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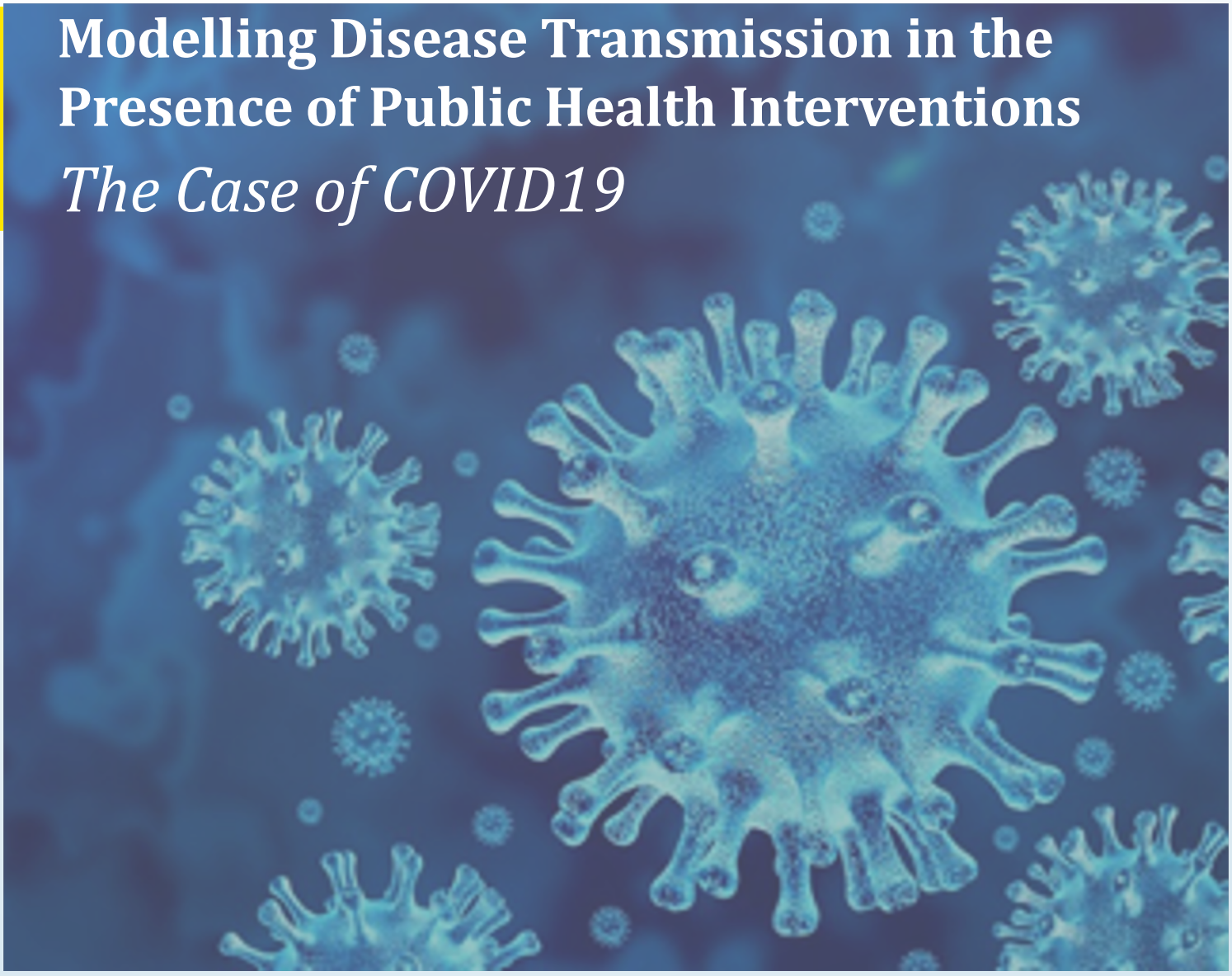
Modelling Disease Transmission in the Presence of Public Health Interventions

The Case of COVID19



Blanca Gallego Luxan and Elliott Zhu

ANU Webinar Series COVID19 in Latin America 05-Nov-2020

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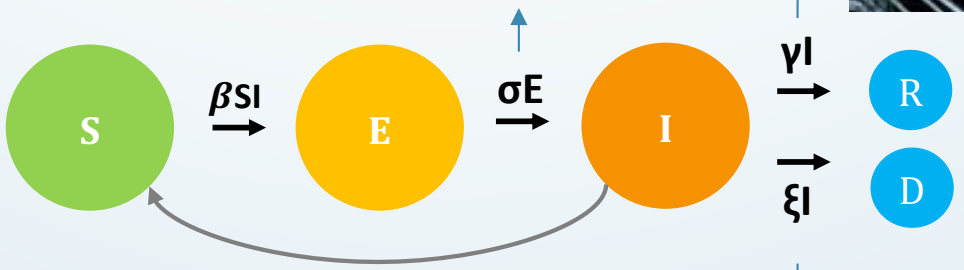
Modelling COVID19 Outbreaks

1/γ = Duration of infection (average 8 – 20 days)
Clinical, can be modifiable with pharmaceutical interventions

1/σ = Incubation period (average 4-6 days)
Biological, non-modifiable



ξ = Fatality rate (0.5% – 10%)
Clinical, modifiable with medical treatment

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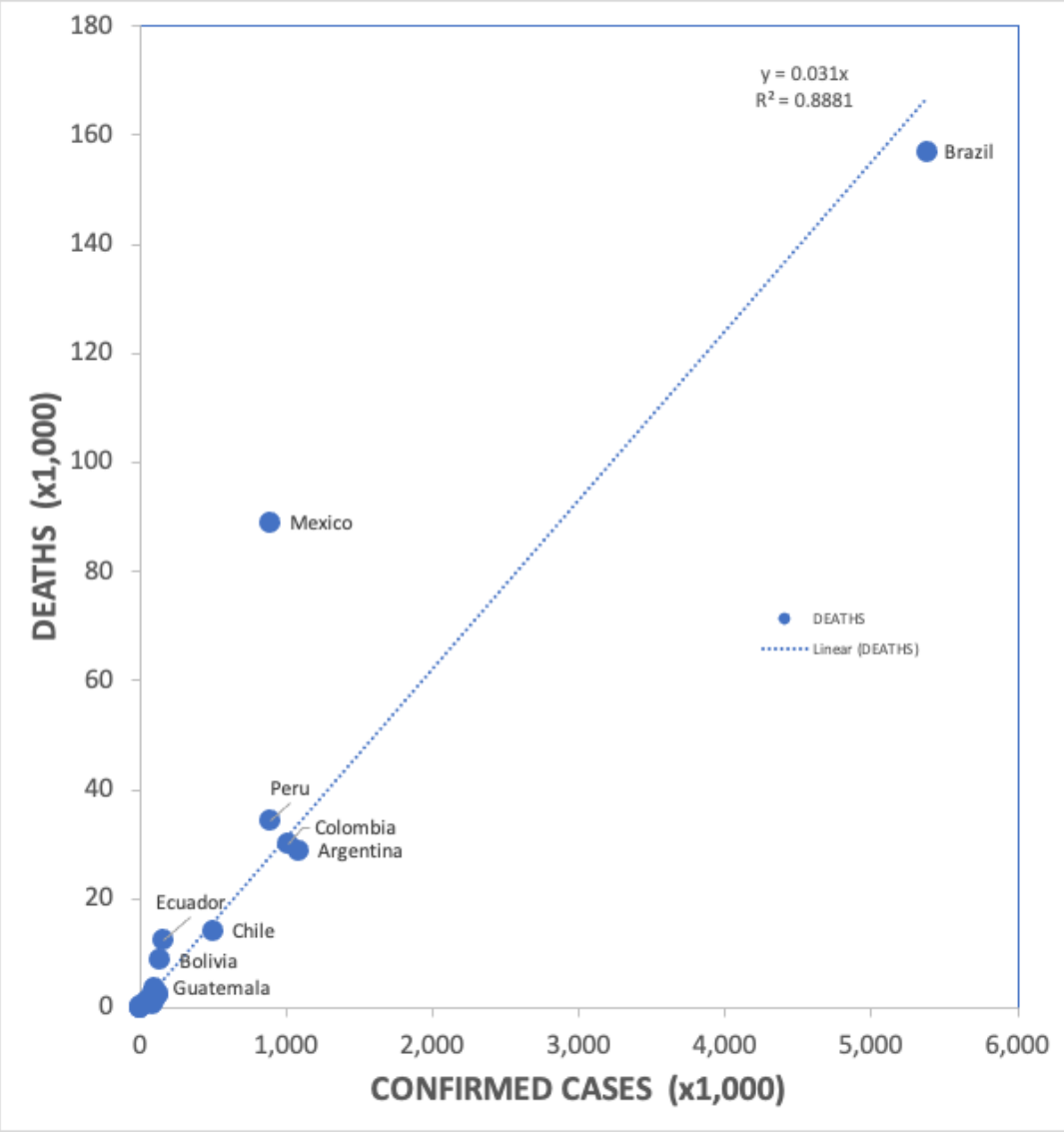
Fatality Rate



COUNTRY	CASE-FATALITY
Mexico	10.00%
Ecuador	7.80%
Bolivia	6.10%
Peru	3.80%
Guatemala	3.50%
Colombia	3.00%
Brazil	2.90%
Nicaragua	2.90%
Chile	2.80%
Honduras	2.80%
Argentina	2.60%
Paraguay	2.20%
Panama	2.00%
Uruguay	1.90%
Cuba	1.90%
Dominican Republic	1.80%
Belize	1.60%
Costa Rica	1.20%
Venezuela	0.90%

Data from Johns Hopkins University: https://coronavirus.jhu.edu/data/mortality

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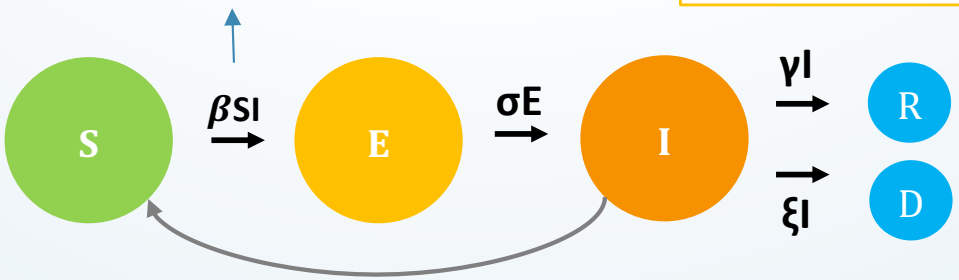
Key Epidemiological Parameters

β=Transmission Rate
Epidemiological, modifiable via public health interventions

R_t=Effective Reproduction Number
$\sim \beta/\gamma$
Average number of secondary infections caused by an infectious individual at a given point in the outbreak's progression



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Estimating the effect of Public Health interventions

16 March 2020 *Imperial College COVID-19 Response Team*

Report 9: Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand

Neil M Ferguson, Daniel Laydon, Gemma Nedjati-Gilani, Natsuko Imai, Kylie Ainslie, Marc Baguelin,

Table 2: Summary of NPI interventions considered.

Label	Policy	Description
CI	Case isolation in the home	Symptomatic cases stay at home for 7 days, reducing non-household contacts by 75% for this period. Household contacts remain unchanged. Assume 70% of household comply with the policy.
HQ	Voluntary home quarantine	Following identification of a symptomatic case in the household, all household members remain at home for 14 days. Household contact rates double during this quarantine period, contacts in the community reduce by 75%. Assume 50% of household comply with the policy.
SDO	Social distancing of those over 70 years of age	Reduce contacts by 50% in workplaces, increase household contacts by 25% and reduce other contacts by 75%. Assume 75% compliance with policy.
SD	Social distancing of entire population	All households reduce contact outside household, school or workplace by 75%. School contact rates unchanged, workplace contact rates reduced by 25%. Household contact rates assumed to increase by 25%.
PC	Closure of schools and universities	Closure of all schools, 25% of universities remain open. Household contact rates for student families increase by 50% during closure. Contacts in the community increase by 25% during closure.

		Total deaths			
R_0	On Trigger	Do nothing	CI_HQ_SD	PC_CI_SD	PC_CI_HQ_SD
2	60	410,000	47,000	6,400	5,600
	100	410,000	47,000	9,900	8,300
	200	410,000	46,000	17,000	14,000
	300	410,000	45,000	24,000	21,000
	400	410,000	44,000	30,000	26,000
2.2	60	460,000	62,000	9,700	6,900
	100	460,000	61,000	13,000	10,000
	200	460,000	64,000	23,000	17,000
	300	460,000	65,000	32,000	26,000
	400	460,000	68,000	39,000	31,000
2.4	60	510,000	85,000	12,000	8,700
	100	510,000	87,000	19,000	13,000
	200	510,000	90,000	30,000	24,000
	300	510,000	94,000	43,000	34,000
	400	510,000	98,000	53,000	39,000
2.6	60	550,000	110,000	20,000	12,000
	100	550,000	110,000	26,000	16,000
	200	550,000	120,000	39,000	30,000
	300	550,000	120,000	56,000	40,000
	400	550,000	120,000	71,000	48,000

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Data-driven approach

Evolution of disease transmission rate during the course of SARS-COV-2: patterns and determinants

June 2020

Jie Zhu[a], Blanca Gallego[a,*]

[a]*Centre for Big Data Research in Health, UNSW Sydney, Sydney, 2052, NSW, Australia*

Abstract

To date, many studies have argued the potential impact of public health interventions on flattening the epidemic curve of SARS-CoV-2. Most of them have focused on simulating the impact of interventions in a region of interest by manipulating contact patterns and key transmission parameters to reflect different scenarios. Our study looks into the evolution of the daily effective reproduction number during the epidemic via a stochastic transmission model. We found this measure (although model-dependent) provides an early signal of the efficacy of containment measures. This epidemiological parameter when updated in real-time can also provide better predictions of future outbreaks. Our results found a substantial variation in the effect of public health interventions on the dynamic of SARS-CoV-2 transmission over time and across countries, that could not be explained solely by the timing and number of the adopted interventions. This suggests that further knowledge about the idiosyncrasy of their implementation and effectiveness is required. Although sustained containment measures have successfully lowered growth in disease transmission, more than half of the 101 studied countries failed to maintain the effective reproduction number close to or below 1. This resulted in continued growth in reported cases. Finally, we were able to predict with reasonable accuracy which countries would experience outbreaks in the next 30 days.

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Available data

CASES/RECOVERIES/TESTS/HOSPITALISATIONS/DEATHS

https://ourworldindata.org/coronavirus

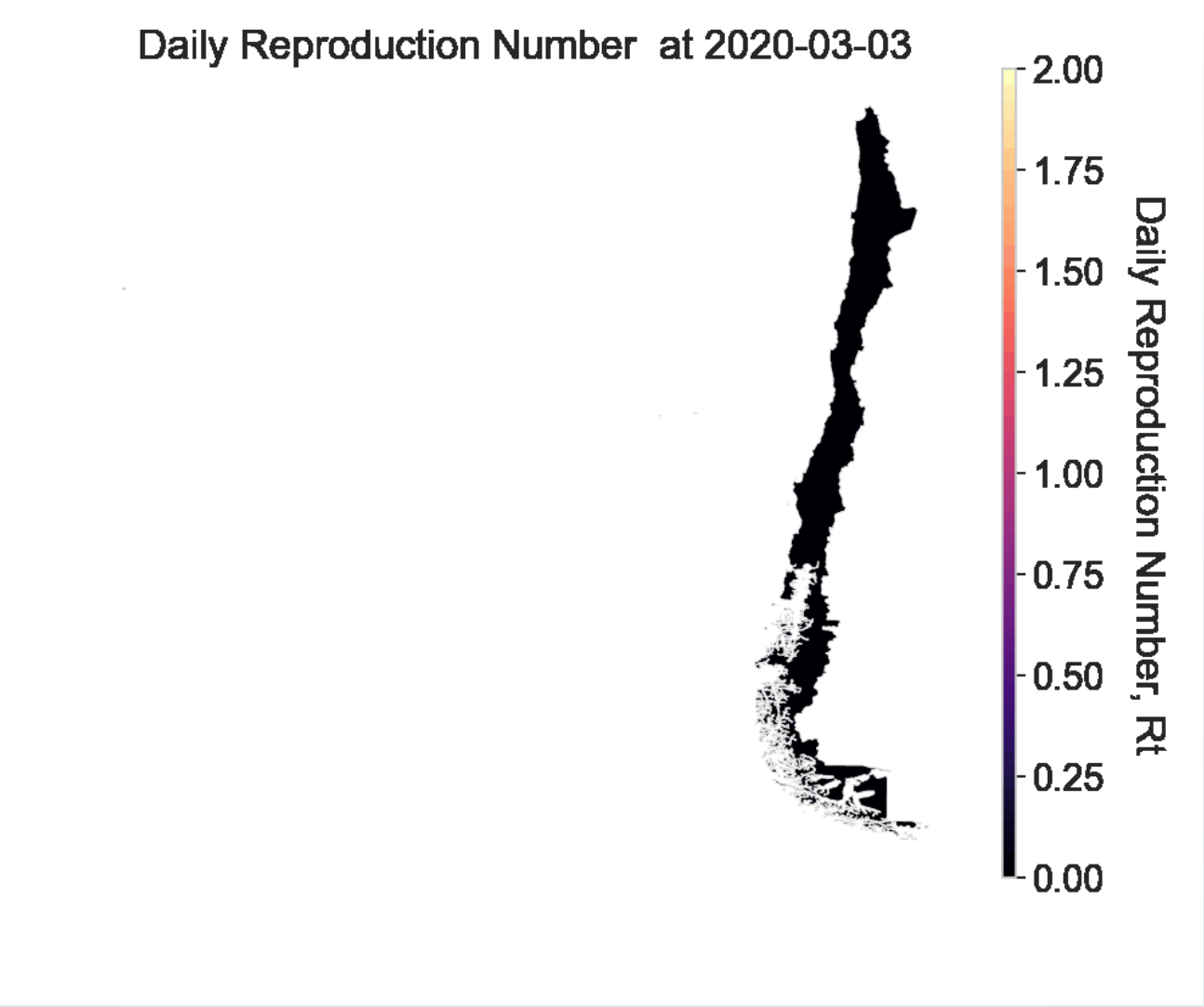
https://coronavirus.jhu.edu/

https://github.com/beoutbreakprepared/nCoV2019

PUBLIC HEALTH INTERVENTIONS

https://lukaslehner.github.io/covid19policytrackers/

Latin America daily Reproduction Number



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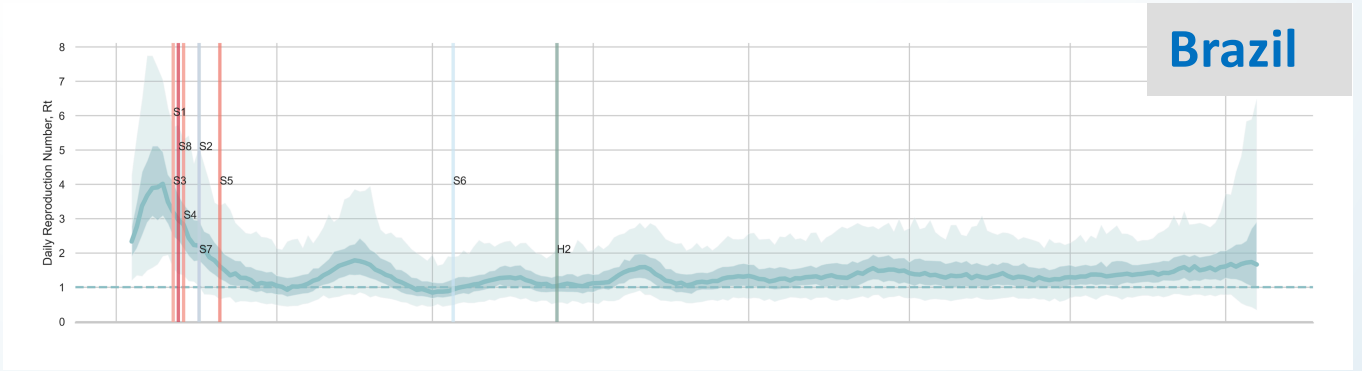
Live estimation of daily R_t

Daily Rt

4th Mar to 28th Oct 2020

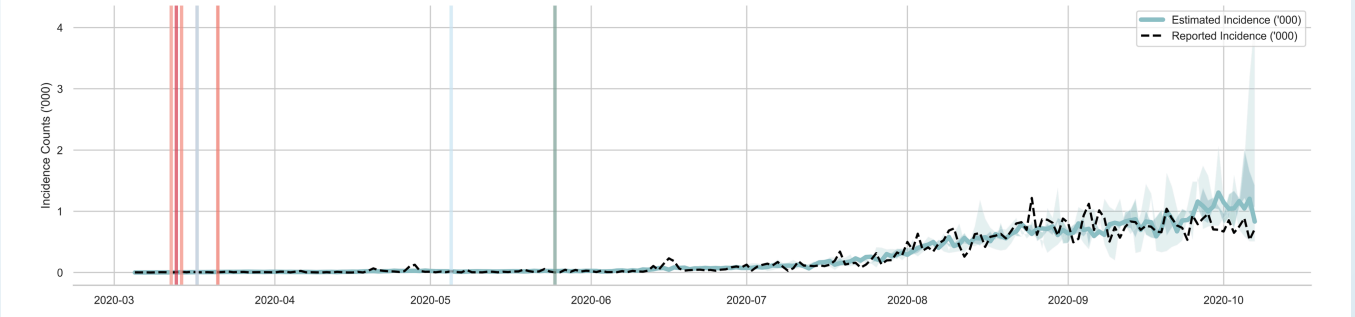
- S1: School closing
- S2: Workplace closing
- S3: Cancel public event
- S4: Restrictions on gatherings
- S5: Close public transport
- S6: Stay at home requirements
- S7: Restrictions on internal movement
- S8: International travel controls
- E1: Income support
- E2: Debt/contract relief
- H1: Public information campaigns
- H2: Testing policy
- H3: Contact tracing'



New Daily Cases

(estimated vs reported)

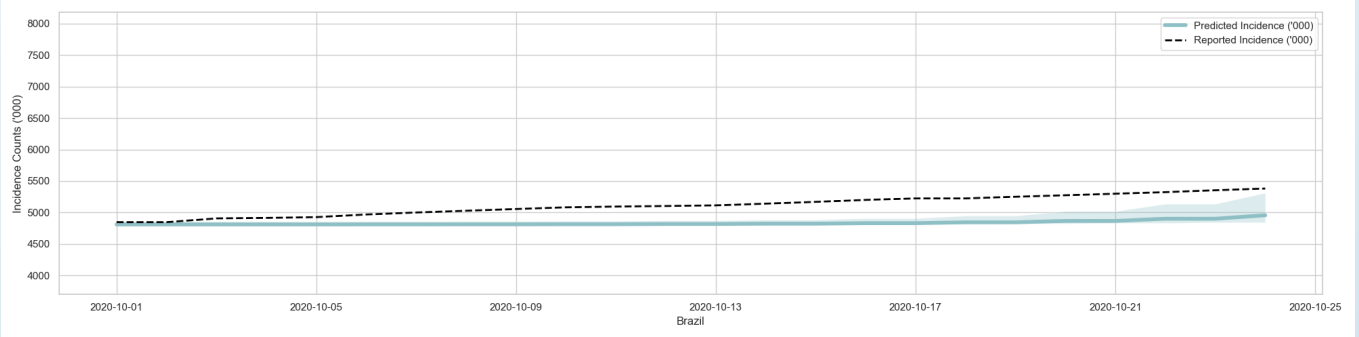
4th Mar to 28th Oct 2020



New Daily Cases

(forecasted vs reported)

1st Oct to 25th Oct 2020



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Limitation of live estimation of daily R_t

Daily Rt

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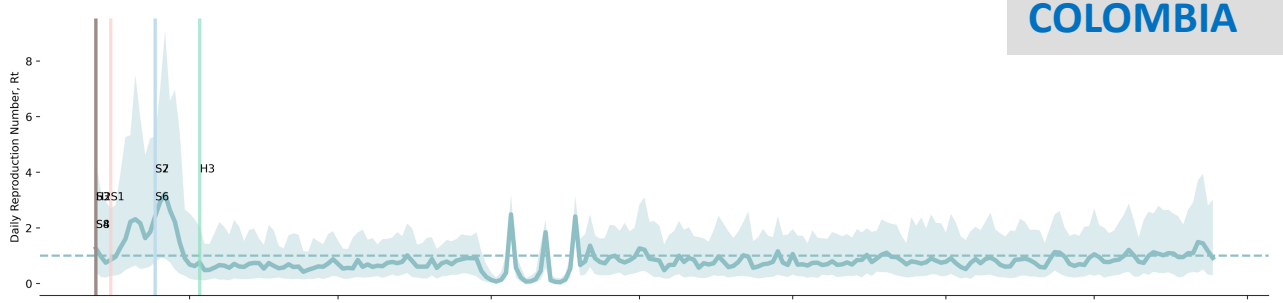
COLOMBIA



New Daily Cases

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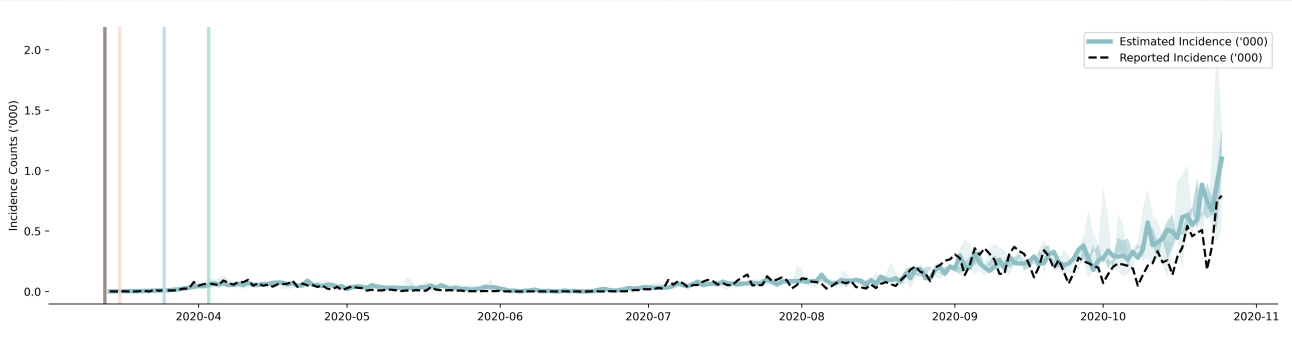

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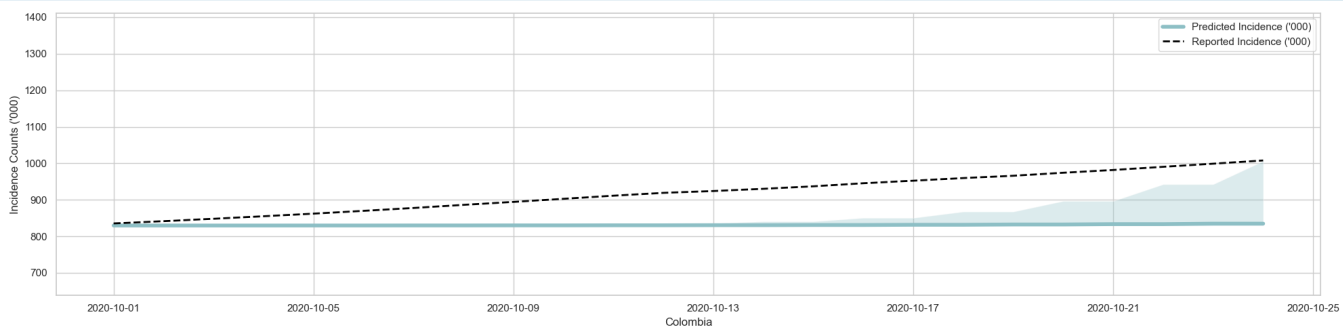

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Live estimation of daily R_t

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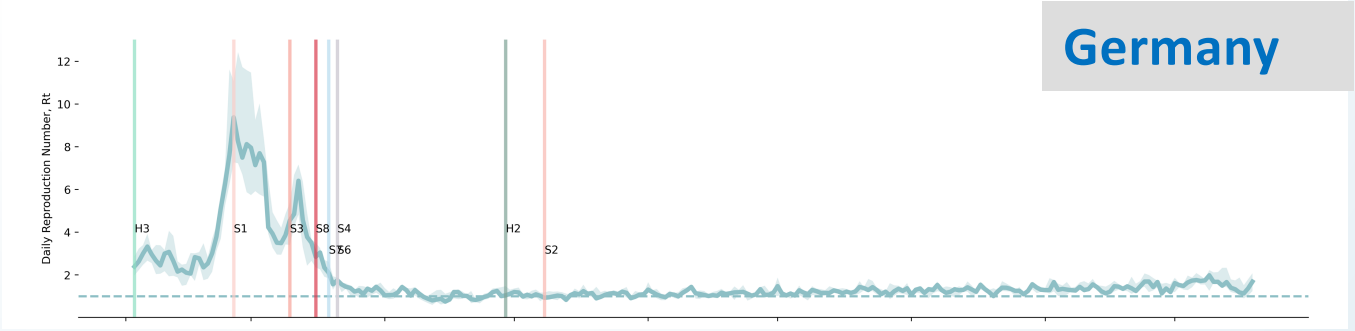

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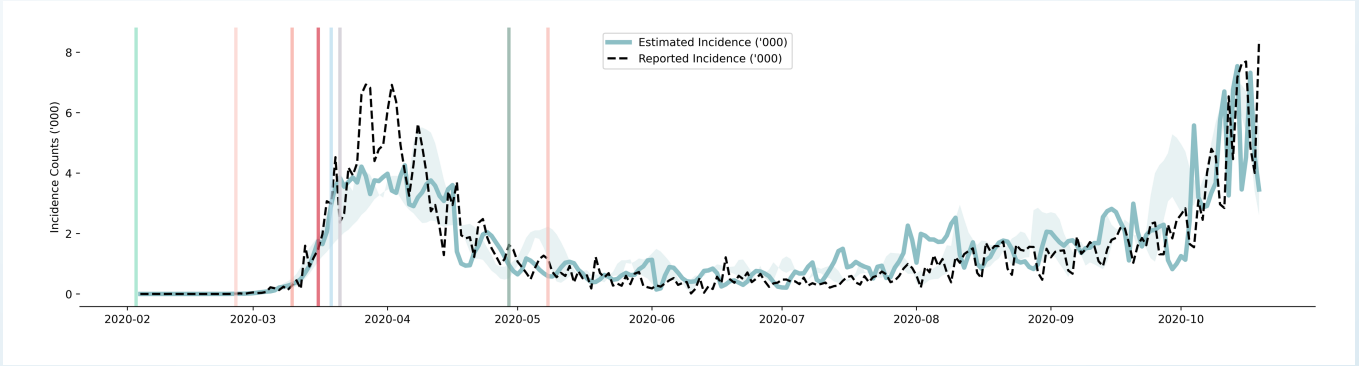

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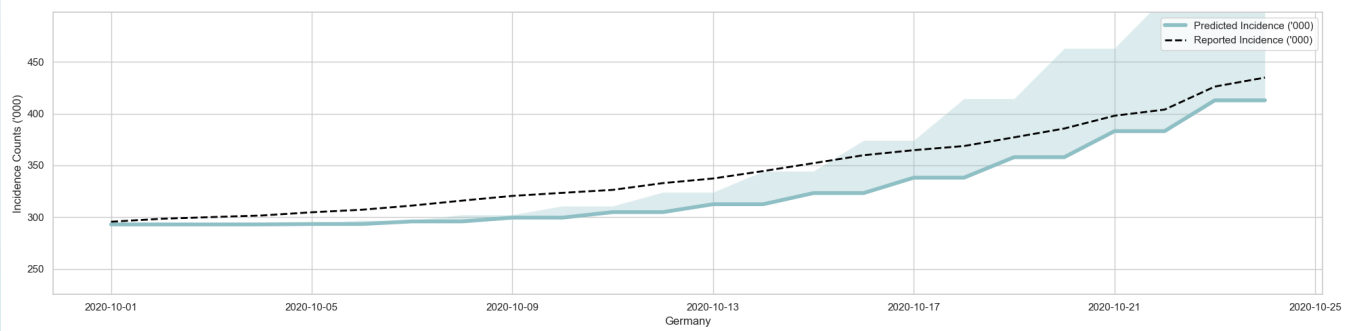

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Thank you for listening

For more information you can find us at:

https://cbdrh.med.unsw.edu.au/clinical-machine-learning-research-unit

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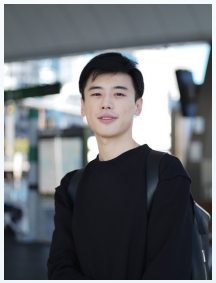

PREPRINT:
https://www.researchsquare.com/article/rs-44647/v1

LIVE WEBSITE:
www.covid19-predictions.net

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