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
Modelling COVID19 Outbreaks

\[ \frac{1}{\gamma} = \text{Duration of infection (average 8 – 20 days)} \]
Clinical, can be modifiable with pharmaceutical interventions

\[ \frac{1}{\sigma} = \text{Incubation period (average 4-6 days)} \]
Biological, non-modifiable

\[ \frac{1}{\gamma} = \text{Duration of infection (average 8 – 20 days)} \]
Clinical, can be modifiable with pharmaceutical interventions

\[ \frac{1}{\sigma} = \text{Incubation period (average 4-6 days)} \]
Biological, non-modifiable

\[ \xi = \text{Fatality rate (0.5% – 10%)} \]
Clinical, modifiable with medical treatment
### Fatality Rate

**Data from Johns Hopkins University:** [https://coronavirus.jhu.edu/data/mortality](https://coronavirus.jhu.edu/data/mortality)

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

Source: 05-Nov-2020
Key Epidemiological Parameters

$\beta = \text{Transmission Rate}$
Epidemiological, modifiable via public health interventions

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

Diagram:
- **S**: Susceptible
- **E**: Exposed
- **I**: Infectious
- **R**: Recovered
- **D**: Dead

05-Nov-2020
Estimating the effect of Public Health interventions

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.

<table>
<thead>
<tr>
<th>Label</th>
<th>Policy</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>CI</td>
<td>Case isolation in the home</td>
<td>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.</td>
</tr>
<tr>
<td>HQ</td>
<td>Voluntary home quarantine</td>
<td>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.</td>
</tr>
<tr>
<td>SDO</td>
<td>Social distancing of those over 70 years of age</td>
<td>Reduce contacts by 50% in workplaces, increase household contacts by 25% and reduce other contacts by 75%. Assume 75% compliance with policy.</td>
</tr>
<tr>
<td>SD</td>
<td>Social distancing of entire population</td>
<td>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%.</td>
</tr>
<tr>
<td>PC</td>
<td>Closure of schools and universities</td>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>R₀</th>
<th>On Trigger</th>
<th>Do nothing</th>
<th>CI</th>
<th>HQ</th>
<th>SD</th>
<th>PC</th>
<th>CI</th>
<th>HQ</th>
<th>SD</th>
<th>Total deaths</th>
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<td>5,600</td>
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<tr>
<td>100</td>
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<td>47,000</td>
<td>9,900</td>
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05-Nov-2020
Evolution of disease transmission rate during the course of SARS-COV-2: patterns and determinants

June 2020

Jie Zhu\textsuperscript{a}, Blanca Gallego\textsuperscript{a,*}

\textsuperscript{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.
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

Daily Reproduction Number at 2020-03-03

05-Nov-2020
Live estimation of daily $R_t$

**Daily $R_t$**
4\textsuperscript{th} Mar to 28\textsuperscript{th} 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

**Brazil**

**New Daily Cases**
(estimated vs reported)
4\textsuperscript{th} Mar to 28\textsuperscript{th} Oct 2020

**New Daily Cases**
(forecasted vs reported)
1\textsuperscript{st} Oct to 25\textsuperscript{th} Oct 2020

05-Nov-2020
Limitation of live estimation of daily $R_t$

**Daily $R_t$**
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**
(1st Oct to 25th Oct 2020)

05-Nov-2020
Live estimation of daily $R_t$

**Daily $R_t$**

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**

(estimated vs reported)

1st Oct to 25th Oct 2020
Thank you for listening

For more information you can find us at:

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

E-mail:

b.gallego@unsw.edu.au
elliott.zhu@unsw.edu.au

PREPRINT:

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

LIVE WEBSITE:

www.covid19-predictions.net