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, 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.

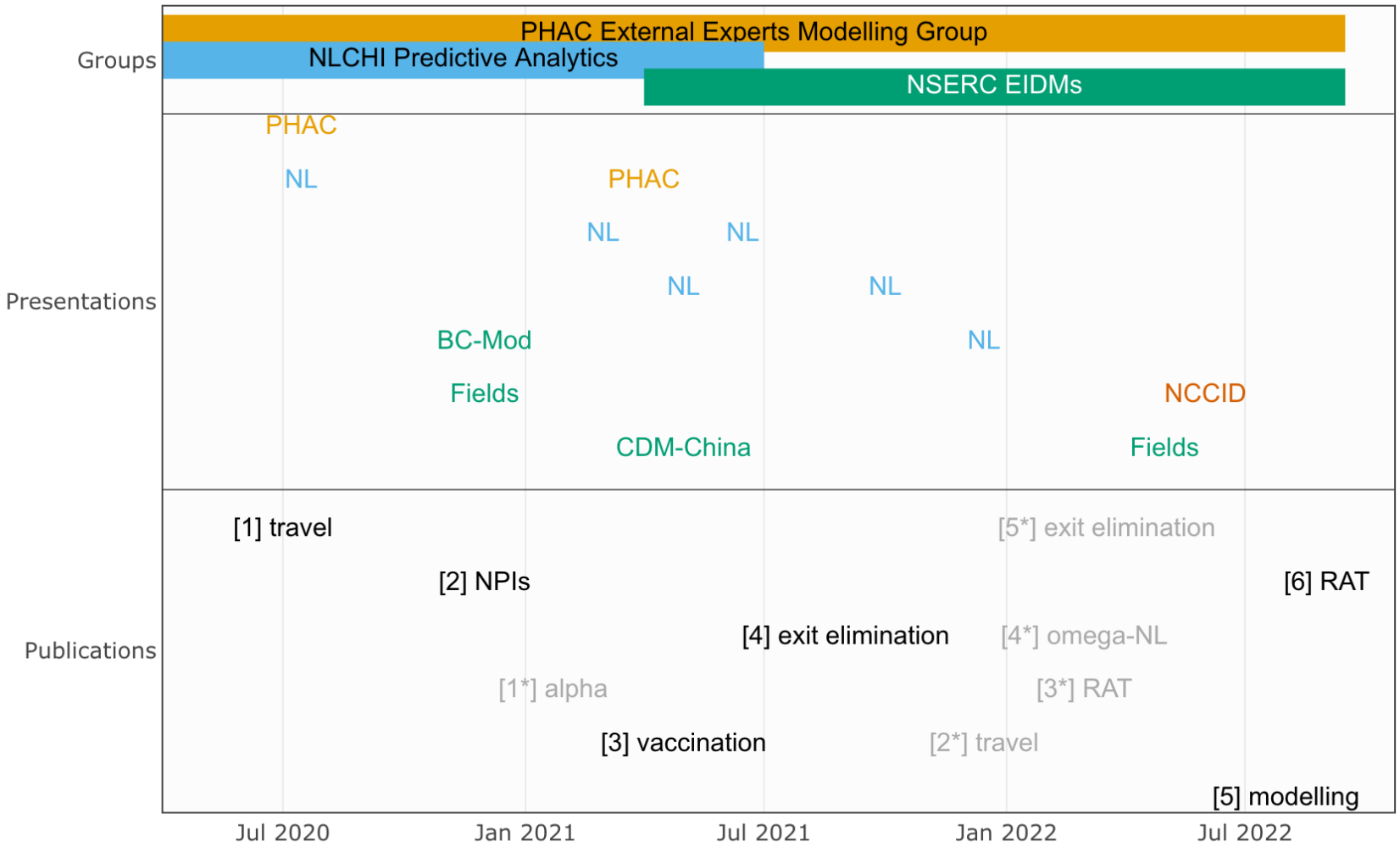
Outline

Background

1. Impact of travel restrictions
2. Recommendations for implementing travel restrictions
3. Regions with no community cases require different modelling approaches
4. When community spread dominates there are well-developed tools
5. Prioritizing rotational workers for vaccination
6. Recording the K-12 RAT results

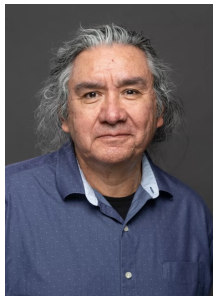
Conclusion

My COVID-19 activities



Key collaborators

Dr. Maria Martignoni



Dr. J.C. Loredo-Osti

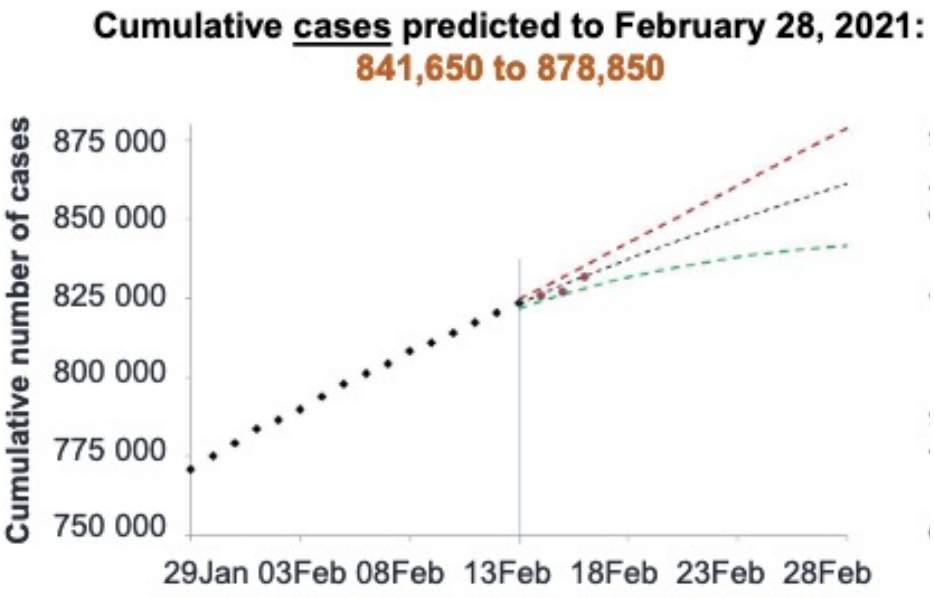
Dr. Proton Rahman

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

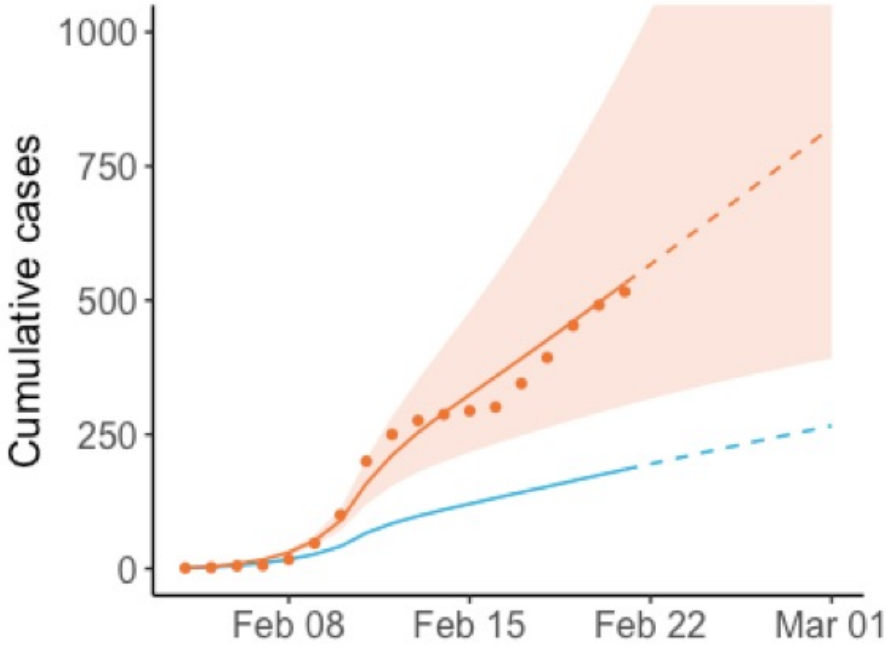
Activity	Venue
Contribute types of modelling not available to the NL govt	[1] travel [2] NPIs [3] vaccination [5] modelling
Advise on appropriate modelling approaches	NLCHI Predictive Analytics
Highlight deviations from national recommendations for NL	[3] vaccination [5] modelling [1*] alpha [2*] travel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

What do we mean “modelling”?

Statistical model



Mechanistic 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

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 ϵ [0,1] affects growth profile
- α > 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

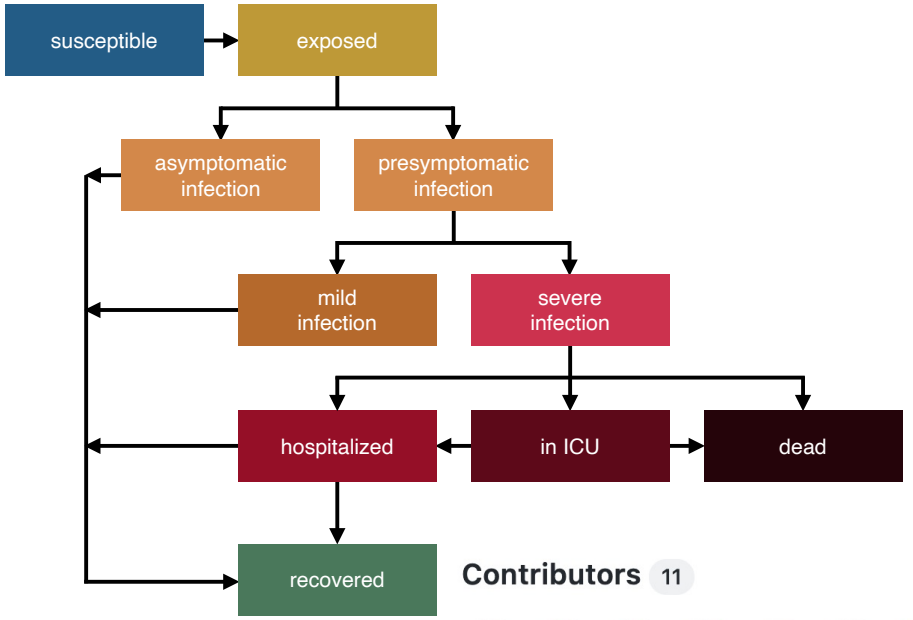
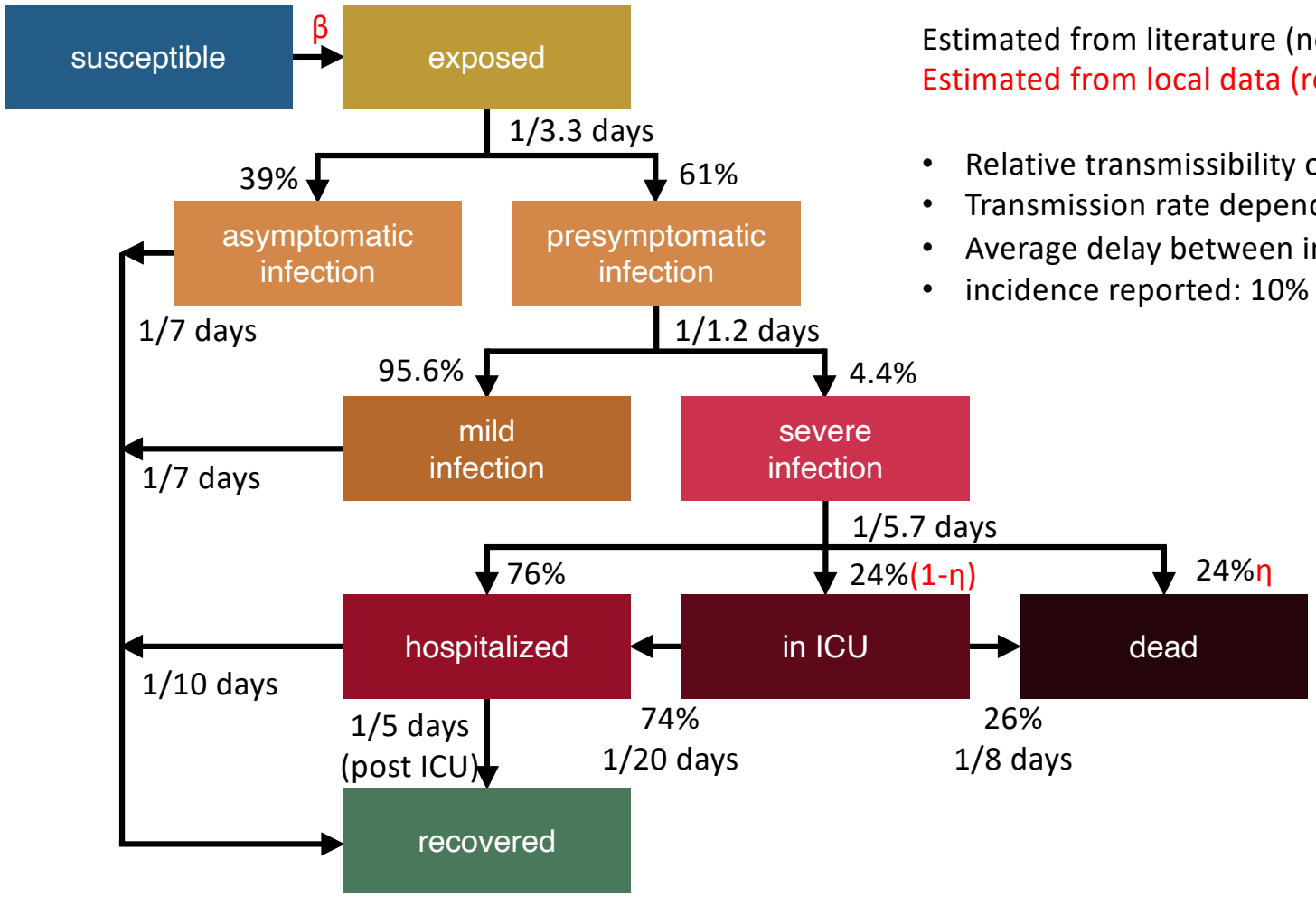


Diagram by Irena Papst

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

Mechanistic modelling: contributions to the pandemic response

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

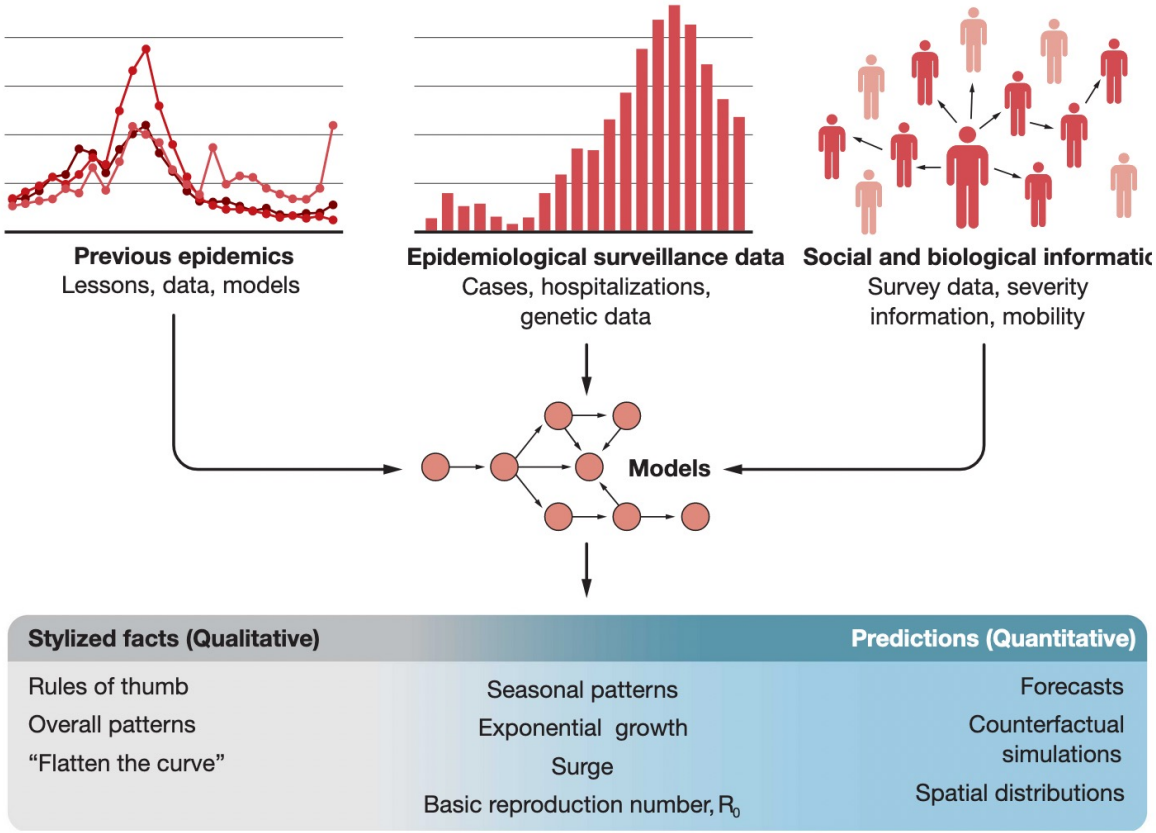


Diagram from Zelner and Eisenberg. 2022. Rapid response modelling of SARS-CoV-2 transmission. Science

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".

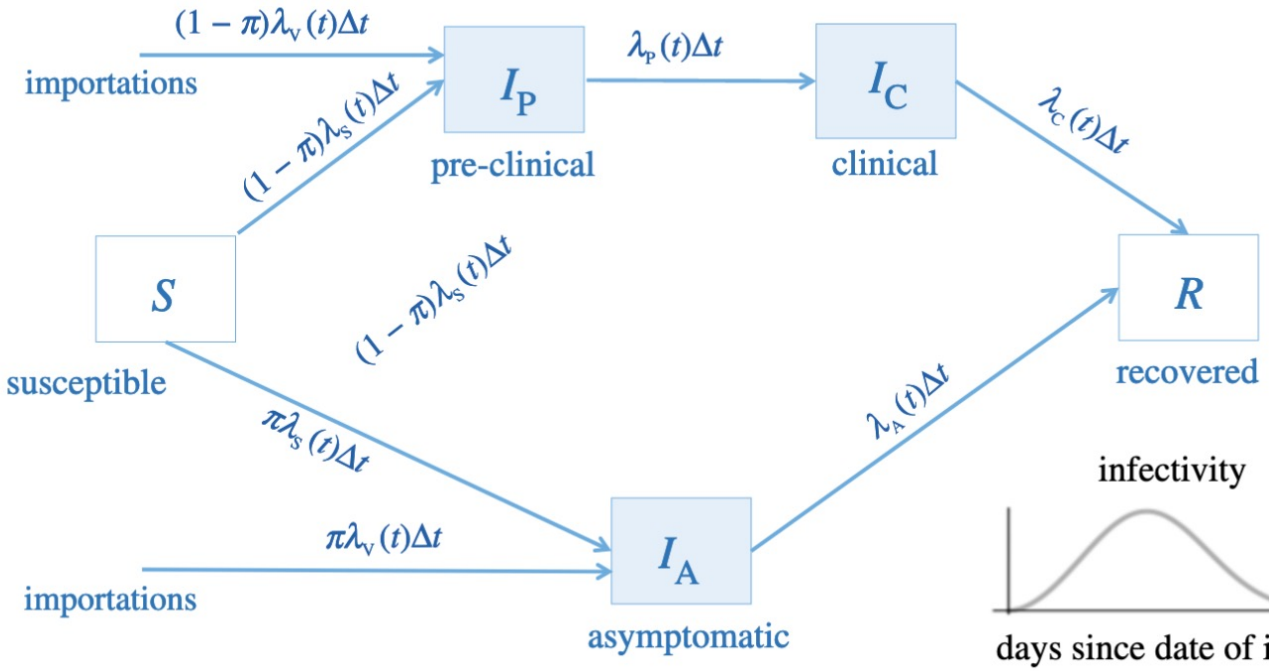
IN THE SUPREME COURT OF NEWFOUNDLAND AND LABRADOR
GENERAL DIVISION

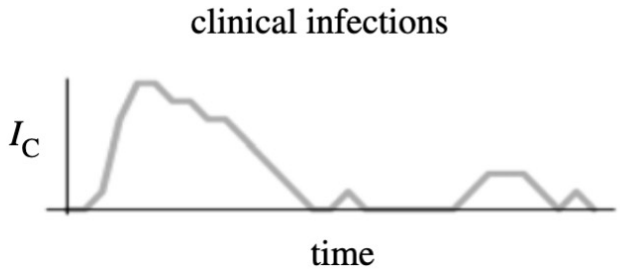
Citation: *Taylor v. Newfoundland and Labrador*, 2020 NLSC 125
Date: September 17, 2020
Docket: 202001G2342

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)


$(1-\pi)\lambda_V(t)\Delta t$
importations
I_P
pre-clinical
$\lambda_P(t)\Delta t$
I_C
clinical
$\lambda_C(t)\Delta t$
$(1-\pi)\lambda_S(t)\Delta t$
S
susceptible
$(1-\pi)\lambda_S(t)\Delta t$
R
recovered
$\pi\lambda_S(t)\Delta t$
$\lambda_A(t)\Delta t$
$\pi\lambda_V(t)\Delta t$
importations
I_A
asymptomatic


clinical infections
I_C
time

infectivity
days since date of infection

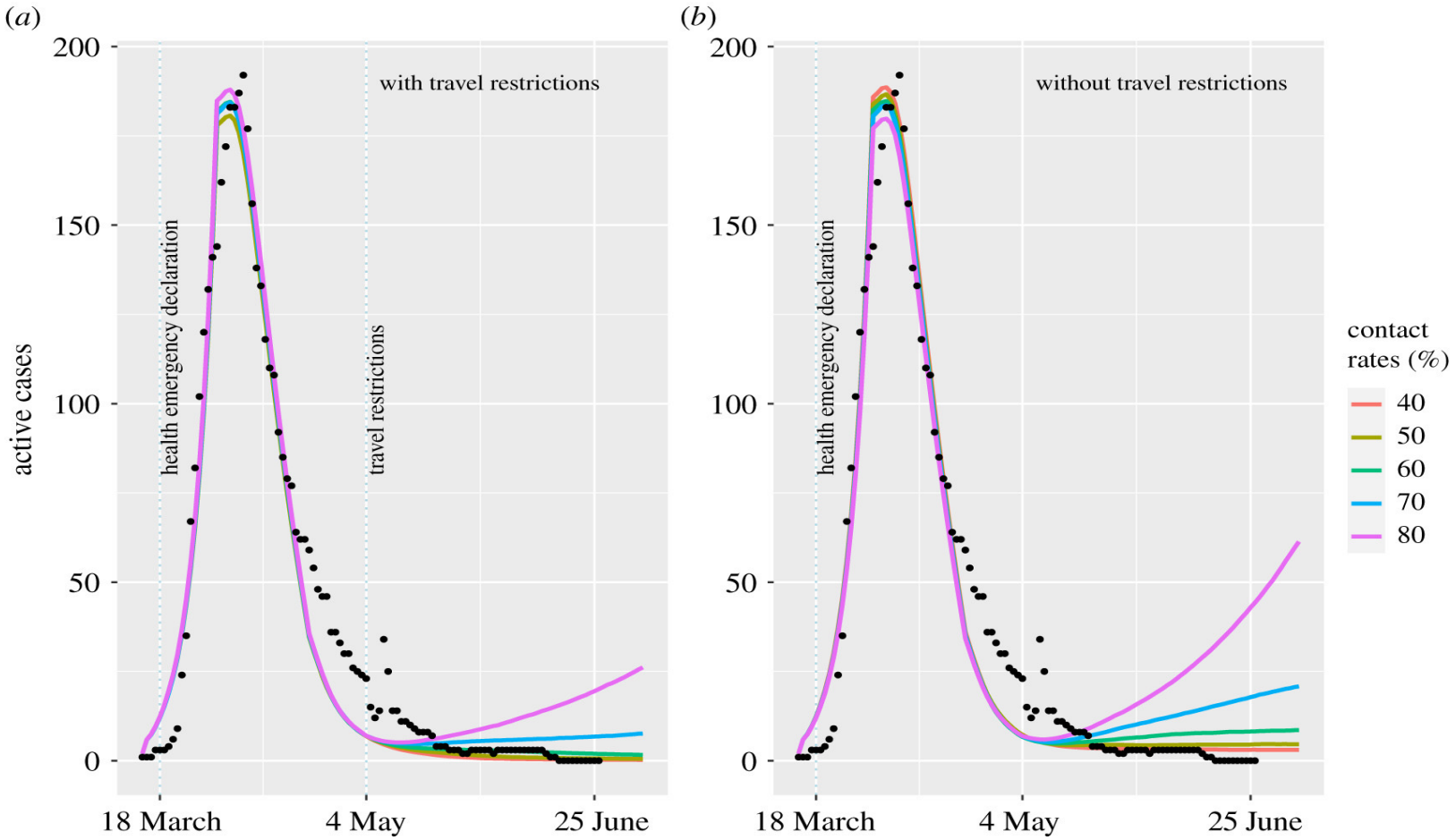
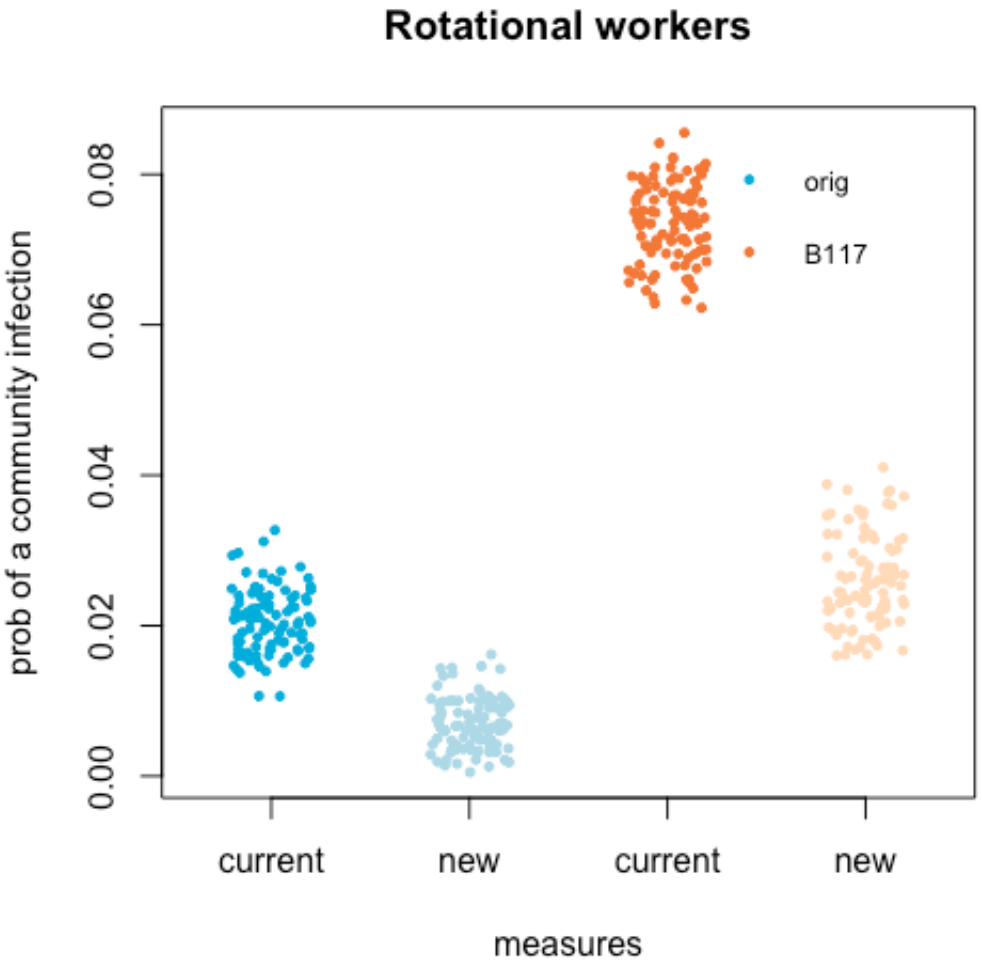

(a)
(b)
200
150
100
50
0
active cases
with travel restrictions
without travel restrictions
health emergency declaration
travel restrictions
18 March
4 May
25 June
contact rates (%)
40
50
60
70
80

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
40%				
mean	1.2	13.6	11.0	91.2%
median	0	12		
95% prediction intervals	[0,9]	[2,35]		
50%				
mean	1.5	18.1	12.0	91.7%
median	0	15		
95% prediction intervals	[0,11]	[3,53]		
60%				
mean	2.1	27.8	13.5	92.4%
median	0	23		
95% prediction intervals	[0,17]	[3,79]		
70%				
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%

Mechanistic extension to calculate the probability of a community infection



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

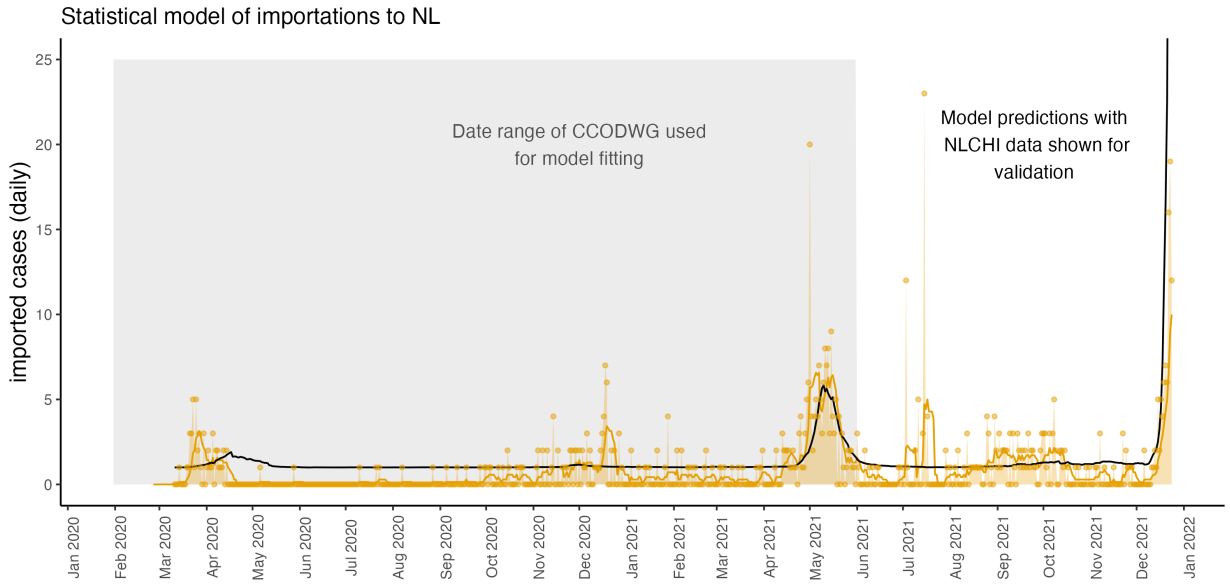
Current

- 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%)

Mechanistic extension to calculate the rate of imported cases to NL

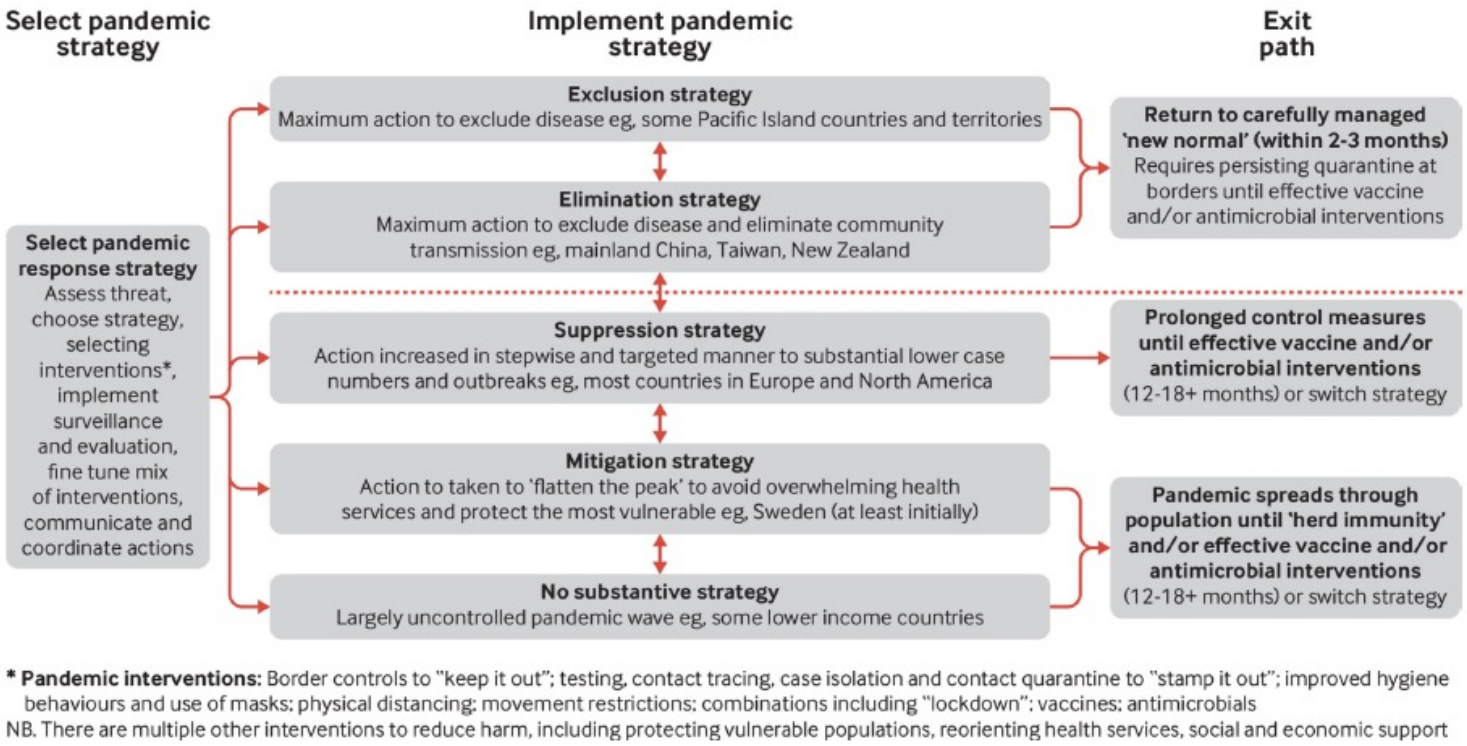


The daily number of imported cases to NL (reported by NLCHI for March 15, 2020-December 24, 2021) is reliably predicted as 0.105 times the number of active cases per 10,000 population in NS.

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

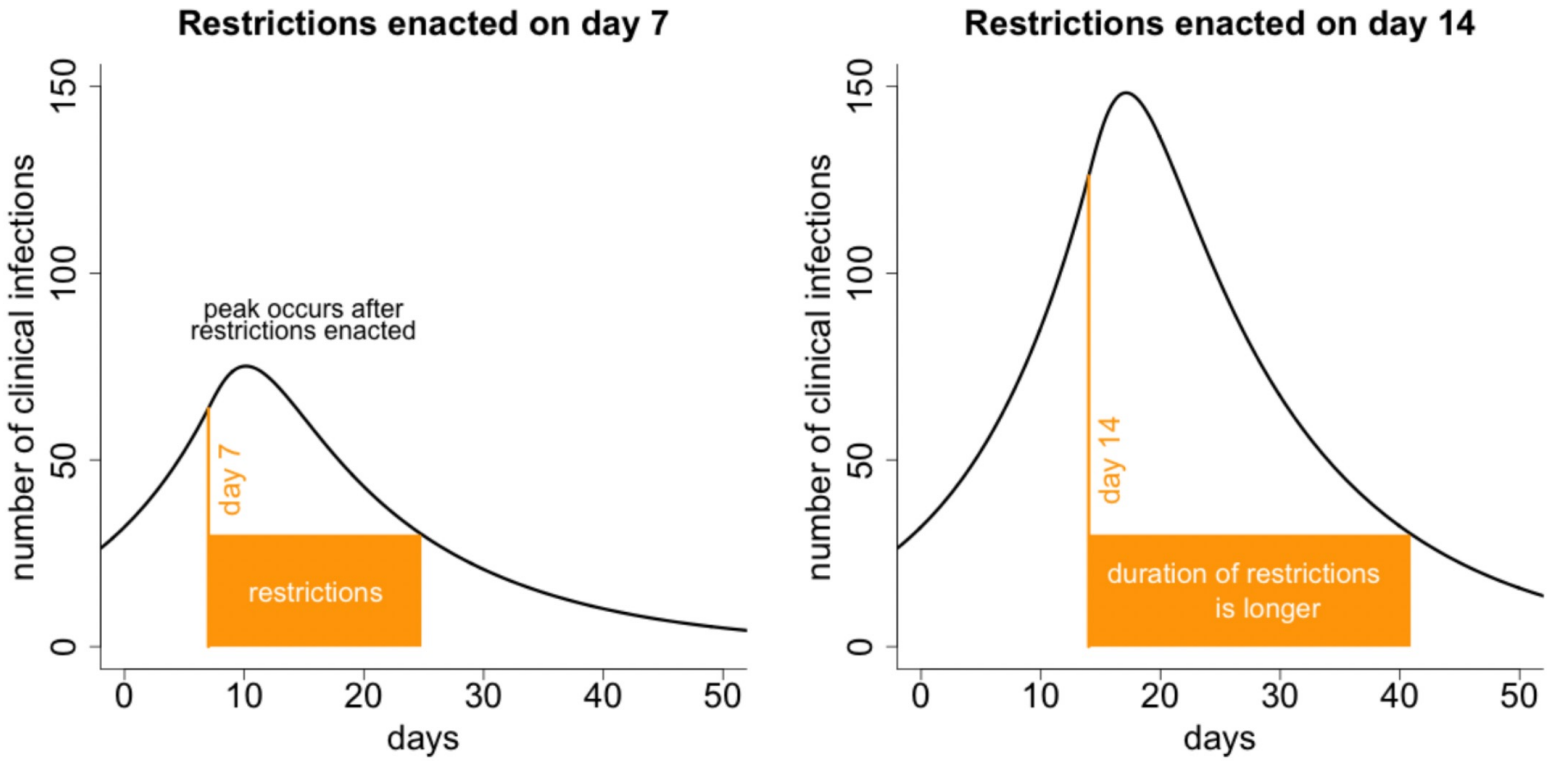
2. Recommendations for implementing travel restrictions

- 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
- Don’t hesitate to implement the restrictions: days matter
- Remove the restrictions when the risk of infection from a community member exceeds the risk from a traveller



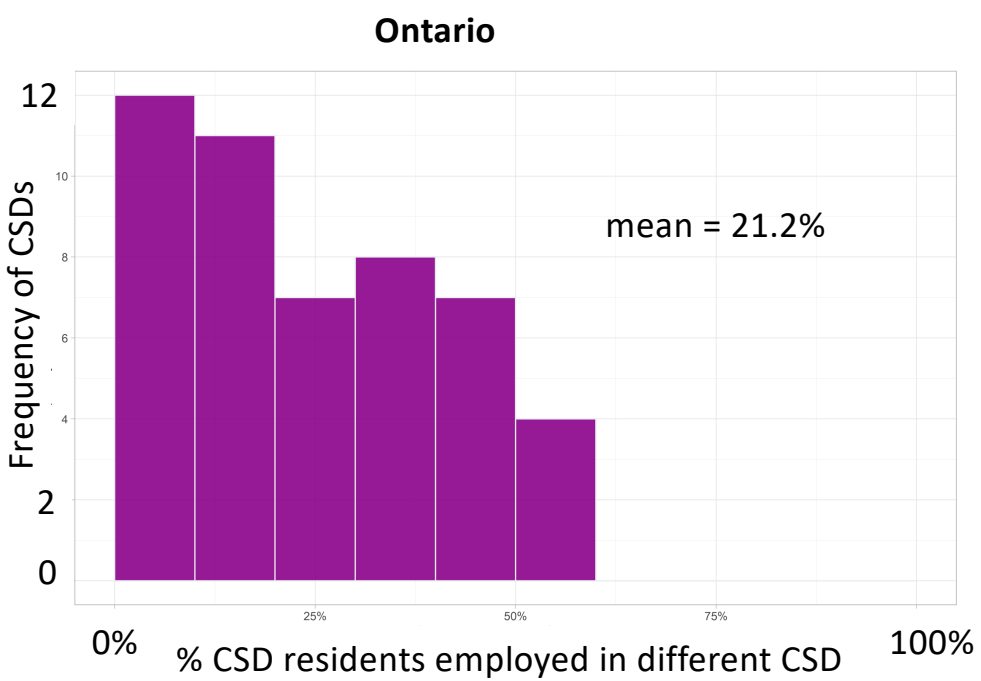
Baker et al. 2020. Elimination could be the optimal response strategy for covid-19 and other emerging pandemic diseases

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.

Regional differences



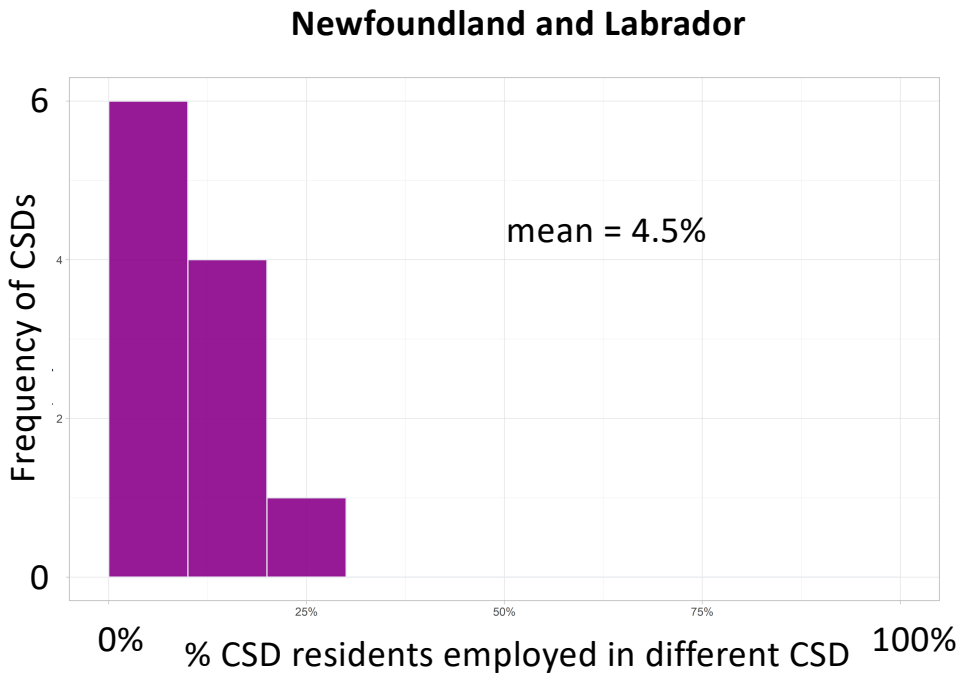
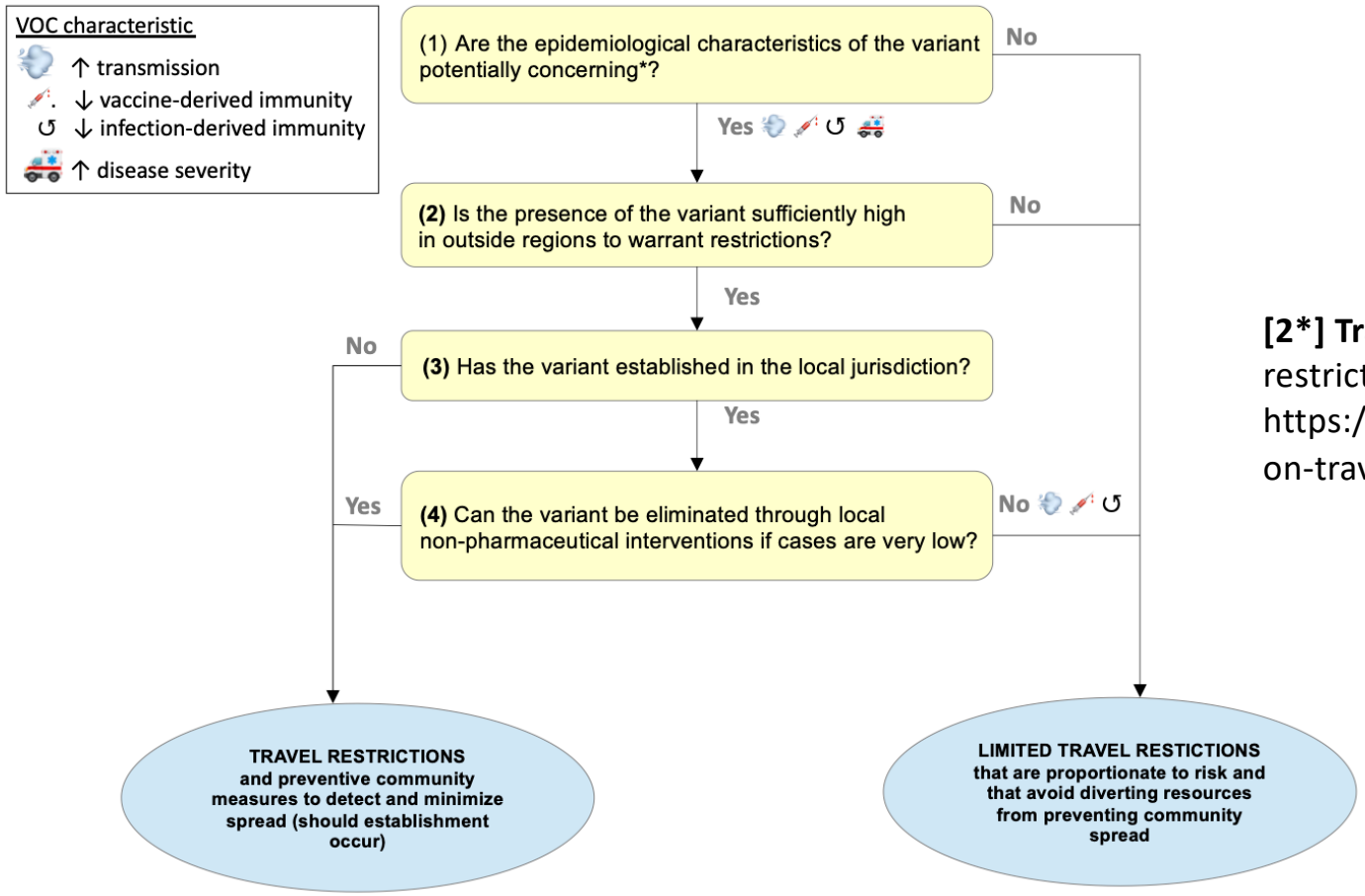


Figure by Zahra Mohammadi

Travel restrictions + NPIs + regional considerations + variants

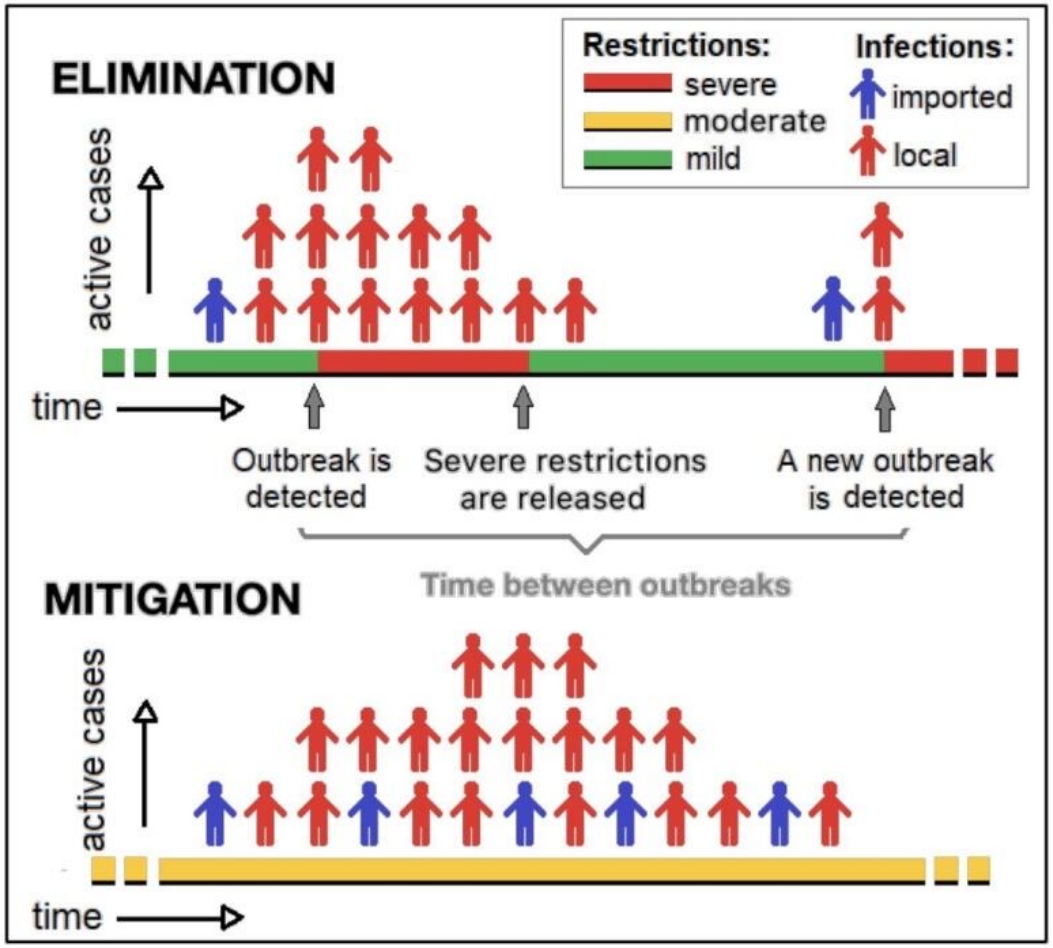


[2*] Travel. Hurford et al. 2021. Travel restrictions and the Omicron variant. https://canmod.net/static/assets/omicron-travel-final.pdf

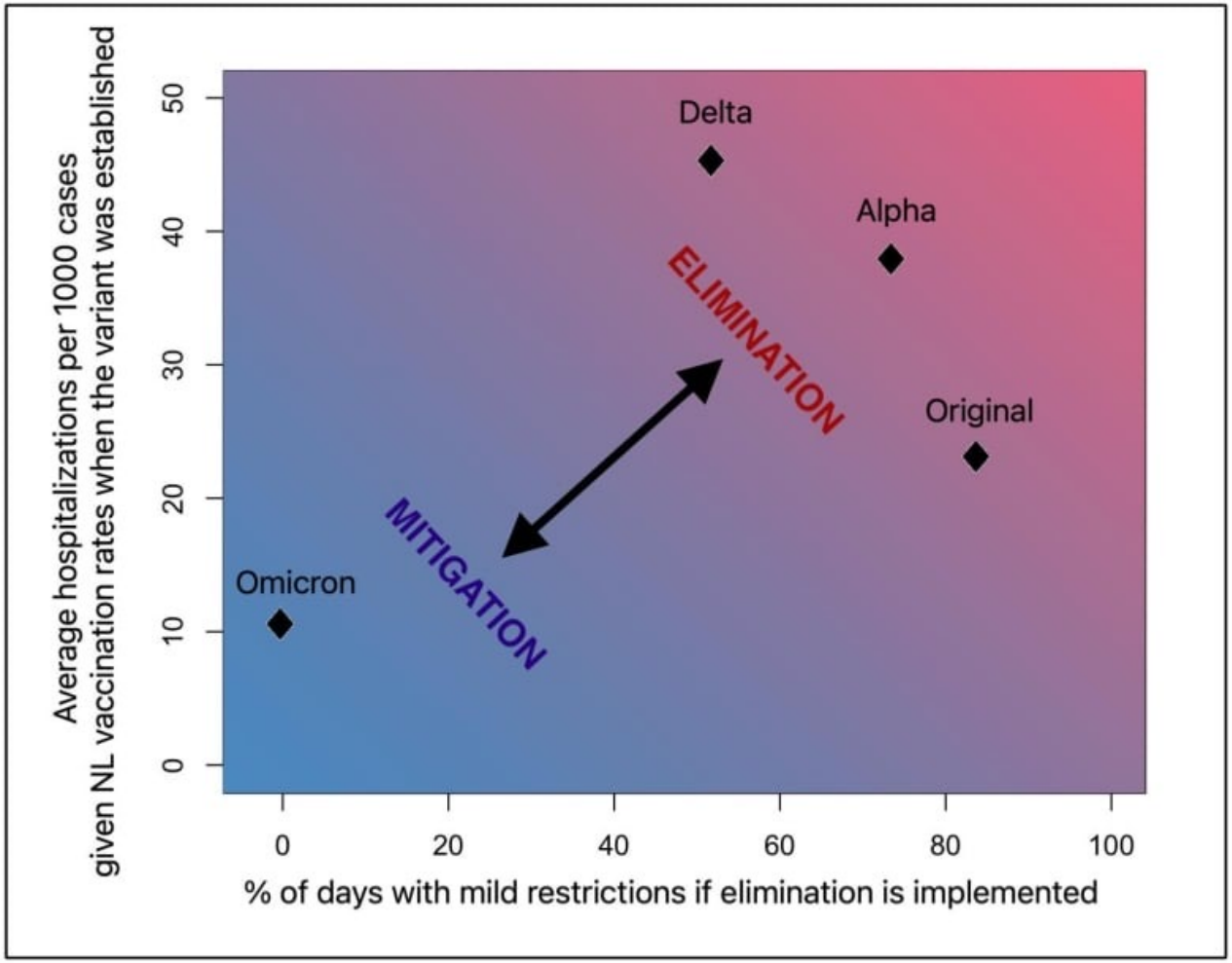
Box 2. Smaller jurisdictions and travel restrictions

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



[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

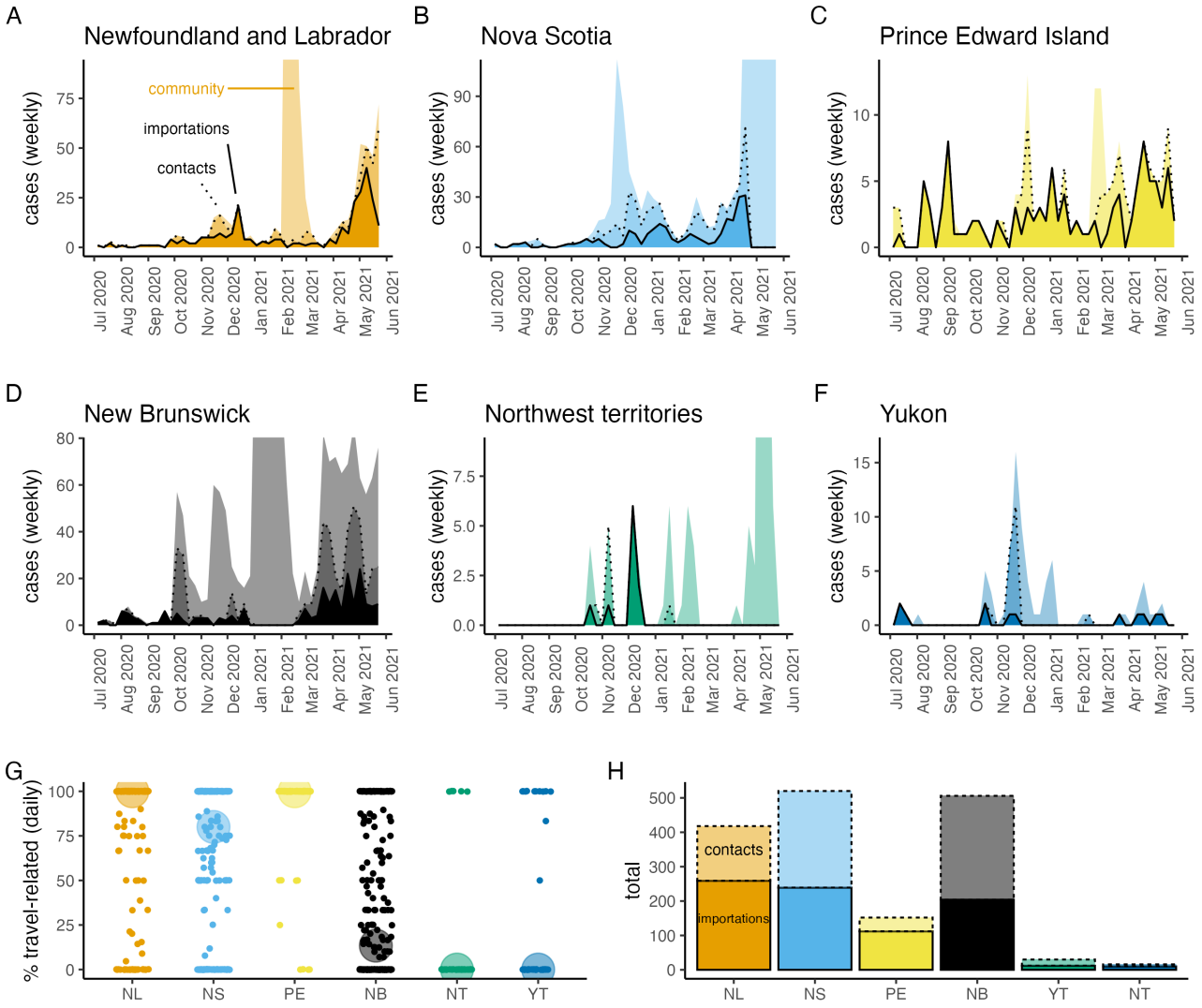
“I used to say that a criticism of travel restrictions is that they ‘delay the inevitable’; however, frequently when we think of what is ‘inevitable,’ we overlook evolution.” – Amy Hurford

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

3. Regions with no community cases have require different modelling approaches

- 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

NL life WITH COVID-19

Together.Again.

Reopening Newfoundland and Labrador

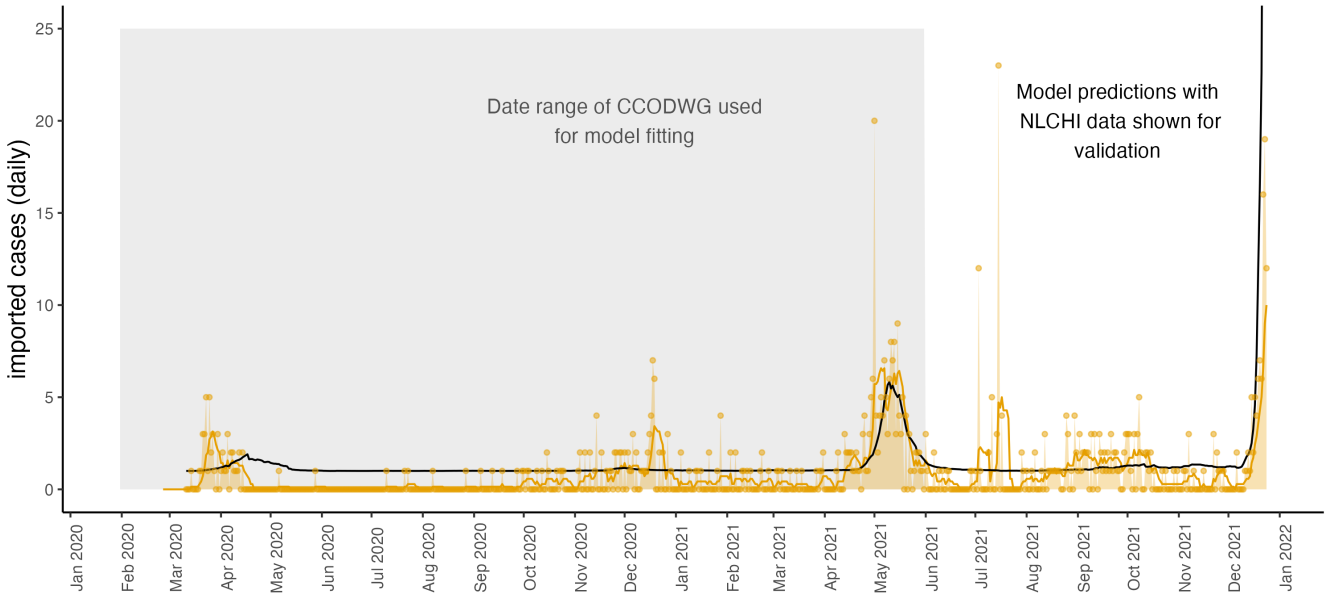
Newfoundland Labrador

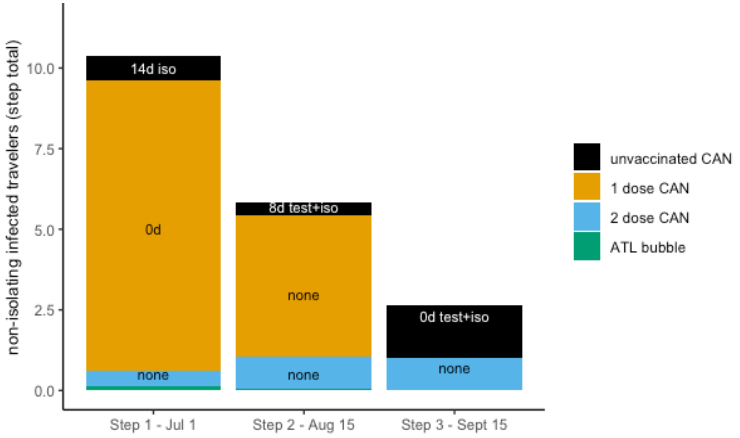
	Your Responsibility	Travel	Formal Gatherings	Personal Gatherings	Businesses	Recreational Activities	Offices and Workplaces
Transition June 15 to July 1	• Wear a non-medical mask in indoor public spaces. • Physical distancing. • If sick, stay home, get tested. • Get both doses of COVID-19 vaccine.	• Follow existing travel guidelines.	• Outdoor gatherings up to 150 people. • Community fireworks, parades and outdoor ceremonial events are permitted with physical distancing.	• Outdoor personal gatherings up to 30 people. • Indoor personal gatherings limited to Steady 20.	• Follow existing business guidelines.	• Outdoor sports tournaments permitted as part of Return to Play plans.	• Begin gradual return to workplaces and offices.
Step 1 As early as July 1 D1: 75% C/H: low	• Wear a non-medical mask in indoor public spaces. • Physical distancing. • If sick, stay home, get tested. • Get both doses of COVID-19 vaccine.	• Non-essential travel from within Canada permitted. • Fully vaccinated Canadians have no testing or self-isolation requirements. • Partially vaccinated Canadians must present a negative test result or self-isolate until receipt of a negative test result. • Unvaccinated Canadians self-isolate for 14 days.	• Outdoor gatherings up to 250 people. • Indoor gatherings lesser of up to 200 people or 75 per cent capacity with physical distancing.	• Outdoor personal gatherings up to 50 people. • Indoor personal gatherings limited to Steady 20.	• No capacity restrictions for retail stores with physical distancing. • Restaurants and lounges can open at 75 per cent capacity, with physical distancing.	• Outdoor sports tournaments permitted with COVID-19 protocols in place. • Recreational and arts facilities follow the limits for formal gatherings.	• Continued return to work. • Workplaces can have small in-person meetings.
Step 2 As early as August 15 D1: 80% D2: 50% C/H: low	• Wear a non-medical mask in indoor public spaces. • Physical distancing. • If sick, stay home, get tested. • Get both doses of COVID-19 vaccine.	• Fully and partially vaccinated Canadians have no testing or self-isolation requirements. • Unvaccinated Canadians tested on day 7, 8 or 9, and self-isolate until receipt of a negative test result.	• Outdoor gatherings up to 500 people. • Indoor gatherings up to 350 people with physical distancing.	• Limited to the number of people that can fit in the space with physical distancing.	• No capacity restrictions at retails stores, restaurants and lounges. • Dancing permitted.	• Indoor and outdoor sports tournaments permitted with COVID-19 protocols. • Recreational and arts facilities follow the limits for formal gatherings.	• Continued return to work. • Larger meetings and conferences can happen.
Step 3 As early as September 15 D2: 80% C/H: low	• Mask guidance will be reviewed based on current evidence. • Physical distancing. • If sick, stay home, get tested. • Get both doses of COVID-19 vaccine.	• Fully and partially vaccinated Canadians have no testing or self-isolation requirements • Unvaccinated Canadians self-isolate until receipt of a negative test result.	• Outdoor gatherings have no capacity restrictions with physical distancing. • Increased capacity at indoor gatherings to be determined.	• Limited to the number of people that can fit in the space with physical distancing.	• No capacity restrictions at retail stores, restaurants and lounges.	• Indoor and outdoor sports tournaments permitted with COVID-19 protocols. • Recreational and arts facilities follow the limits for formal gatherings.	• Workplaces are back to normal with appropriate COVID-19 protocols in place, as required.

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





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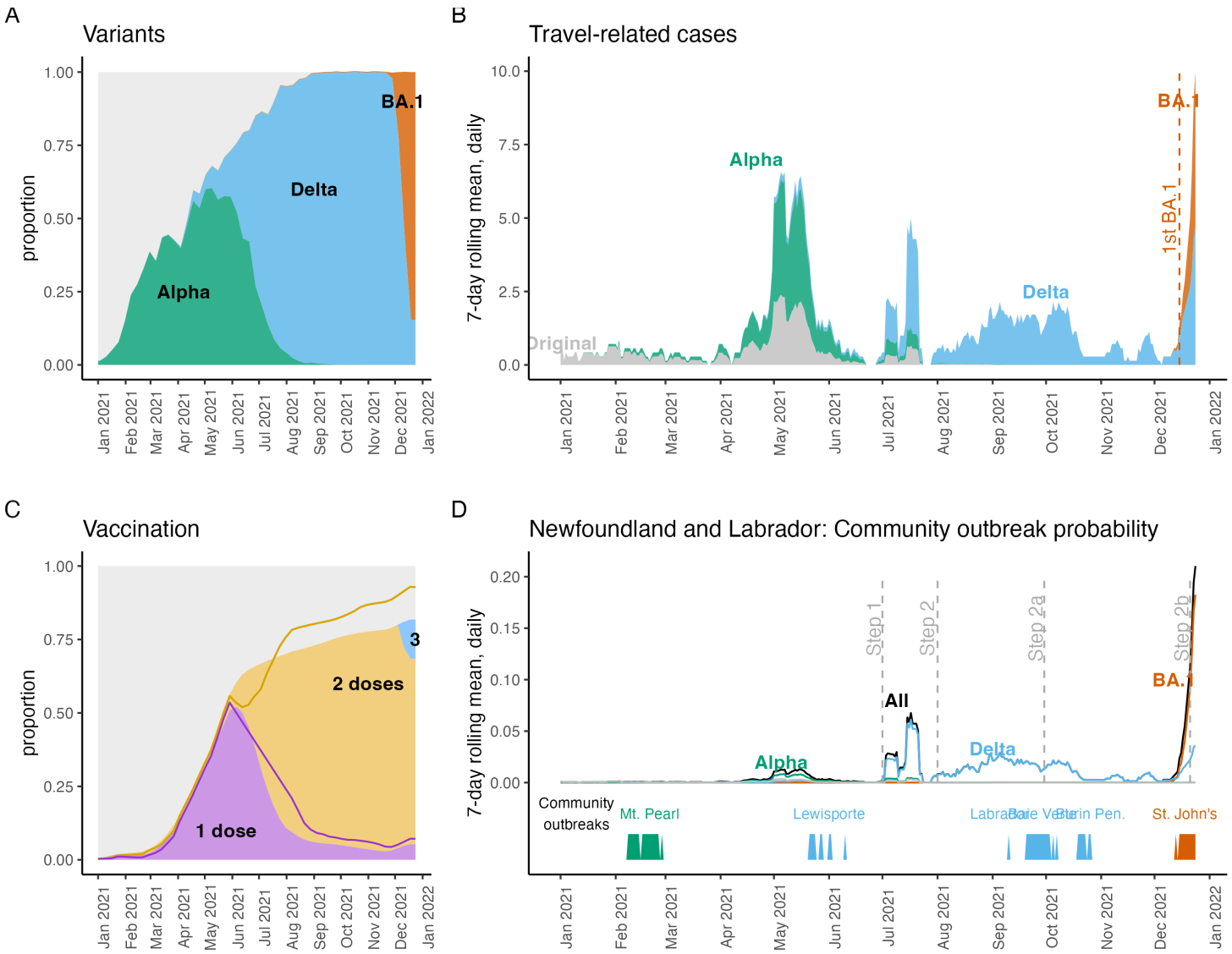

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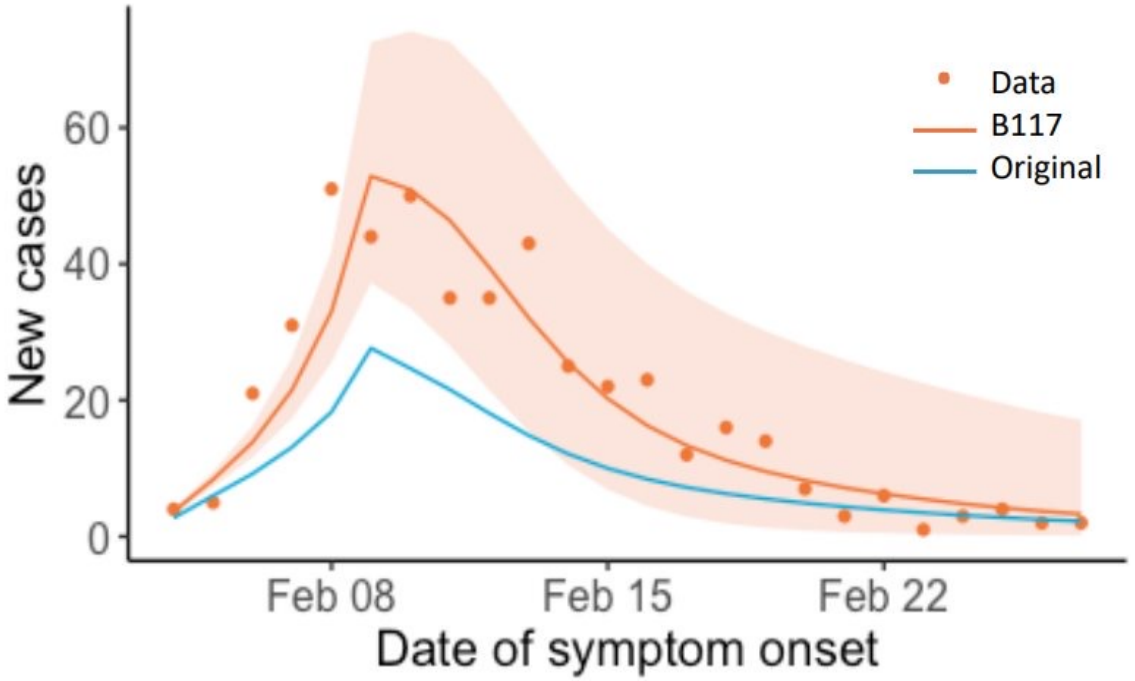
Centre for Health Information

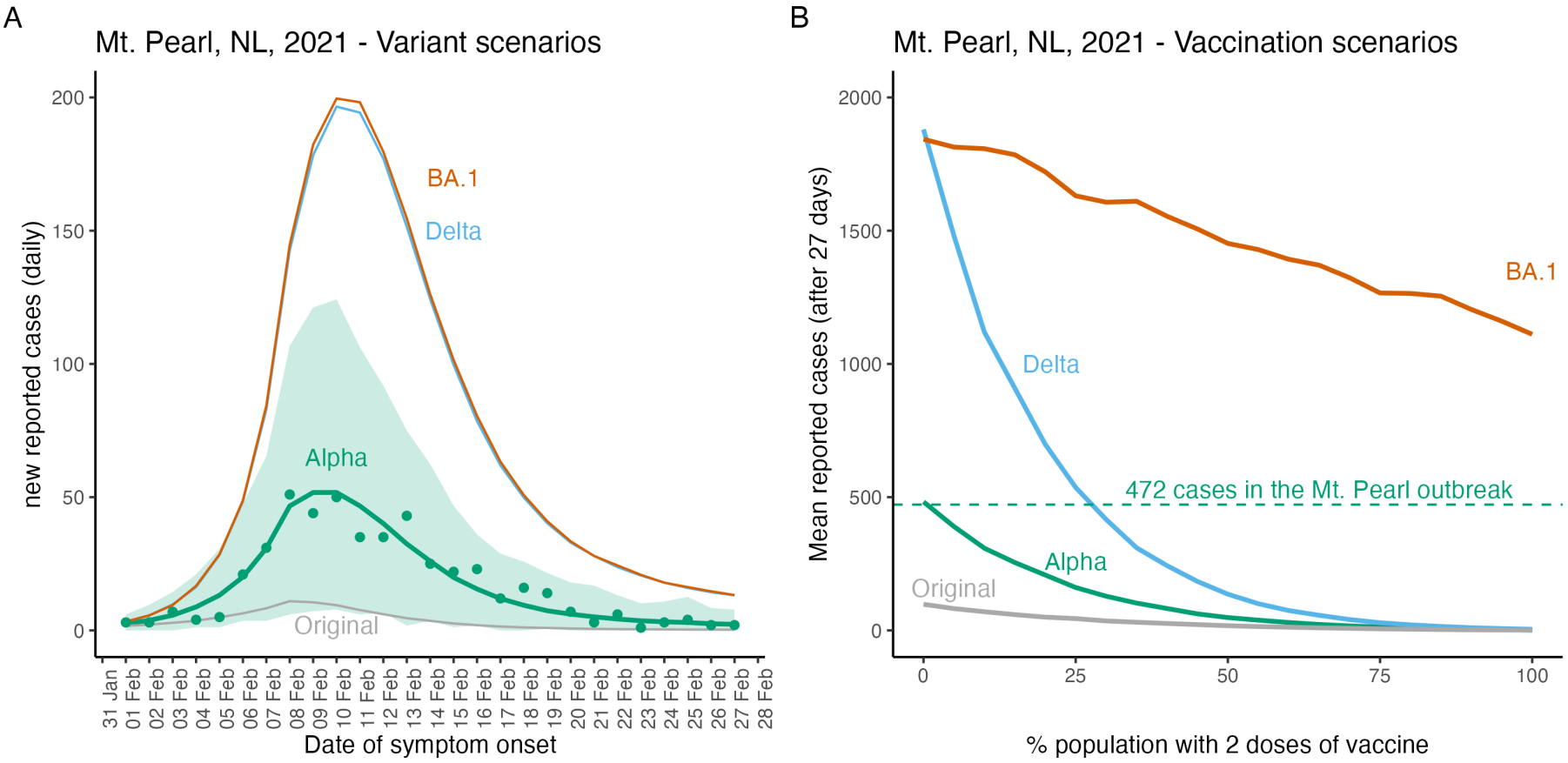
Comparison of B117 vs. "original" SARS-CoV2 Outbreak



Reproduction number

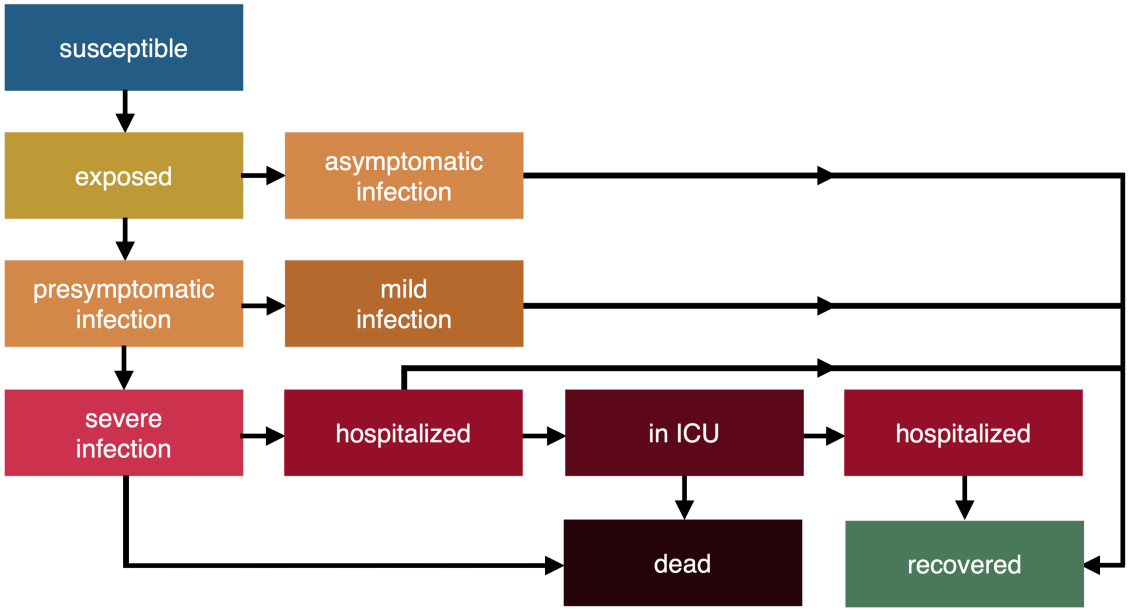
	B117	Original*
Before Feb 9	6.4	4.3
After Feb 9	0.6	0.4

* Inferred by assuming 50% greater for B117



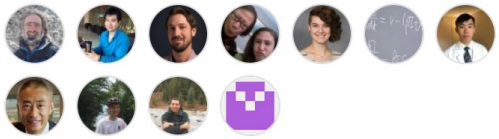
[5] Modelling. Hurford et al. Pandemic modelling for regions implementing an elimination strategy. Under review at the Journal of Theoretical Biology

4. When community spread dominates there are well-developed tools



mac-theobio / McMasterPandemic Public

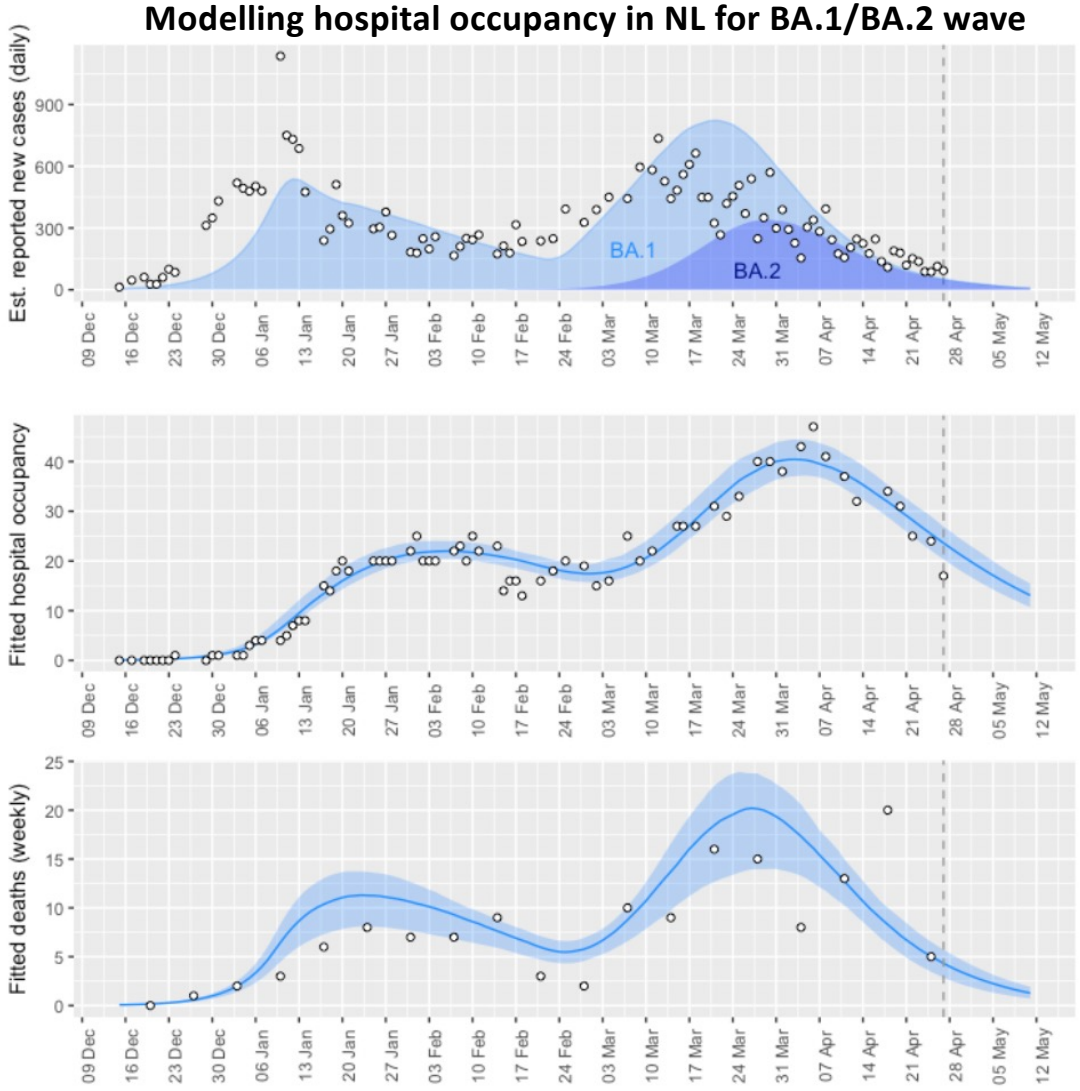
Contributors 11



Used by PHAC and Ontario Science Table

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

Modelling hospital occupancy in NL for BA.1/BA.2 wave



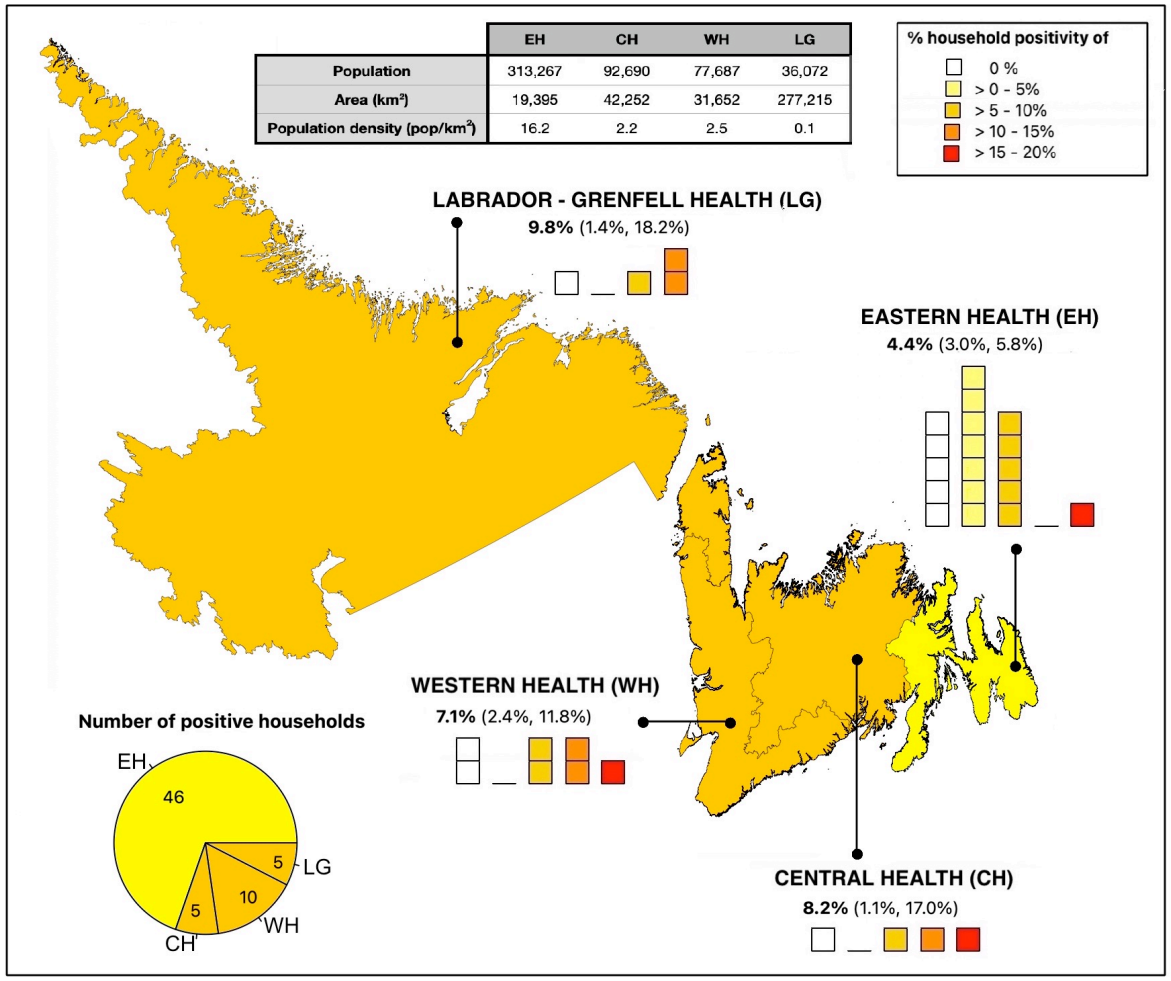
[4*] omega-nl The Omicron wave in NL. Twitter & The telegram https://rpubs.com/ahurford/883365

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

ACKNOWLEGEMENTS

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Troy Day, Queen's U

Lisa Kanary, Yukon U

Steve Walker

Public Health
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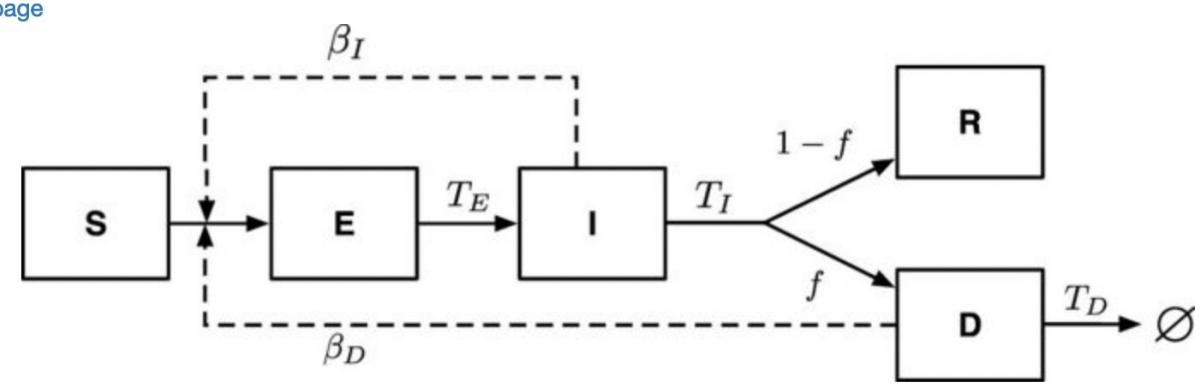
Theobio main page



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.[1] 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.

Public Health Ontario | Santé publique Ontario

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

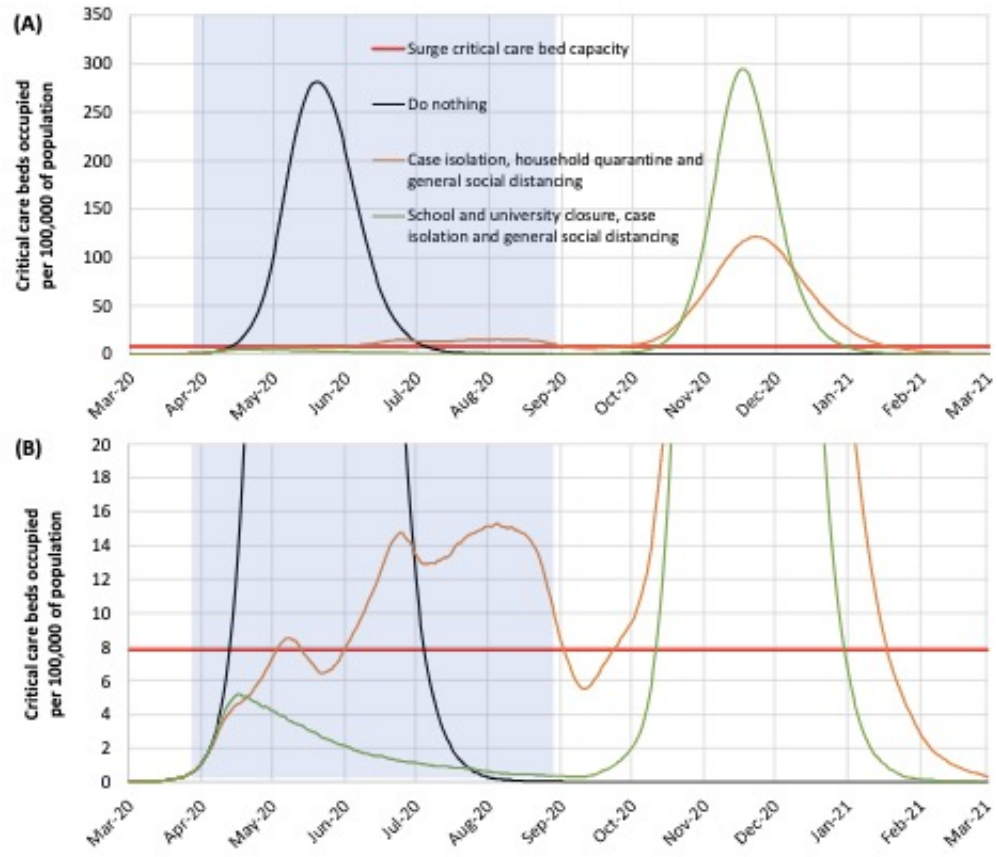
Adam 2020. Nature

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.

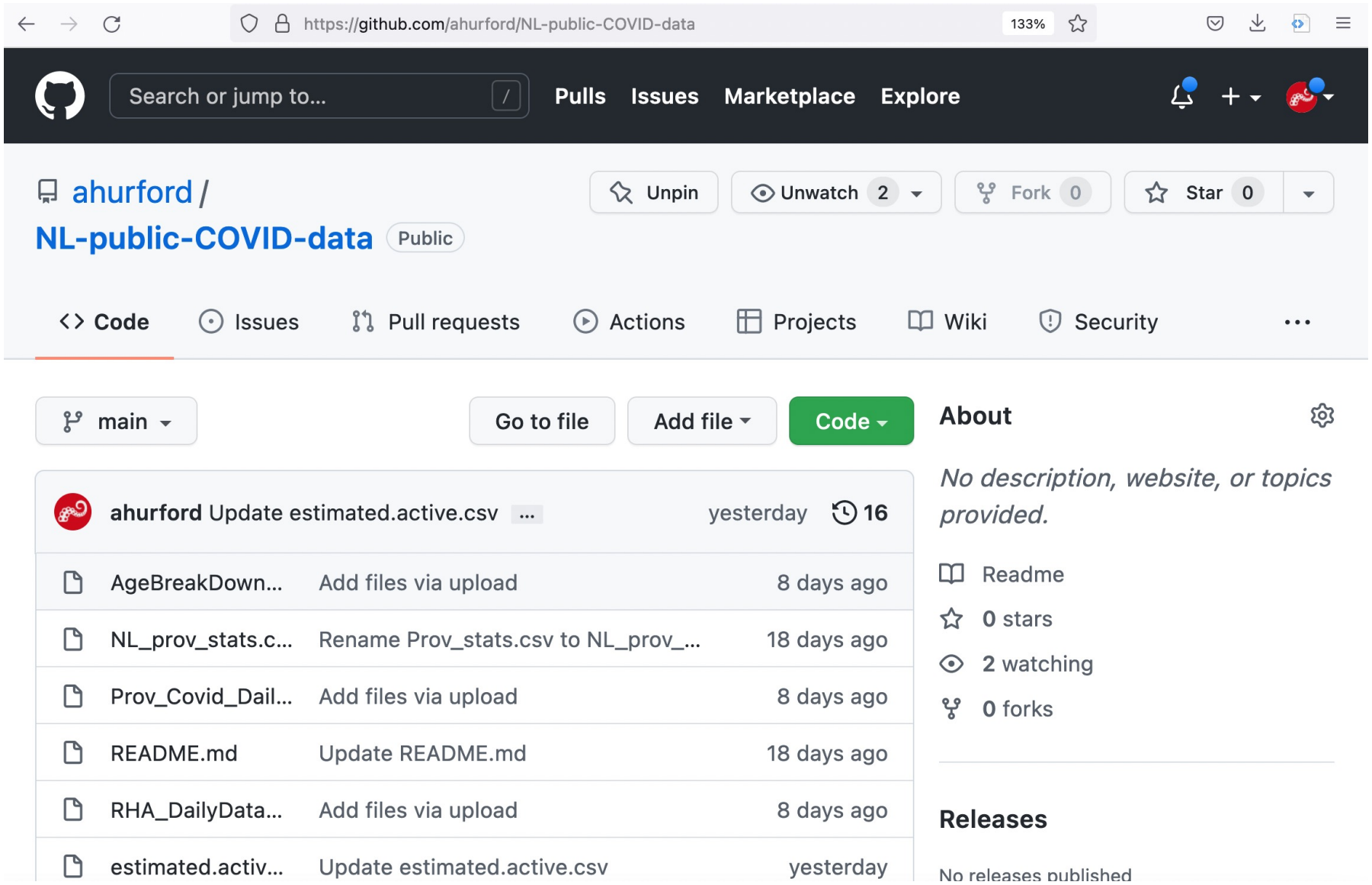
Up to two-thirds of the differences in the model's results could be put down to changes in just three key variables

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%
Search or jump to...
/
Pulls
Issues
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NL-public-COVID-data
Public
Unpin
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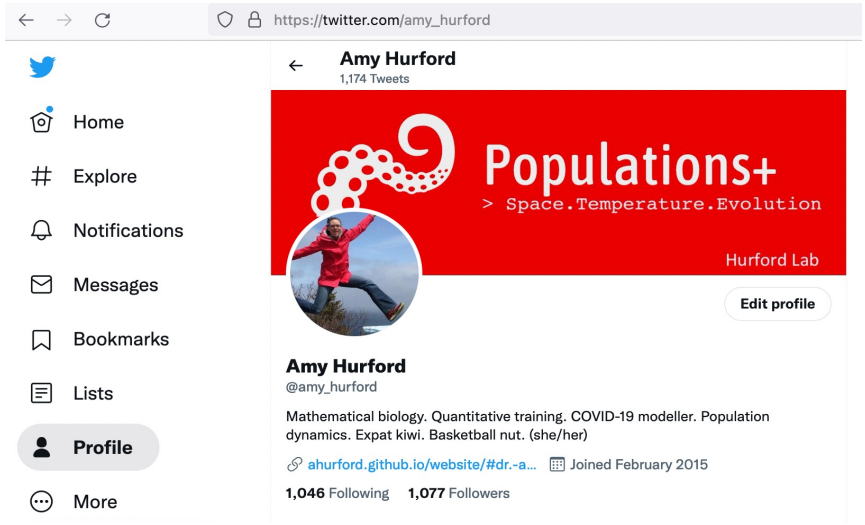
Star 0
Code
Issues
Pull requests
Actions
Projects
Wiki
Security
main
Go to file
Add file
Code
ahurford Update estimated.active.csv ...
yesterday
16
AgeBreakDown...
Add files via upload
8 days ago
NL_prov_stats.c...
Rename Prov_stats.csv to NL_prov_...
18 days ago
Prov_Covid_Dail...
Add files via upload
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



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


www.fields.utoronto.ca/activities/Mathematical-Modelling-COVID-19
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Mathematical Modelling of COVID-19
The Fields Institute, in partnership with AARMS, 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

https://canmod.net/training
CANMOD
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We are building expertise amongst the next generation of infectious disease modellers, and preparing them for careers in academia, industry, and the public sector.
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Canadian Center for Disease Modeling (CCDM)
Welcome to CCDM
People
Lectures
COVID-19
Events
Publications
Opportunity
NOV
25
2021
25 November 2021 @ 9:00 am - 10:00 am
LAMPS Seminar On Modelling of COVID-19
Speaker: Professor Manos Papagelis 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 09:3010:00Opening Remarks (Jane Heffernan, David Buckeridge)10:0010:30John Glasser10:3011:00Carole Vignals11:0011:30Marie Alexandre11:3012:00Rahul Arora12:0012:30Panel (John Glasser, Rahul Arora, Marie Alexandre, Carole Vignals)12:3013:00Lunch 13:0013:30Lauren Childs13:3014:00Caroline Wagner14:0014:30In-host Modelling Working Group14:3015:00Panel (Lauren Childs, Caroline Wagner, James Ooi, Jianhong Wu)15:0015:30Health Break15:3016:00Katia Koelle16:0016:30Morgan Craig16:3017:00Freya Shearer17:0017:30Panel (Katia Koelle, Morgan Craig, Freya Shearer, James

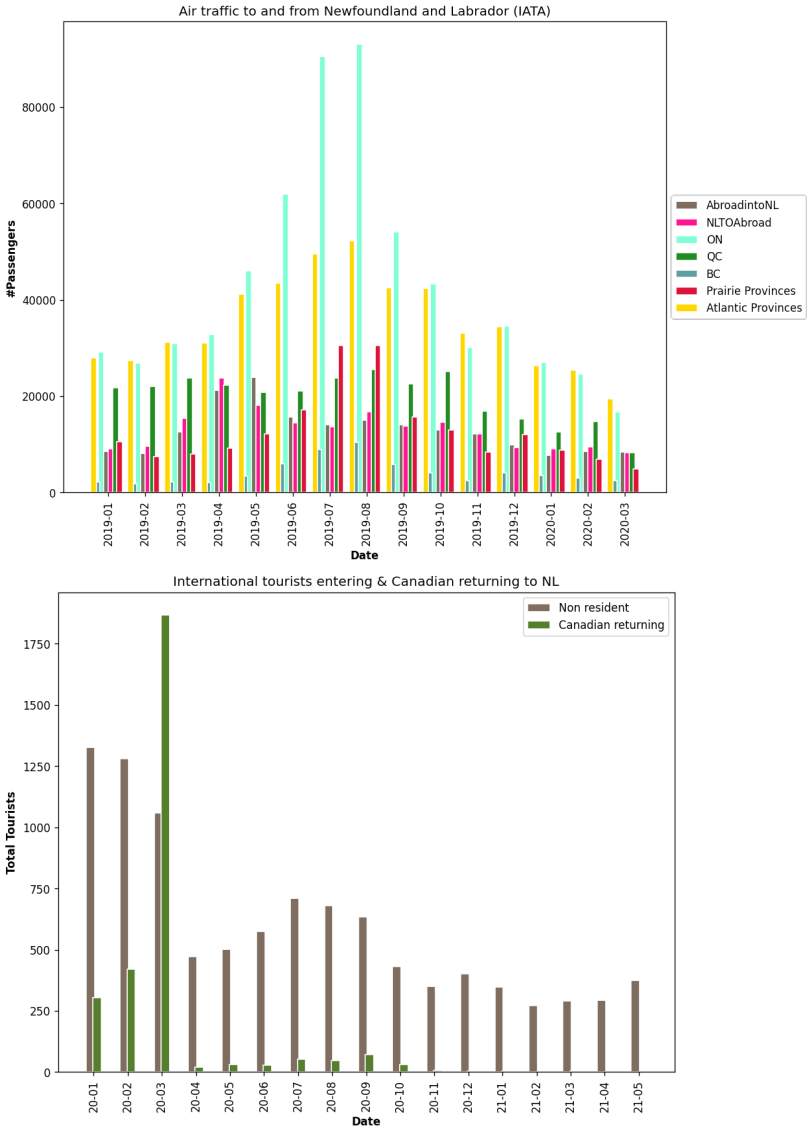
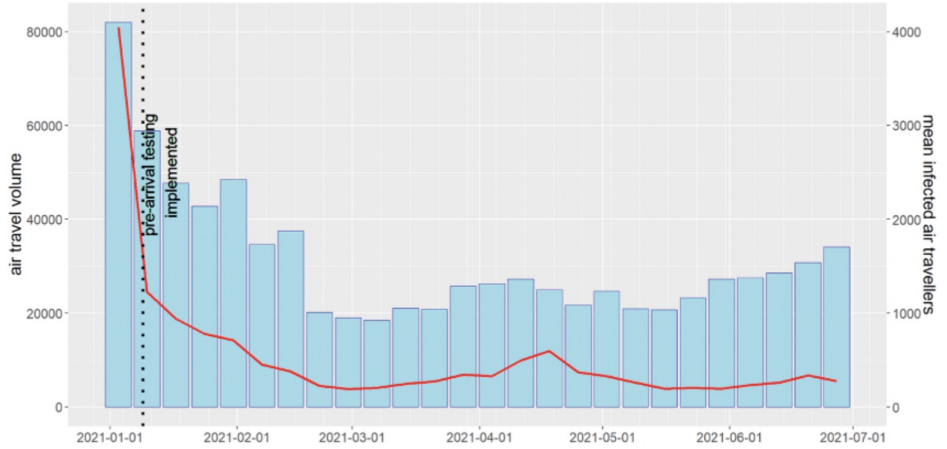
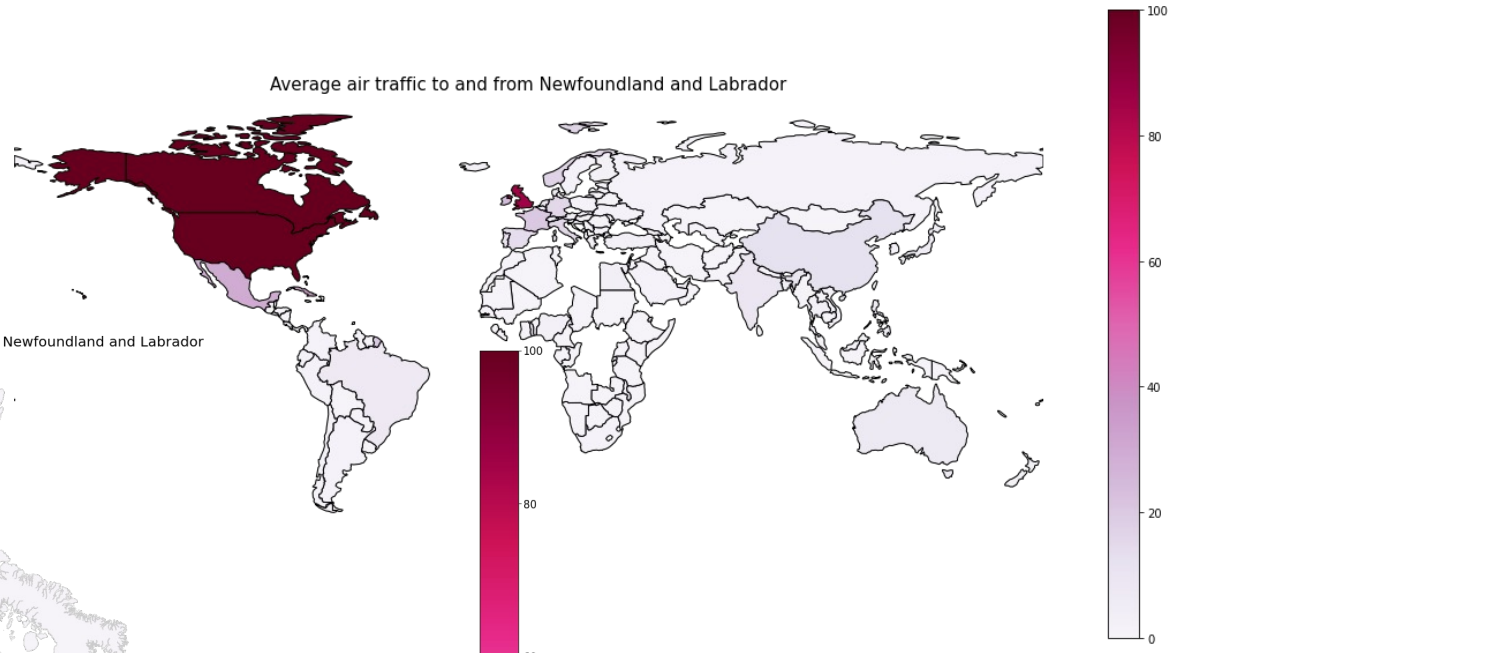
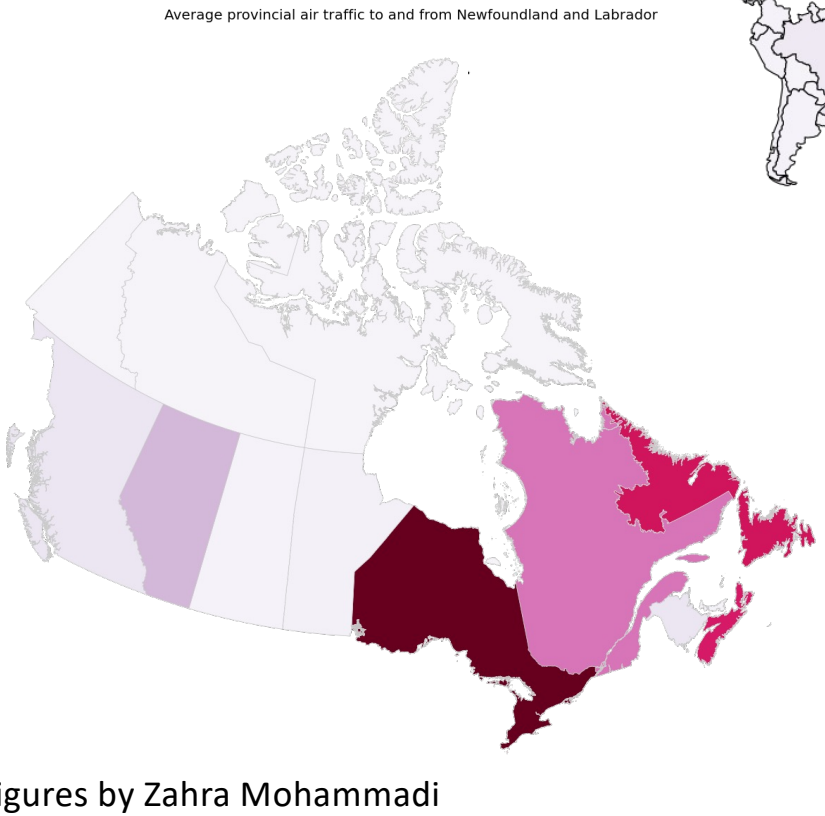
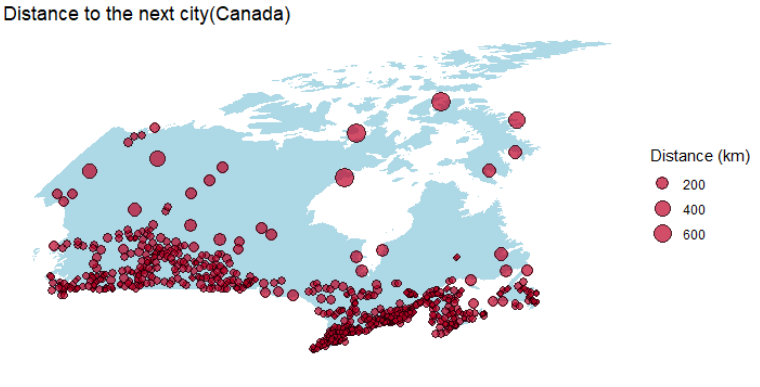


Figure 1. Estimated number of air travellers arriving infected to Canadian airports over time (red line), and volume of air travellers (blue bars). Data are shown relative to the date when the pre-arrival test was implemented on January 7, 2021.



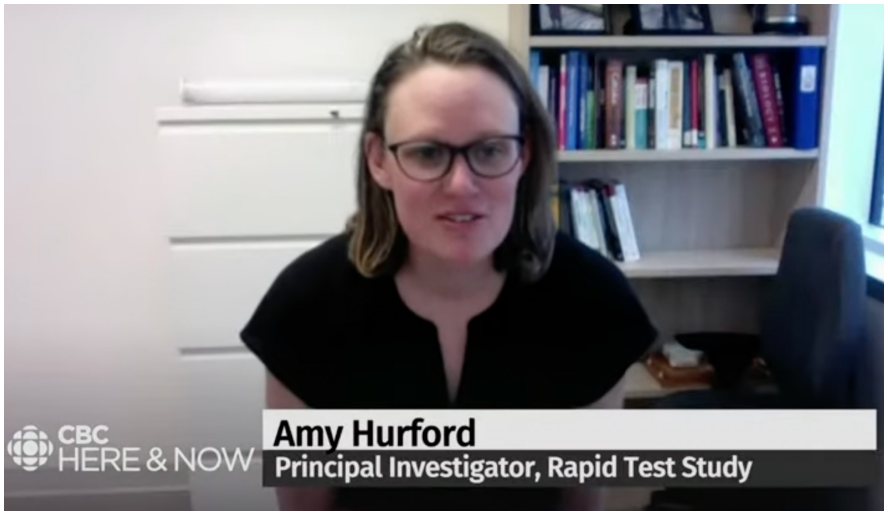






Figures by Zahra Mohammadi

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



Methods The observed number of positive test results is,

$$N^+ = pN\sigma^+ + (1-p)N(1-\sigma^-), \tag{1}$$

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[7]. 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[8].

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

$$p = \frac{1-\sigma^- - \frac{N^+}{N}}{1-\sigma^- - \sigma^+}. \tag{2}$$

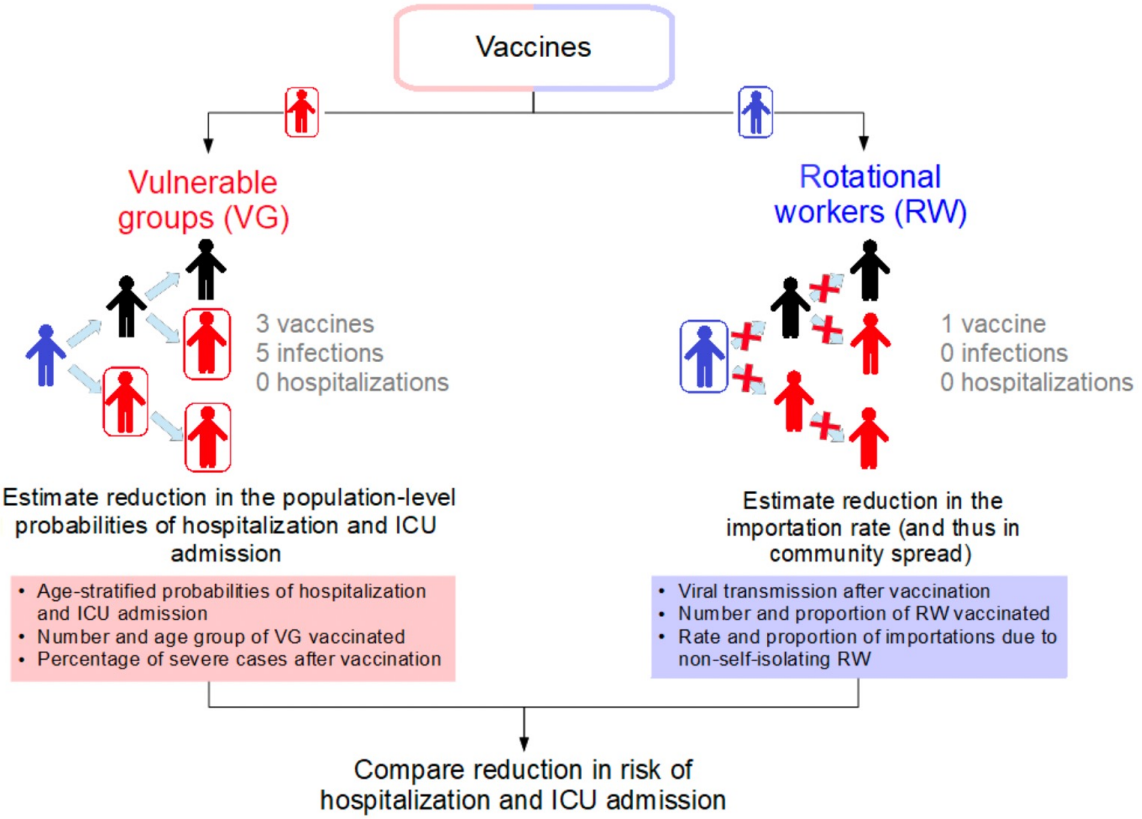
Credible intervals report the interval expected to contain a given percentage of estimates. Credible intervals were calculated using Jeffreys interval, i.e., a beta distribution with shape parameters $pN + 1/2$ and $N(1-p) + 1/2$.

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;[2]
- 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 indirection protection to vulnerable groups in regions with low COVID-19 prevalance. Under Review at Mathematics in Science and Industry.