.

The project is one of [96 funded by CIHR](#) in a concerted effort to understand and control COVID-19.

#### Workshops and Conferences

##### [CIHR COVID-19 Task Force Showcase](#)

April 7, 2022

##### [Panel Discussion on Systemic Recovery](#)

April 28, 2021



The Canadian Center for Disease Modeling (CCDM) website. The header includes the CCDM logo, navigation links for Welcome to CCDM, People, Lectures, COVID-19, Events, Publications, and Opportunity. A red banner at the top says "Canadian Center for Disease Modeling (CCDM)".

NOV  
25  
2021

25 November 2021 @ 9:00 am - 10:00 am

#### [LAMPS Seminar On Modelling of COVID-19](#)

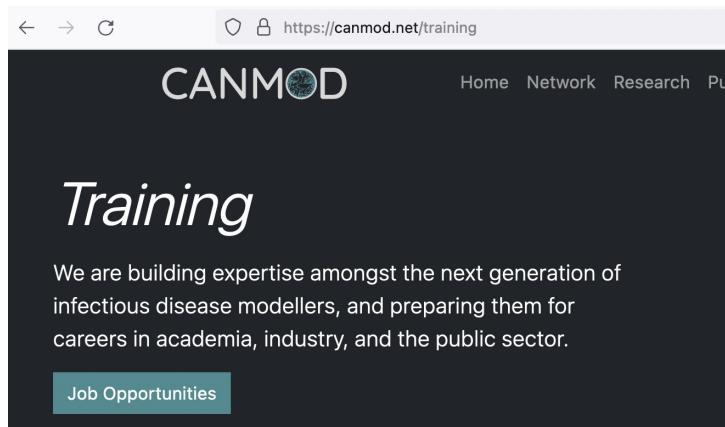
Speaker: Professor Manos Papageorgiou Title: Mobility-based Models of Epidemic Spreading Abstract: As people move around, over time, they regularly engage in social interactions. The spatiotemporal network representing these interactions constitutes the backbone on which an epidemic spreads, causing outbreaks. In the first part of the talk, I will present our research on epidemic spreading in [...]

NOV  
1  
2021

1 November 2021 @ 9:30 am - 6:00 pm

#### [Workshop on Modelling Immunity](#)

Schedule  
09:30 10:00 Opening Remarks (Jane Heffernan, David Buckeridge)  
10:00 10:30 John Glasser  
10:30 11:00 Carole Vignal  
11:00 11:30 Marie Alexandre  
11:30 12:00 Rahul Arora  
12:00 12:30 Panel (John Glasser, Rahul Arora, Marie Alexandre, Carole Vignal)  
12:30 13:00 Lunch  
13:00 13:30 Lauren Childs  
13:30 14:00 Caroline Wagner  
14:00 14:30 In-host Modelling Working Group  
14:30 15:00 Panel (Lauren Childs, Caroline Wagner, James Ooi, Jianhong Wu)  
15:00 15:30 Health Break  
15:30 16:00 Katia Koelle  
16:00 16:30 Morgan Craig  
16:30 17:00 Freya Shearer  
17:00 17:30 Panel (Katia Koelle, Morgan Craig, Freya Shearer, James



The CANMOD website. The header includes the CANMOD logo and navigation links for Home, Network, Research, and Publications. The main section features a large image with the word "Training" overlaid. Below the image, text reads: "We are building expertise amongst the next generation of infectious disease modellers, and preparing them for careers in academia, industry, and the public sector." A blue button labeled "Job Opportunities" is visible at the bottom left.

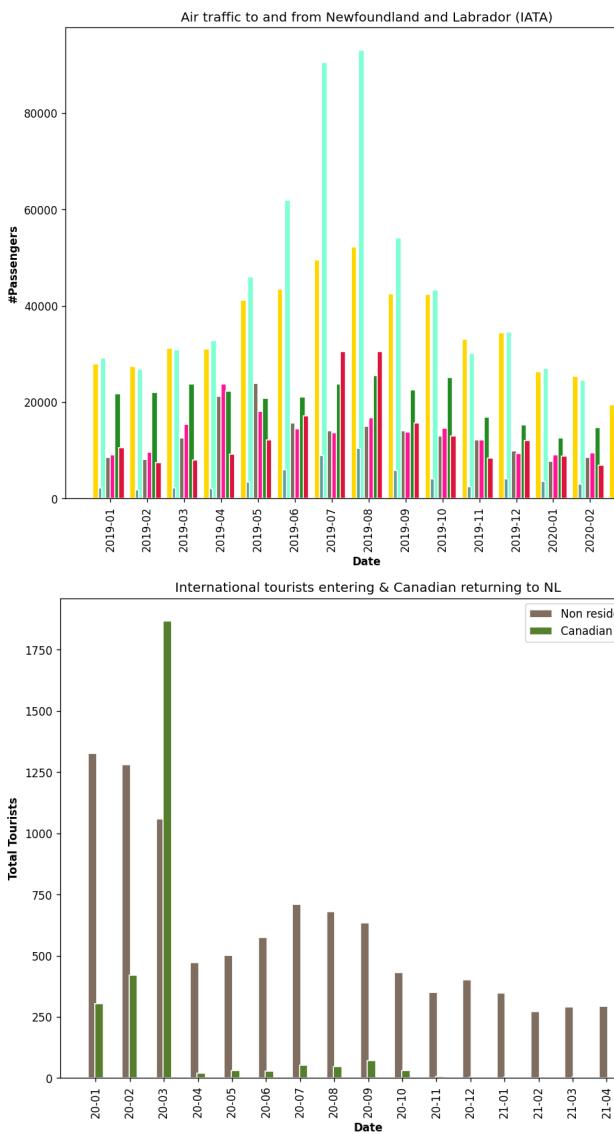
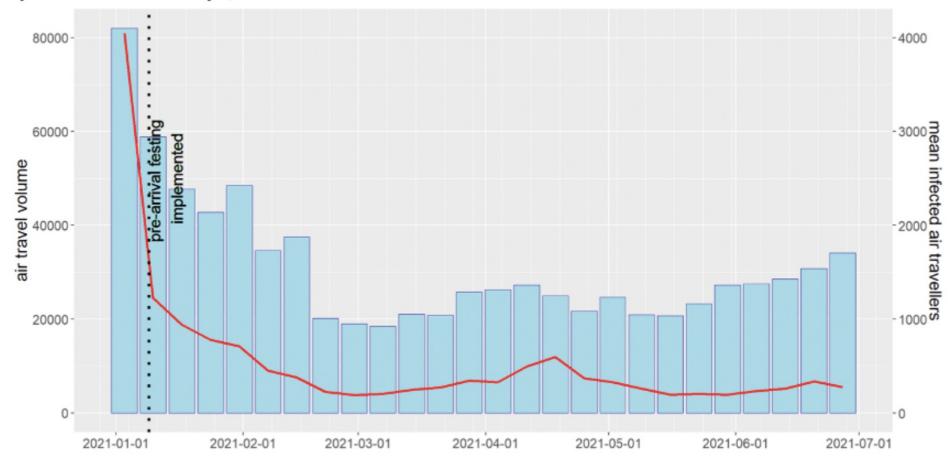
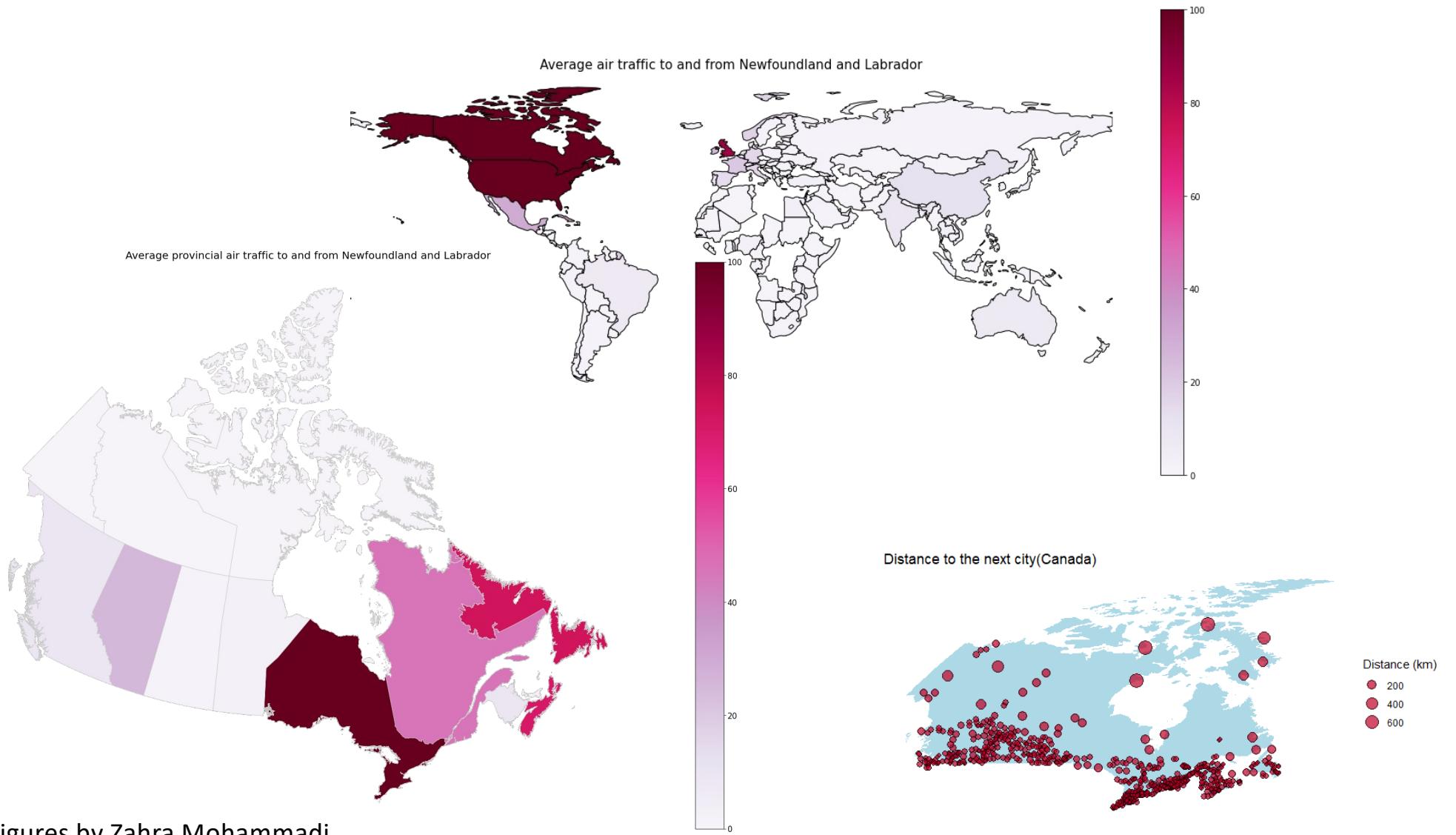


Figure 1. Estimated number of air travellers arriving infected to Canadian airports over time (red line), and volume of air travellers (blue bars). Data are shown relative to the date when the pre-arrival test was implemented on January 7, 2021.





Figures by Zahra Mohammadi

	<b>Fast results</b>	<b>Realistic assumptions</b>	<b>Few cases</b>	<b>Insight</b>	<b>Reference</b>
<b>Agent-based model</b>	No	Yes	Yes	A little	Adams 2020
<b>Stochastic model</b>	Depends	Depends	Yes	Moderate	Bertozzi et al. 2020
<b>Compartmental model</b>	Yes	No	No	Yes	Arino et al. 2006; Adams 2020; Saltelli et al.; Bertozzi et al. 2020
	<b>Short-term predictions</b>		<b>Scenarios</b>		
<b>Statistical model</b>	Yes		No		Holmdahl and Buckee 2020
<b>Mechanistic model</b>	Yes		Yes		Funk and King 2020
<b>Ensemble model</b>	Yes		Yes		Adam 2020; Shea et al 2020



**Methods** The observed number of positive test results is,

$$N^+ = pN\sigma^+ + (1 - p)N(1 - \sigma^-), \quad (1)$$

which is the sum of observed positive test results from infected individuals and false positive test results from uninfected individuals, where  $p$  is the proportion infected, and  $N$  is the total number of tests. The estimated sensitivity of rapid antigen tests, i.e., the probability of testing positive if infected, is  $\sigma^+ = 0.75$ . This sensitivity is intermediate to the low and high sensitivity scenarios from the Coronavirus (COVID-19) Infection Survey in the United Kingdom<sup>7</sup>. Low sensitivity may have occurred for the January 25th return to K-12 school in Newfoundland and Labrador as the tests were self-administered or administered by caregivers. The estimated specificity of rapid antigen tests, i.e., the probability of testing negative if uninfected, is  $\sigma^- = 0.992$ , and was calculated as the mean across brands from Table S7 of Wells et al. 2022<sup>8</sup>.

We estimate the proportion of K-12 students infected with COVID-19 by rearranging equation (1):

$$p = \frac{1 - \sigma^- - \frac{N^+}{N}}{1 - \sigma^- - \sigma^+}. \quad (2)$$

Credible intervals report the interval expected to contain a given percentage of estimates. Credible intervals were calculated using Jeffreys interval, i.e., a beta distribution with shape parameters  $pN + 1/2$  and  $N(1 - p) + 1/2$ .

# Objective: Work within my expertise and prioritize impact for NL people

Activity	Venue
Contribute types of modelling not available to the NL govt	[1] travel [2] NPIs [3] vaccination [5] modelling
Advise on appropriate modelling approaches	NLCHI Predictive Analytics
Highlight deviations from national recommendations for NL	[3] vaccination [5] modelling [1*] alpha [2*] travel
Provide modelling to the NL public	NLCHI Predictive Analytics [3*] RAT [4*] omega-NL
Record data	[6] RAT

# Regional differences

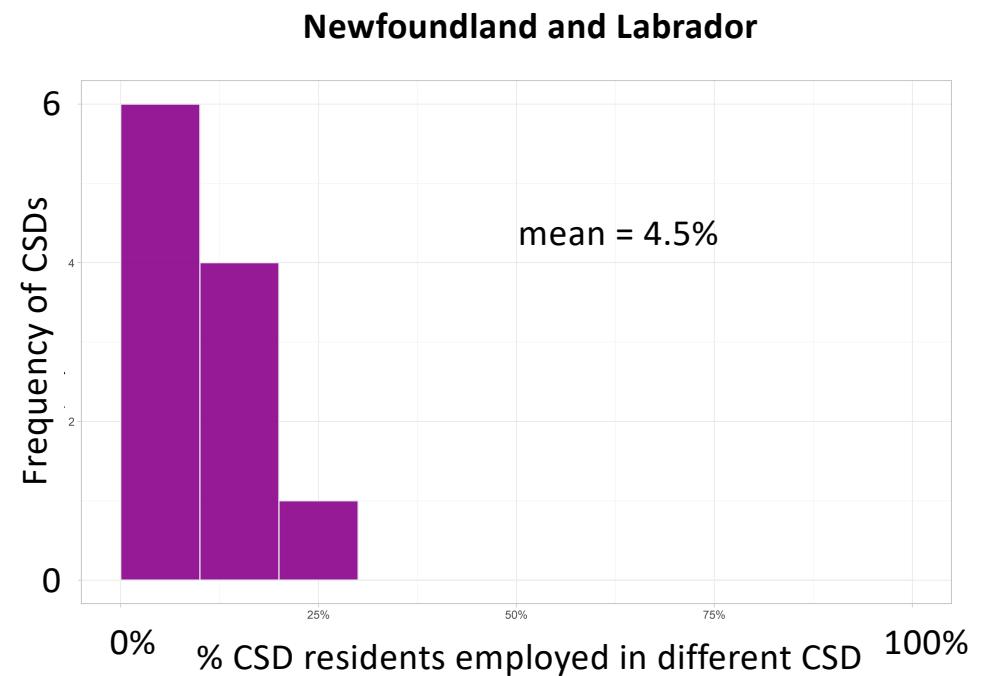
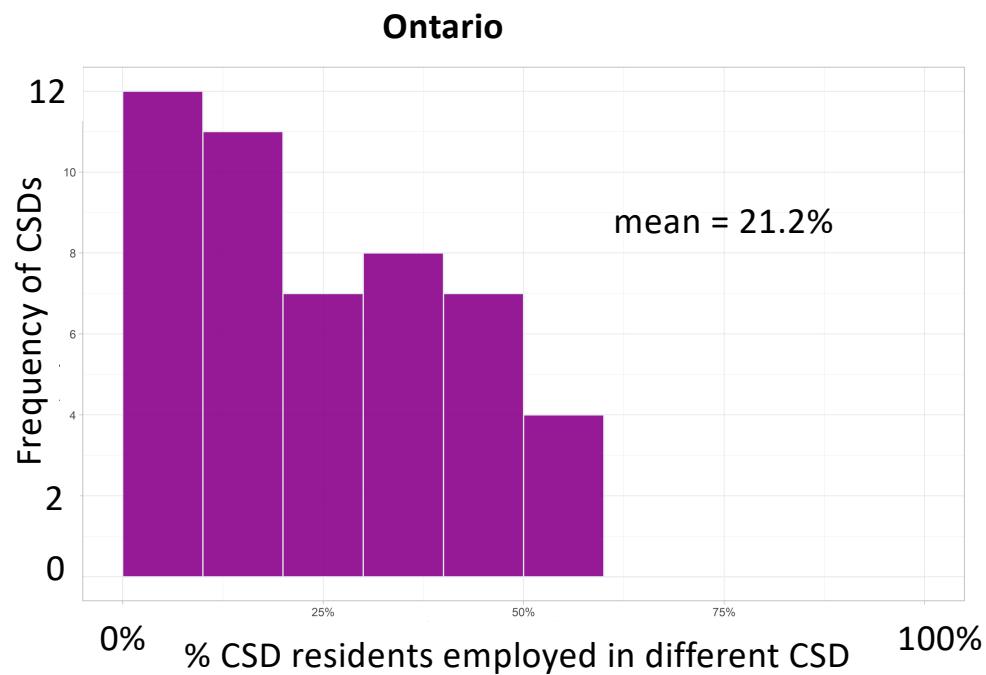


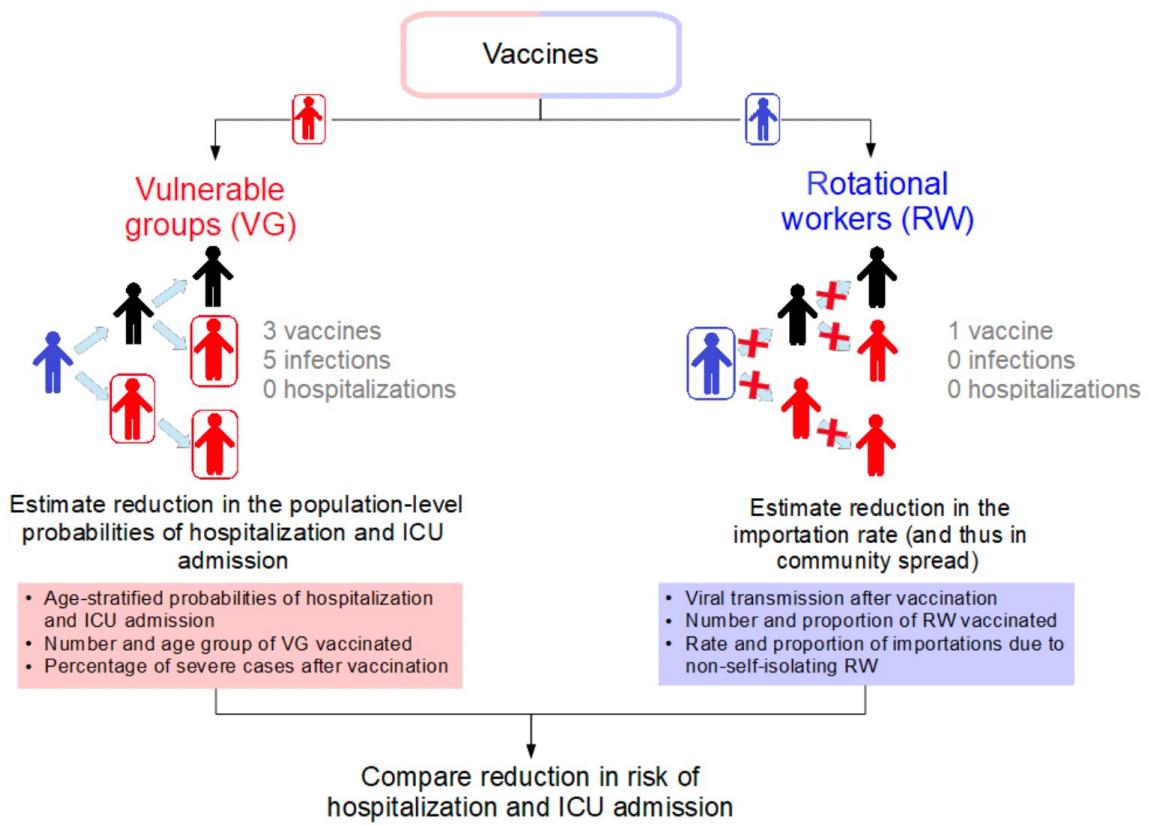
Figure by Zahra Mohammadi

## Phase 1

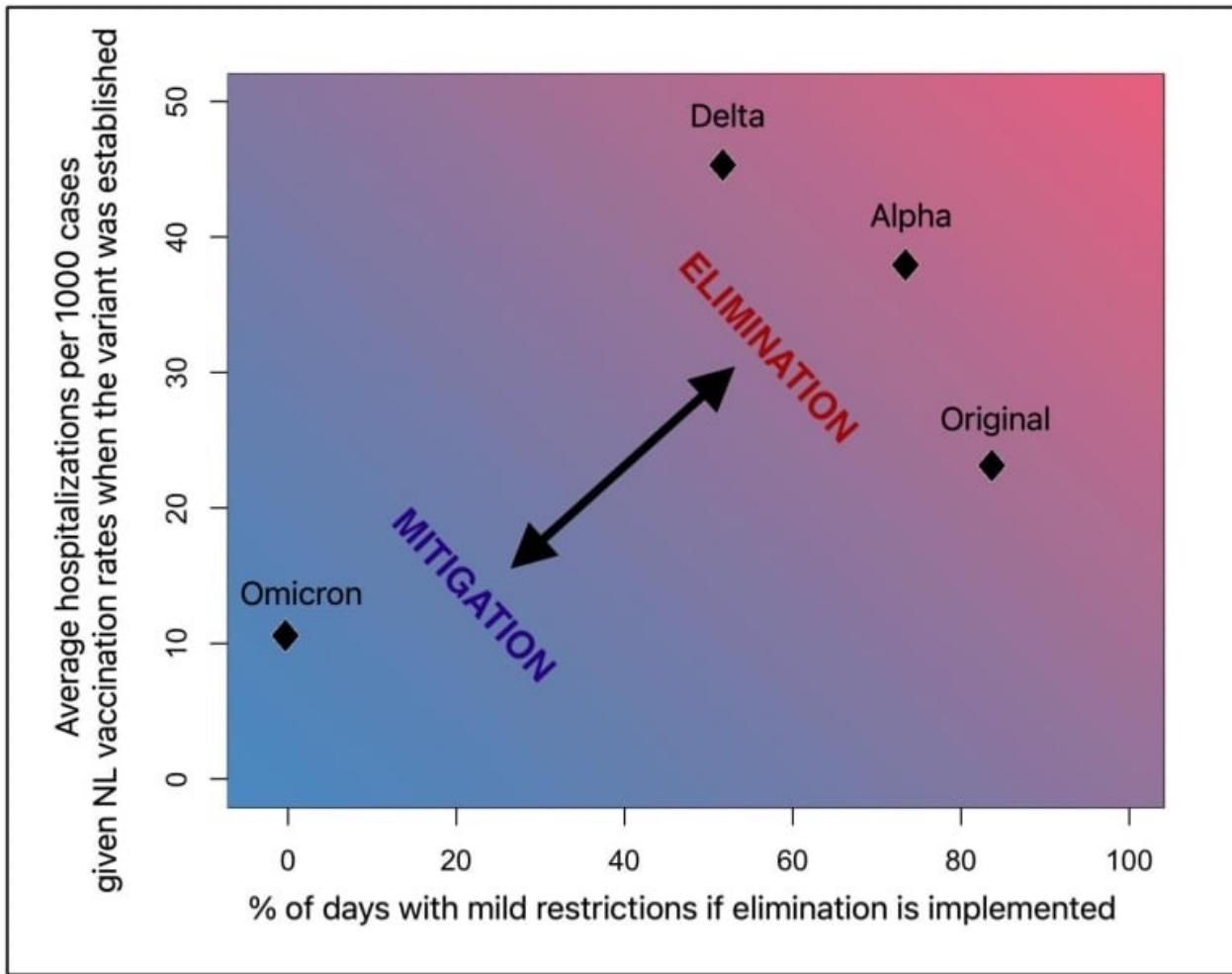
This phase focuses on those most at risk of exposure to COVID-19, those most likely to experience severe complications due to COVID-19 infection, and those essential to maintaining the provincial pandemic response. In keeping with recommendations from NACI, the initial supply of COVID-19 vaccine in Newfoundland and Labrador will be prioritized for the following groups:

- Congregate living settings for seniors;
- Health care workers at high risk of exposure to COVID-19, and those who are directly involved in the pandemic response;<sup>2</sup>
- Adults 85 years of age and older; and
- Adults in remote and isolated Indigenous communities.

Newfoundland and Labrador COVID-19 Immunization Plan.



Martignoni,, M., P. Rahman, and A. Hurford. Rotational worker vaccination provides indirect protection to vulnerable groups in regions with low COVID-19 prevalence. Under Review at Mathematics in Science and Industry.



[5\*] **Exit elimination.** It's not realistic to eliminate COVID-19 in Newfoundland and Labrador. Here's why. March 2022. Martignoni and Hurford. CBC NL. <https://www.cbc.ca/news/canada/newfoundland-labrador/covid-19-here-to-stay-1.6384033>