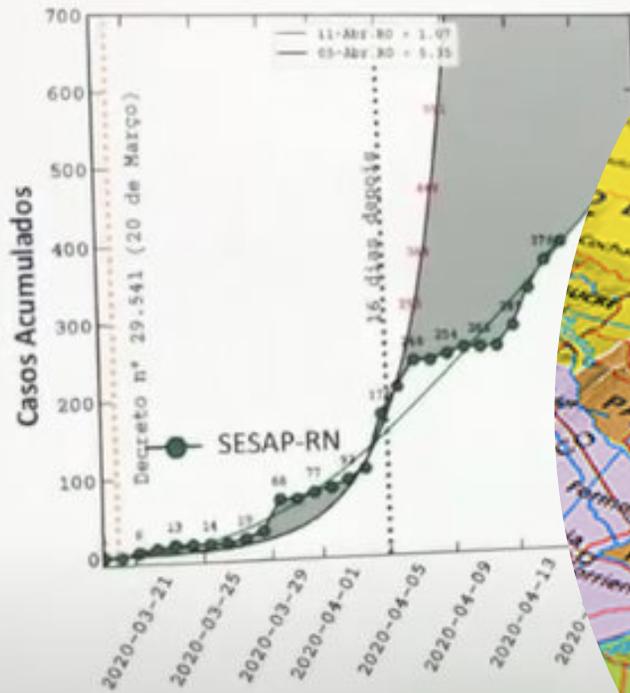


Projeções do MOSAIC* Para o Estado de



*Modelo Epidemic Infectious Disease of Large population C
<https://astro.dfte.ufrn.br/html/Ciente/COVID19.p>



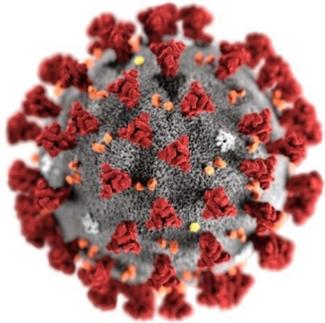
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UFRN

Modelos podem dizer o que queremos saber?

Modelos Físico-matemáticos SEIR para análise de populações. COVID – 19 (Brasil, Nordeste, RN)



Prof. José-Dias do Nascimento Júnior

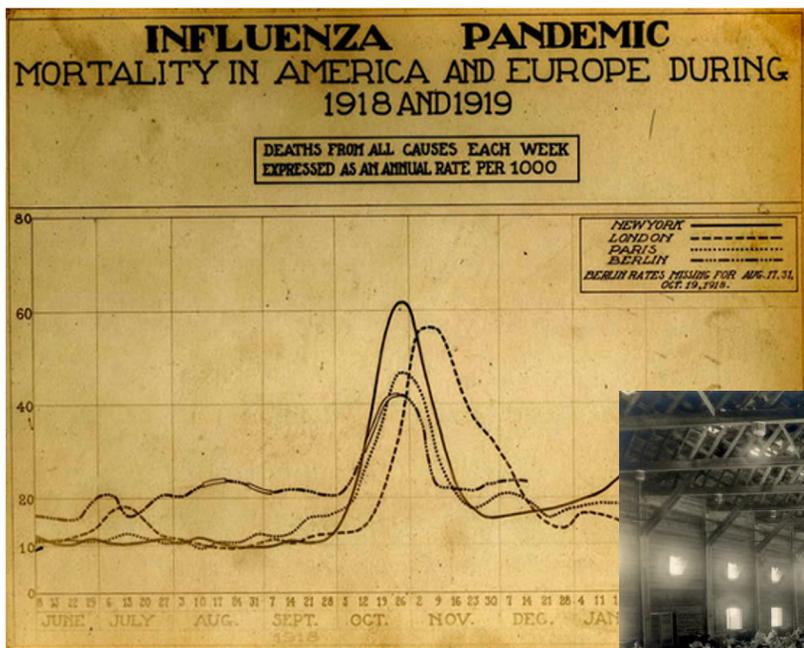
Departamento de Física, UFRN, Brasil

Wladimir Lyra (US), Jaber Belkhiria (US), Pedro Paulo M. Chrispim (SP), Leandro de Almeida (UFRN), Ion de Andrade (LAIS/UFRN), Ricardo Valentim (LAIS/UFRN). José Soares (UFC) (Físicos, Médicos, Epidemiólogos e pesquisadores da área de saúde)

Equações comuns em muitos lugares da Física

- Dinâmica de Incêndio
- Reações Químicas
- Astrofísica, Formação Estrelas e Planetas
- Economia
- Espalhamento de Informação (ideias. meme)
- Genética e Evolução





Física



700 W. O. Kermack and A. G. McKendrick.

Summary.

The various possible mechanisms for the production of ammonia in a nitrogen hydrogen mixture by means of thermions have been investigated in detail. It is shown that synthesis can occur due to the following reactions—

$N_2 + H$ at the surface of platinum or nickel.
 $N_2 + H'$ in the bulk at 13 volts.

The following molecular species are shown to be chemically reactive—

N_2^+ in the bulk at 17 volts,
 N^+ in the bulk at 23 volts,

and possible modes of mechanism involving N_2' and H' are elaborated.

Our thanks are due to Prof. T. M. Lowry, F.R.S., who communicated this paper, and to Messrs. Brunner Mond and Co., for providing a grant to defray part of the cost of the apparatus employed.

A Contribution to the Mathematical Theory of Epidemics.
 By W. O. KERMACK AND A. G. MCKENDRICK.
 (Communicated by Sir Gilbert Walker, F.R.S.—Received May 13, 1927.)
 (From the Laboratory of the Royal College of Physicians, Edinburgh.)

1919

1927

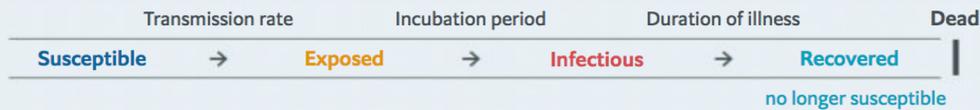
(Esquerda) Gráfico histórico mostrando as taxas de mortalidade na América e na Europa durante a pandemia de 1918 - 1919.
 (Direita). Marco fundamental para a epidemiologia matemática (1927), Kermack e McKendrick

Seer's succour

1

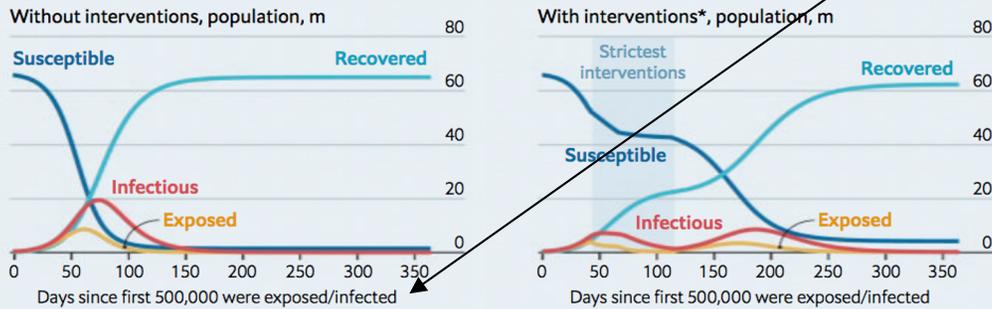
How a SEIR model shows what's to come

One of the most established ways of modelling epidemics divides the population into four groups: those **susceptible to infection (S)**, **exposed to the virus (E)**, **infectious (I)** or **recovered (R)**—a category which also, oddly, includes the dead. Conditions are then set for how people move from one group to the next and thus how the groups change in size over time



Model of a covid-like epidemic in Britain

To begin with the population is entirely susceptible. As some susceptibles are exposed, that number sinks and the exposed number grows, with the number of the infectious following close behind. In the left-hand panel there is no intervention; the infected number sinks back down until the whole population is recovered. On the right, interventions lower the rate at which the susceptible population shrinks. When the interventions are lifted, exposure picks back up, creating a second rise in the infectious

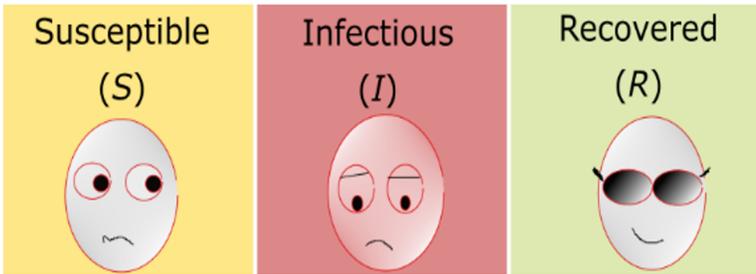


Sources: Institute for Disease Modelling; *The Economist*

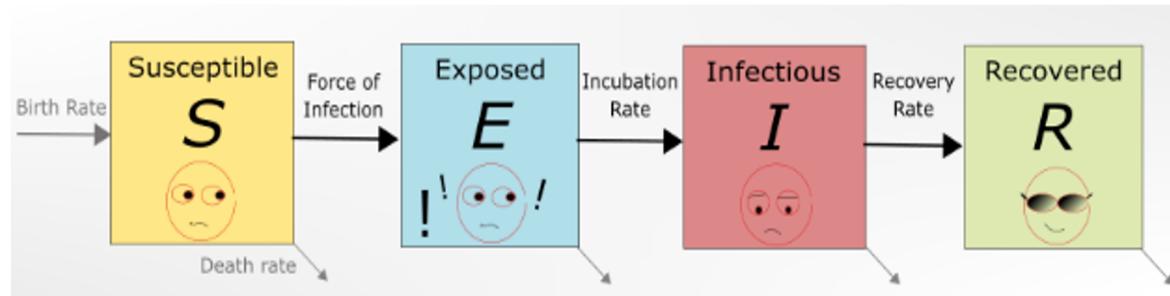
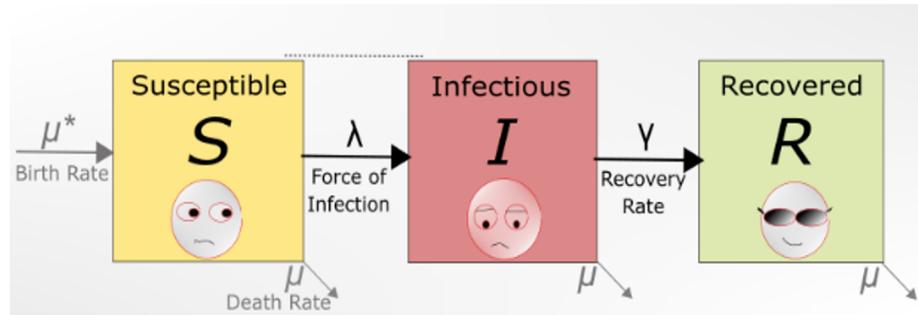
*Interventions end ten weeks after reaching strictest level

The Economist, UK. 4 de
Abril 2019





The standard SIR model can be schematically represented as:



COVID-19 pandemics modeling with SEIR(+CAQH), social distancing, and age stratification. The effect of vertical confinement and release in Brazil.

Wladimir Lyra^{1,*}, José-Dias do Nascimento Jr.^{2,3}, Jaber Belkhiria⁴, Leandro de Almeida², Pedro Paulo M. Chripim^{4,5}, Ion de Andrade^{6,7},

1 Department of Astronomy, New Mexico State University, PO Box 30001, MSC 4500, Las Cruces, NM 88003-8001, USA

2 Dep. de Física Teórica e Experimental, DFTE, Universidade Federal do Rio Grande do Norte, Avenida Senador Salgado Filho, 3000. Campus Universitário. 59078-970 Lagoa Nova. Natal/RN, Brazil.

3 Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138, USA

4 Center for Animal Disease Modeling and Surveillance, Department of Medicine & Epidemiology, School of Veterinary Medicine, University of California Davis, CA.

4 Instituto Alicerce Ensino Pesquisa e Inovação em Saúde, R Cinco De Julho, 176/101, Rio De Janeiro, RJ, CEP 22051030, Brazil

5 Hospital do Coração, R Desembargador Eliseu Guilherme, 147, Paraíso SP, 04004-030, Brazil

6 Departamento de Saúde Coletiva, Universidade Federal do Rio Grande do Norte, Avenida Senador Salgado Filho, 3000. Campus Universitário. 59078-970 Lagoa Nova. Natal/RN, Brazil.

7 Laboratório de Inovação Tecnológica em Saúde, Av. Nilo Peçanha, 620 - 59012-300 Petrópolis - Natal/RN - Brazil

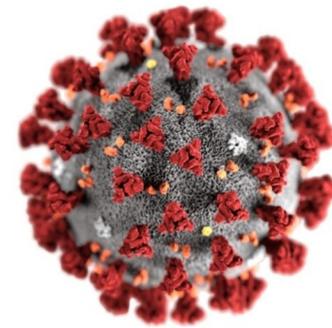


Illustration showing the structure of COVID-19. CDC / Alissa Eckert, MS

1,232 Results for term "COVID-19"

Items/Page Order by

1,232 papers now, when we search for COVID-19. By April 14th

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COVID-19 pandemics modeling with SEIR(+CAQH), social distancing, and age stratification. The effect of vertical confinement and release in Brazil.

Wladimir Lyra, Jose Dias do Nascimento, Jaber Belkhiria, Leandro de Almeida, Pedro Paulo Chrispim, Ion de Andrade

doi: <https://doi.org/10.1101/2020.04.09.20060053>

This article is a preprint and has not been certified by peer review [what does this mean?]. It reports new medical research that has yet to be evaluated and so should not be used to guide clinical practice.

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Abstract

As the COVID-19 epidemic rages, the total number of cases and deaths is raising across the world. This is certainly a challenging situation particularly for countries in a perilous socio-economic situation. With the rapid evolution of the disease, once introduced, making decisions becomes challenging particularly when past experience or data are not so relevant. This is when mathematical models could come handy to predict the evaluations of the epidemic. We designed a modified SEIR-type mathematical model which we assessed with up-to-date data of COVID-19 cases and deaths around the world, and in which the rate of transmission is derived from the observed delayed fatality rate. We used Brazil as an example for middle income countries and applied our model to the Brazilian context. We implement age stratification, horizontal confinement followed by a "vertical confinement" exit strategy.

Competing Interest Statement

The authors have declared no competing interest.

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COVID-19 SARS-CoV-2 preprints from medRxiv and bioRxiv

Subject Area

Epidemiology

Subject Areas

All Articles

- Addiction Medicine
- Allergy and Immunology
- Anesthesia
- Cardiovascular Medicine
- Dentistry and Oral Medicine
- Dermatology
- Emergency Medicine
- Endocrinology (including Diabetes Mellitus and Metabolic Disease)
- Epidemiology
- Forensic Medicine

Set of equations of **SEIR(+CAQH)**

$$\frac{dS_i}{dt} = -\lambda(t)S_i - \psi_i(t)S_i + \phi_i(t)C_i, \quad (1)$$

$$\frac{dC_i}{dt} = \psi_i(t)S_i - \phi_i(t)C_i, \quad (2)$$

$$\frac{dE_i}{dt} = \lambda(t)S_i - \sigma E_i, \quad (3)$$

$$\frac{dA_i}{dt} = (1-p)\sigma E_i - \theta A_i, \quad (4)$$

$$\frac{dI_i}{dt} = p\sigma E_i - (\gamma + \xi)I_i + (1-w)\theta A_i, \quad (5)$$

$$\frac{dQ_i}{dt} = \gamma I_i - \xi Q_i, \quad (6)$$

$$\frac{dH_i}{dt} = q_i \xi I_i - \eta H_i, \quad (7)$$

$$\frac{dR_i}{dt} = w\theta A_i + (1-q_i)\xi I_i + \eta H_i. \quad (8)$$

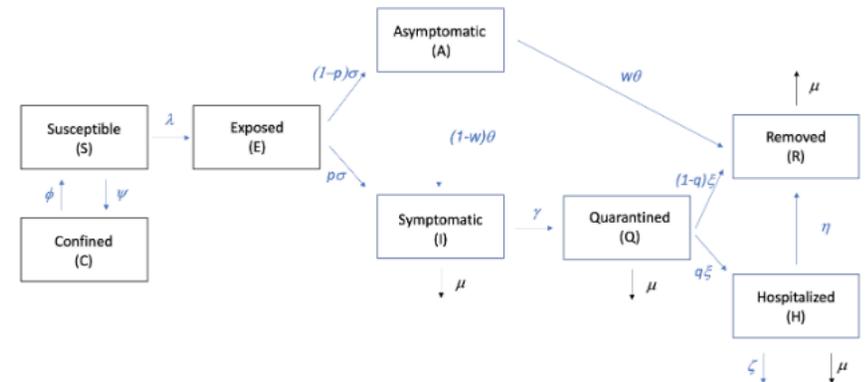


Fig 1. Schematic flow chart between compartments.

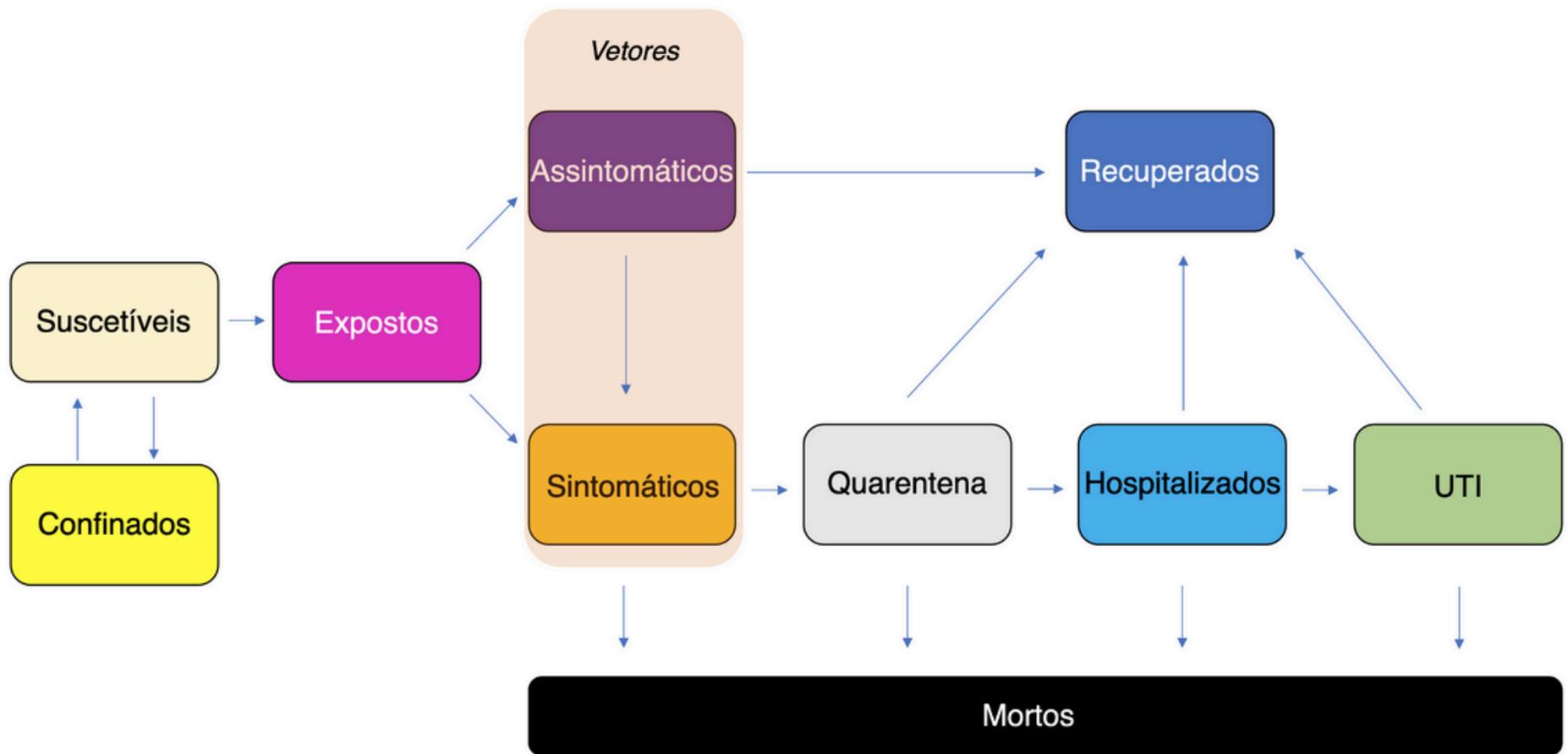


Figura 1: Fluxo entre os diferentes compartimentos usados no modelo epidemiológico.

*Modelo Epidemic Infectious Disease of Large population Code – MOSAIC (W. Lyra, J.D. do Nascimento et al 2020). Fonte: José Dias (UFRN)

MOSAIC

(Epidemiologic Infectious Disease of Large population Code)

We use a modified version of an **SIR** type deterministic compartmental model to trace COVID-19 epidemic evolution in an isolated population of N individual.

S: COVID-19 Susceptible individuals

E: Susceptible that have been exposed to infective individuals

A: Infected and infective but showing mild or no symptoms

I: Infected and infective but showing symptoms

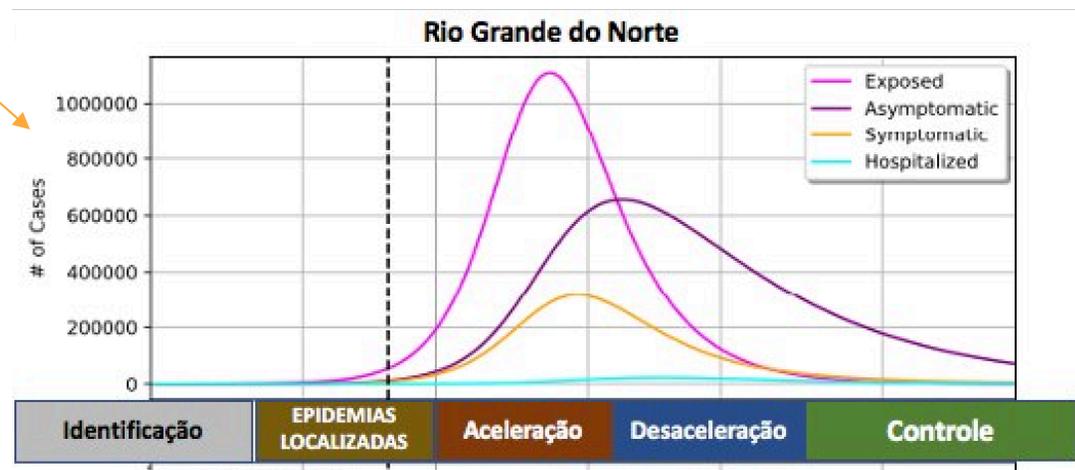
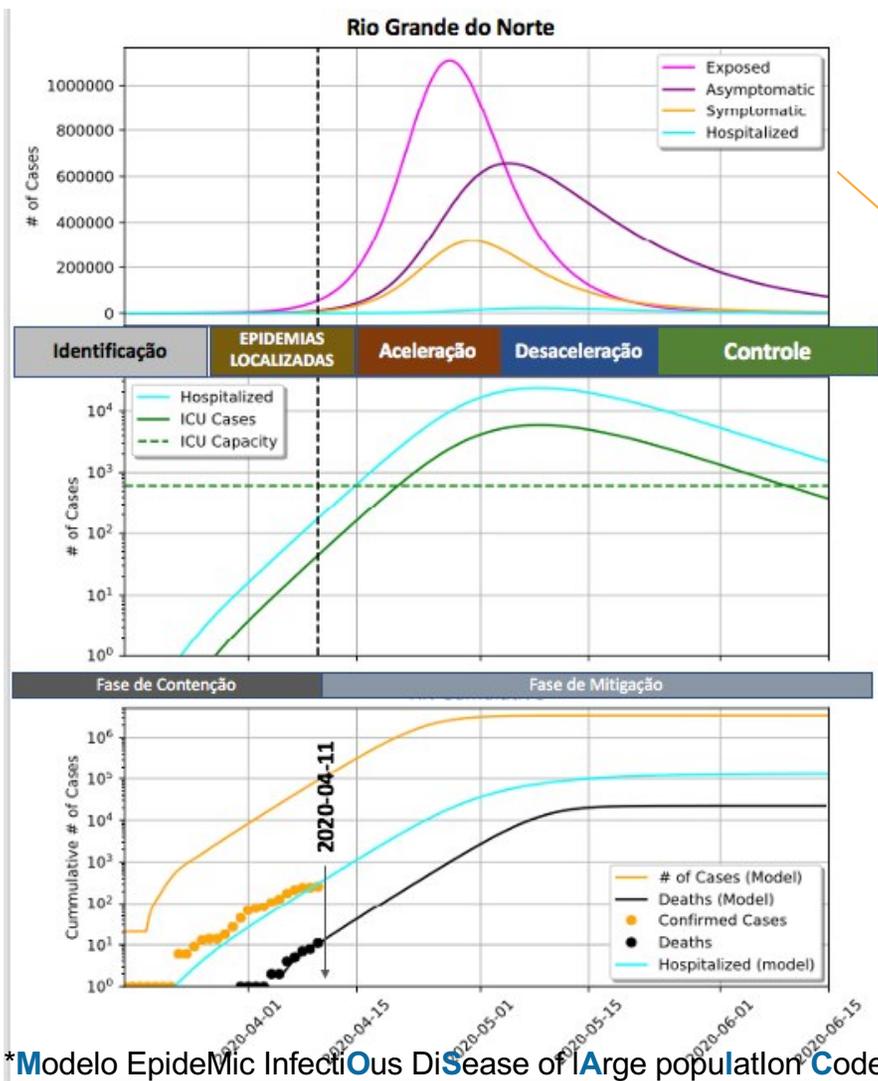
Q: Symptomatic that are not infective

H: Symptomatic, not infective, who are being treated

R: People removed from the epidemic dynamics by recovering or passing away

C: Model the effect of confinement of a proportion of susceptible

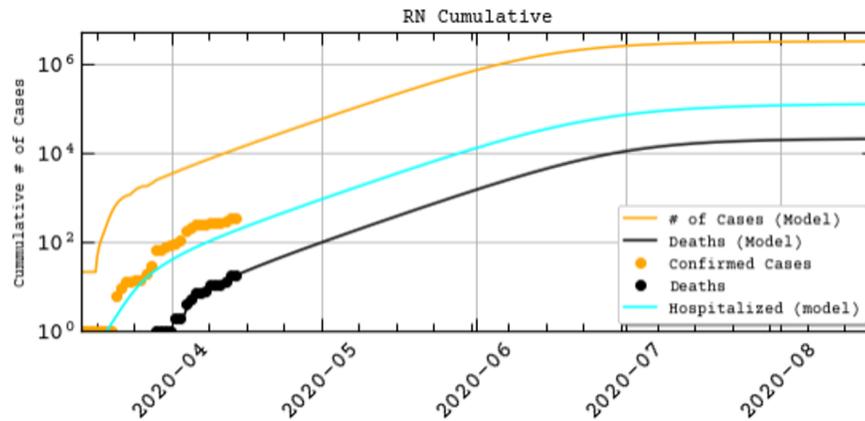
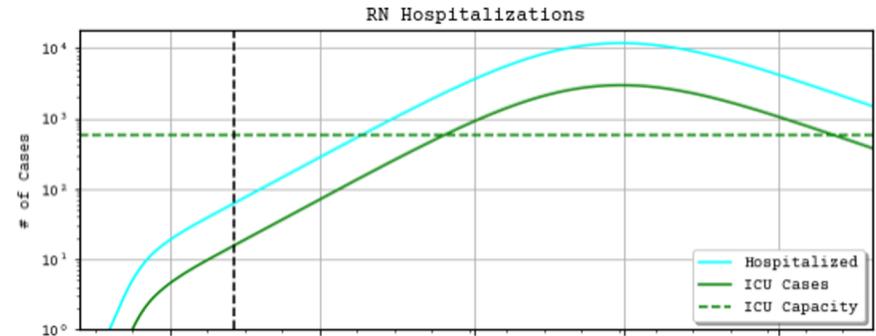
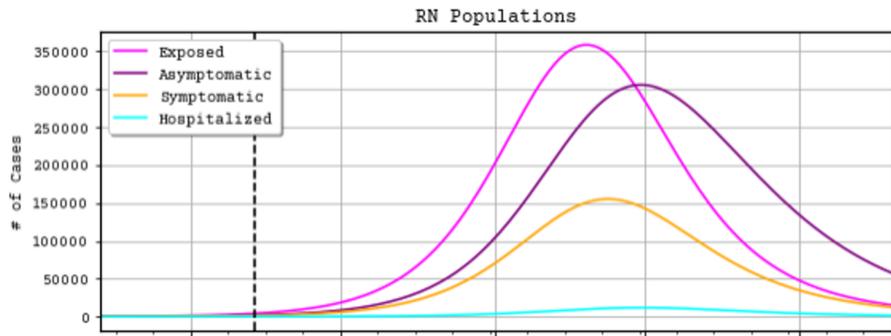
*Modelo Epidemio Infectioso Disease of Large population Code – MOSAIC (W. Lyra, J.D. do Nascimento et al 2020). Fonte: José Dias (UFRN)



*Modelo Epidemic Infectious Disease of Large population Code – MOSAIC (W. Lyra, J.D. do Nascimento et al 2020). Fonte: José Dias (UFRN)

MOSAIC

Output



*Modelo Epidemic Infectious Disease of Large population Code – MOSAIC (W. Lyra, J.D. do Nascimento et al 2020). Fonte: José Dias (UFRN)

Markov chain Monte Carlo (MCMC) Ceará - Brasil

$p = 0.58^{+0.14}_{-0.14}$ p = fração entre os sintomáticos e assintomáticos

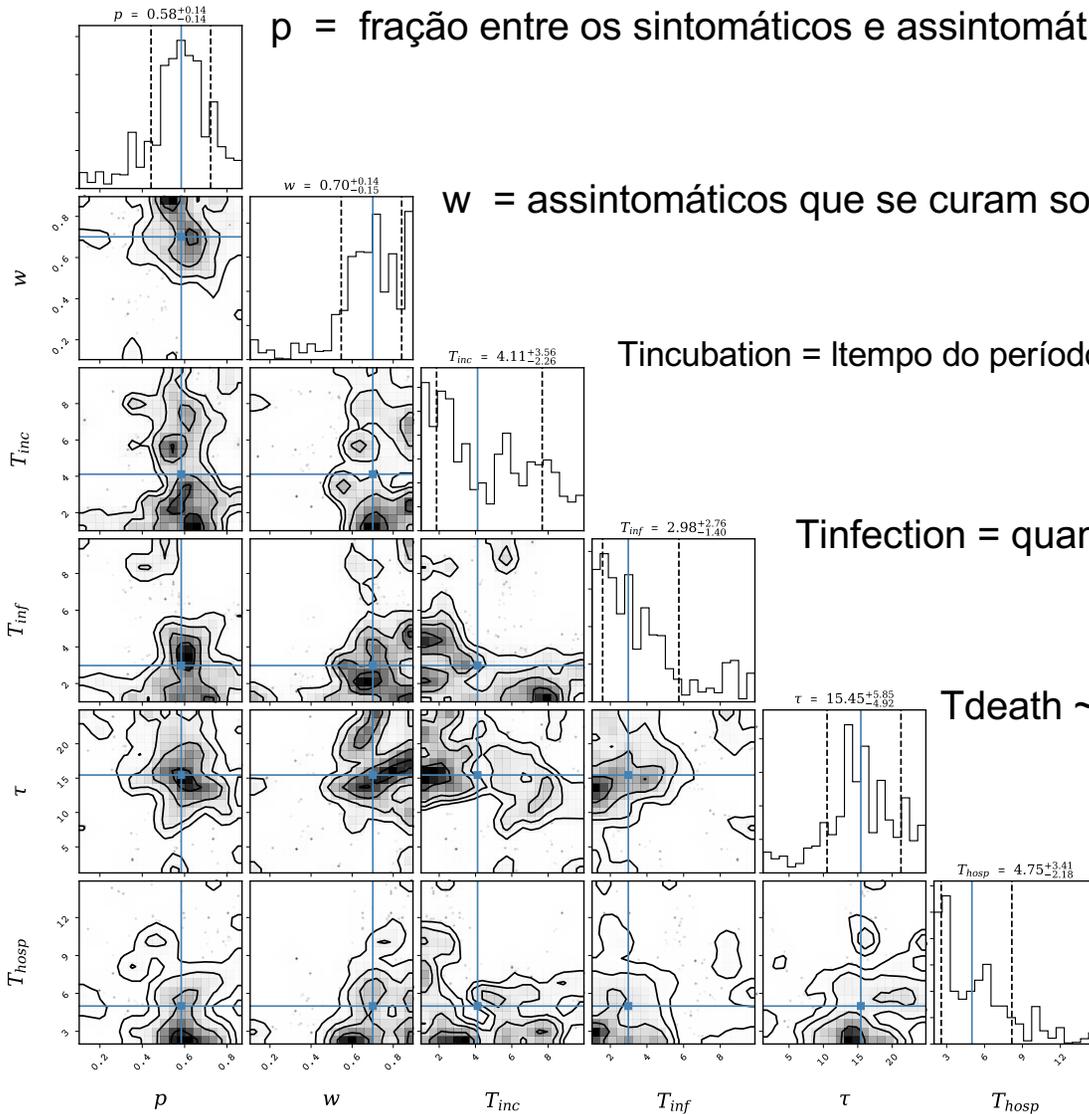
$w = 0.70^{+0.14}_{-0.15}$ w = assintomáticos que se curam sozinhos

$T_{inc} = 4.11^{+3.56}_{-2.26}$ Tincubation = tempo do período de incubação do vírus

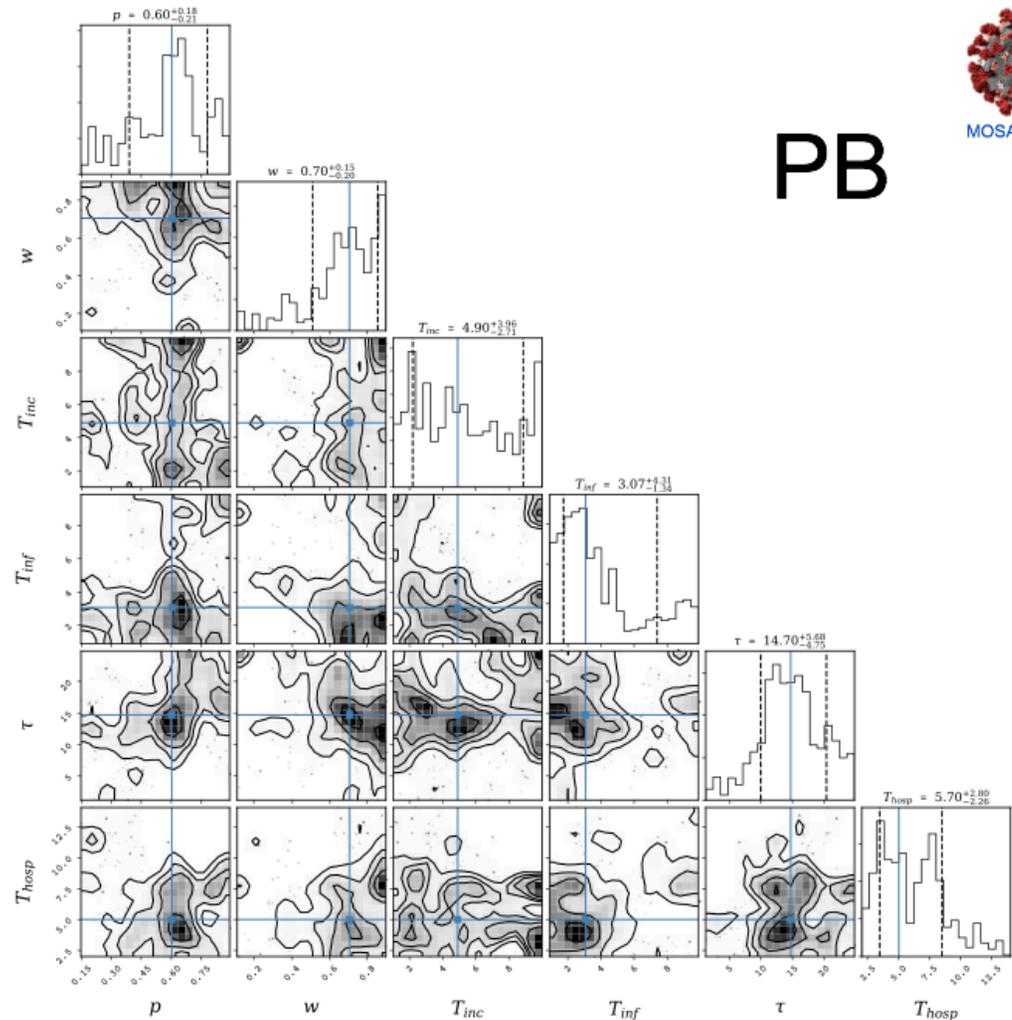
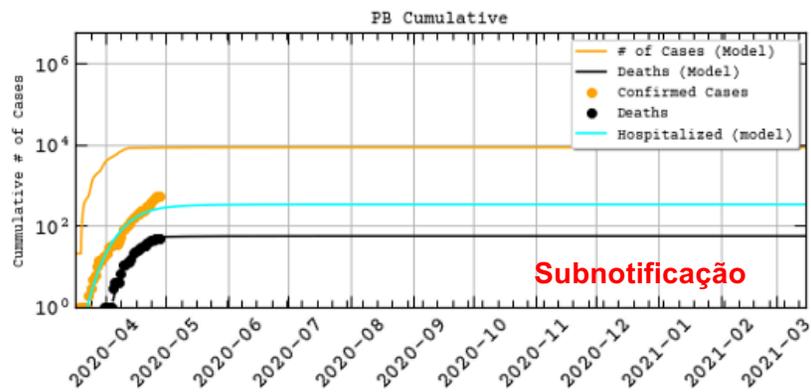
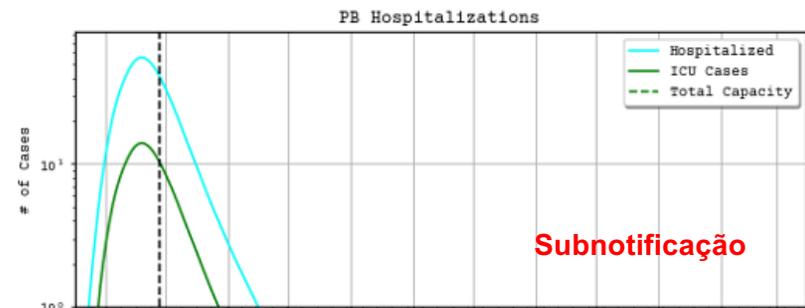
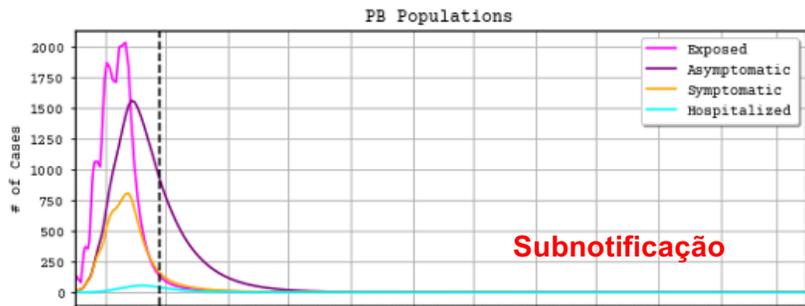
$T_{inf} = 2.98^{+2.76}_{-1.40}$ Tinfection = quanto tempo a pessoa pode infectar

$\tau = 15.45^{+5.85}_{-4.92}$ Tdeath ~ 15 d. Tempo desde a contaminação até óbito

$T_{hosp} = 4.75^{+3.41}_{-2.18}$ Thospitalized = tempo que fica no hospital
Thospitalization = tempo até a hospitalização



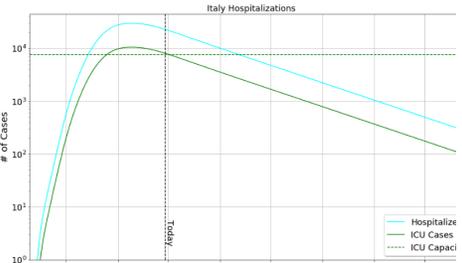
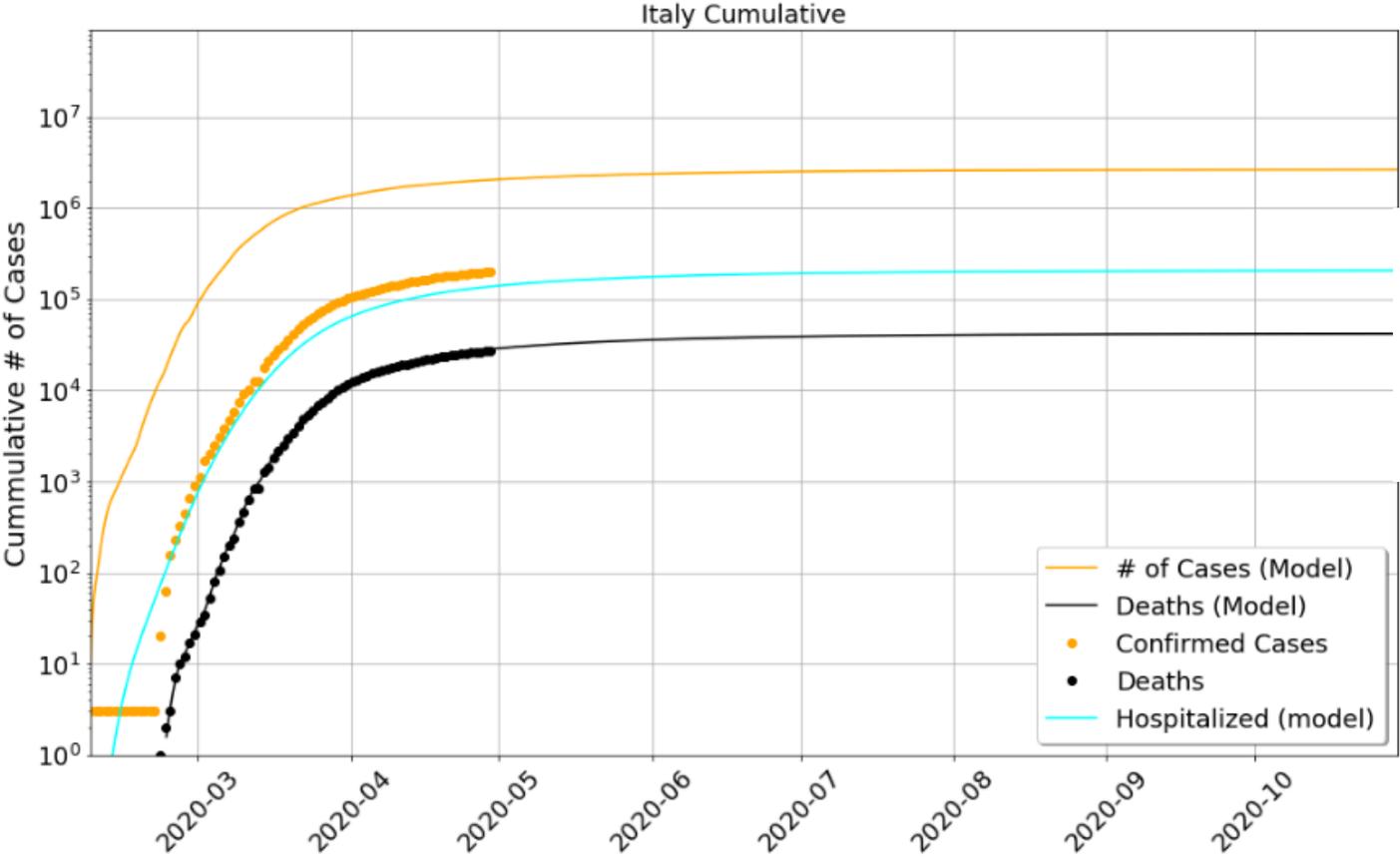
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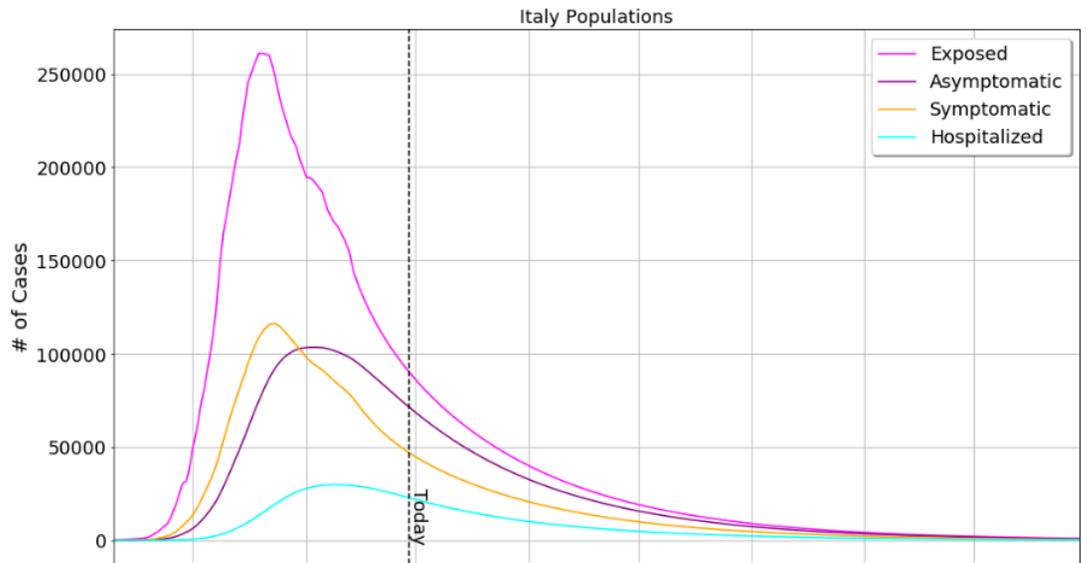
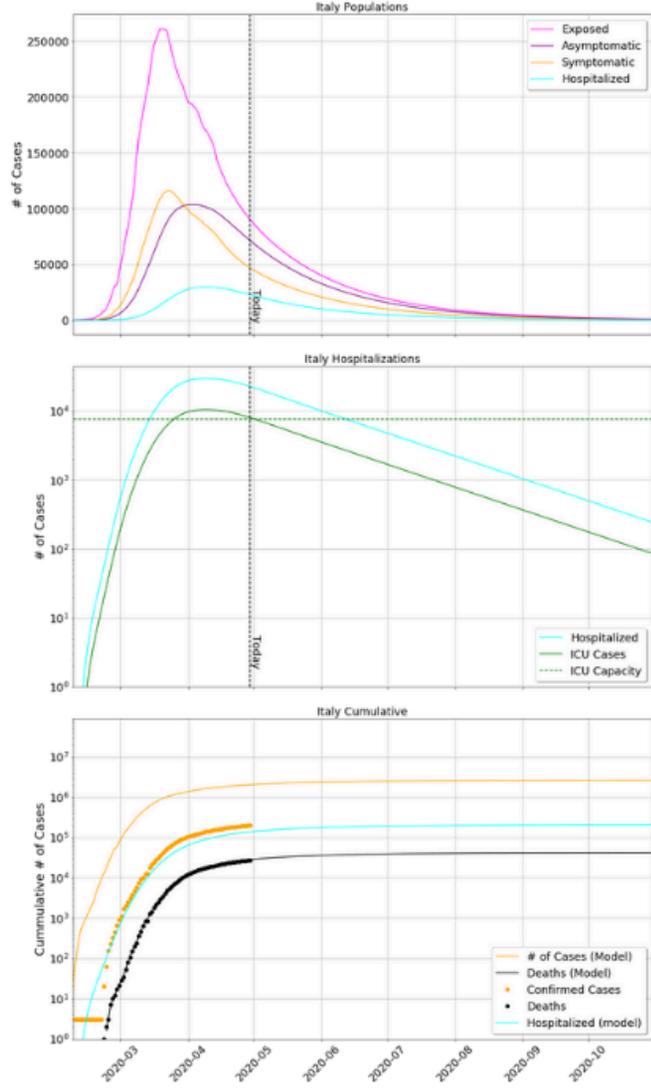
*Modelo Epidemic Infectious Disease of Large population Code – MOSAIC (Lyra, do Nascimento et al 2020). Fonte: José Dias (UFRN)

<https://astro.dfte.ufrn.br/html/Cliente/COVID19.php> & <https://covid.lais.ufrn.br/#projecoes>

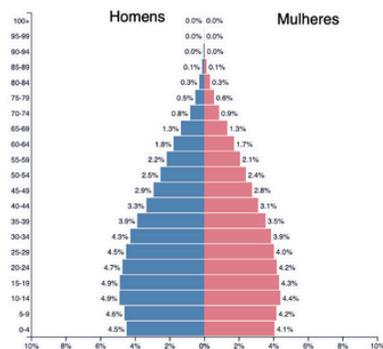
ITALIA



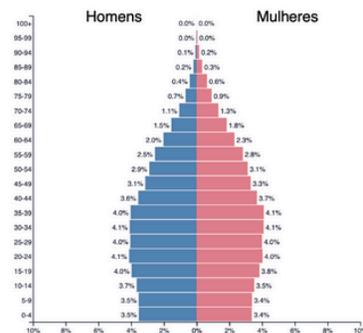
Number of dead: 41909.0



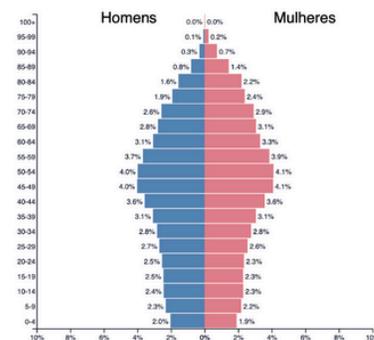
Índia
2019



Brasil
2019



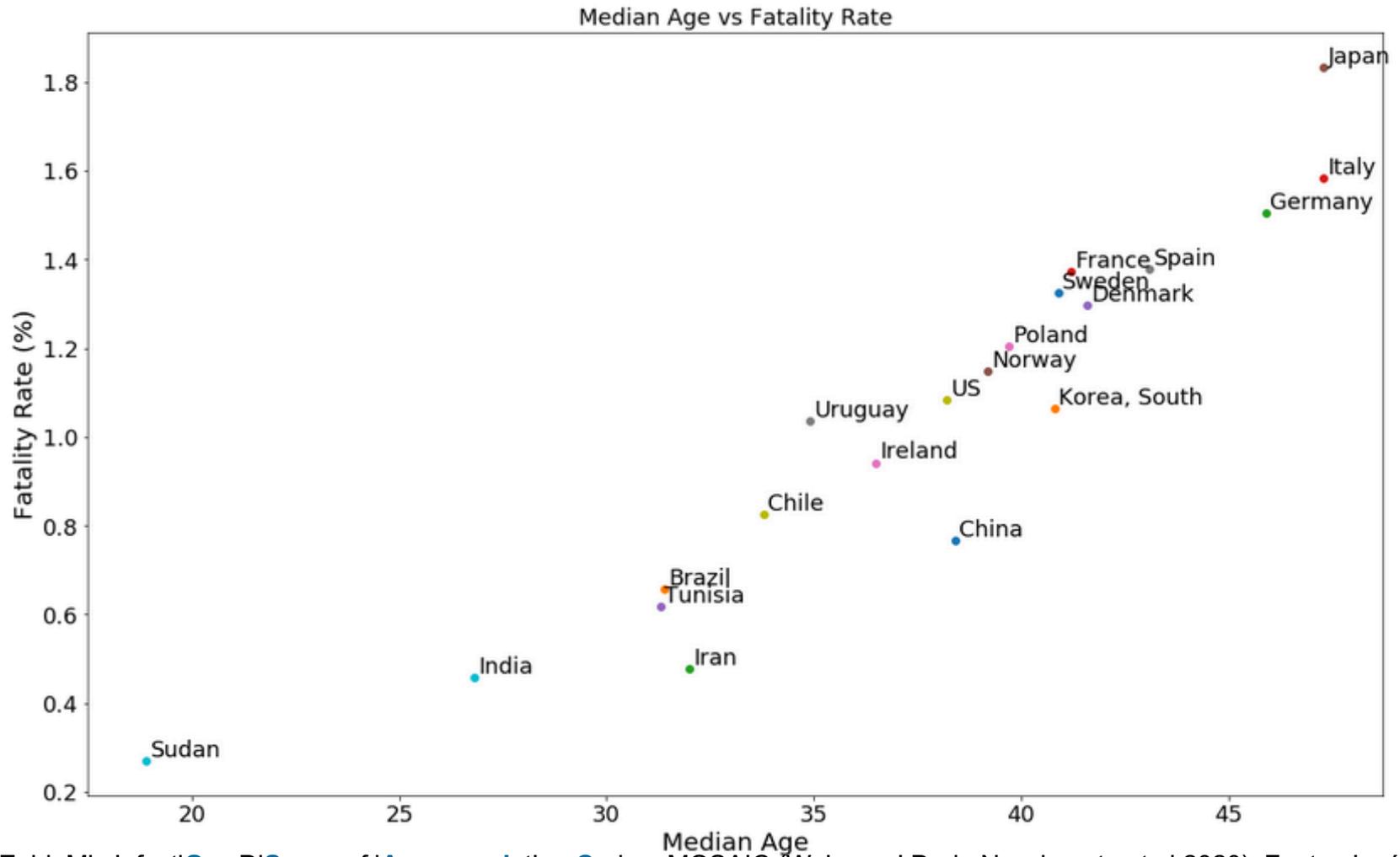
Itália
2019



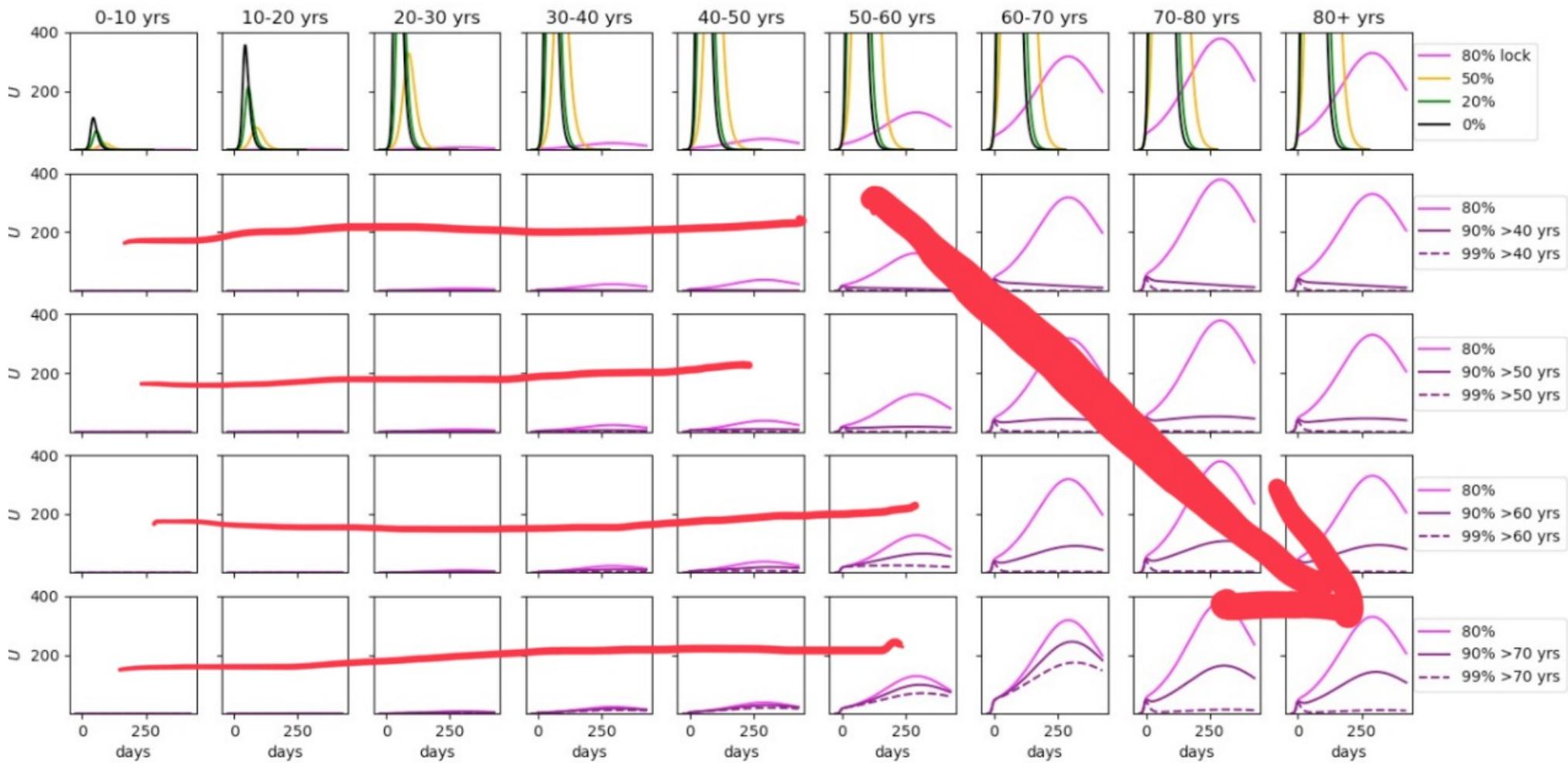
| Segmento Etário (anos) | % de casos sintomáticos requerendo hospitalização | % de hospitalizações requerendo UTI | Taxa de mortalidade |
|------------------------|---|-------------------------------------|---------------------|
| 0 a 9 | 0.1% | 5.0% | 0.002% |
| 10 a 19 | 0.3% | 5.0% | 0.006% |
| 20 a 29 | 1.2% | 5.0% | 0.03% |
| 30 a 39 | 3.2% | 5.0% | 0.08% |
| 40 a 49 | 4.9% | 6.3% | 0.15% |
| 50 a 59 | 10.2% | 12.2% | 0.60% |
| 60 a 69 | 16.6% | 27.4% | 2.2% |
| 70 a 79 | 24.3% | 43.2% | 5.1% |
| 80+ | 27.3% | 70.9% | 9.3% |

Tabela 1. Taxa de hospitalização, fração de casos que precisam de UTI, e taxa de mortalidade seguindo infecção por SARS-CoV-2 para diferentes grupos etários, estimados por pesquisadores do Imperial College

*Modelo Epidemic Infectious Disease of Large population Code – MOSAIC (W. Lyra, J.D. do Nascimento et al 2020). Fonte: José Dias (UFRN)



*Modelo Epidemio Infectioso Disease of Large population Code – MOSAIC (W. Lyra, J.D. do Nascimento et al 2020). Fonte: José Dias (UFRN)



80% lock
 50%
 20%
 0%

80%
 90% >40 yrs
 99% >40 yrs

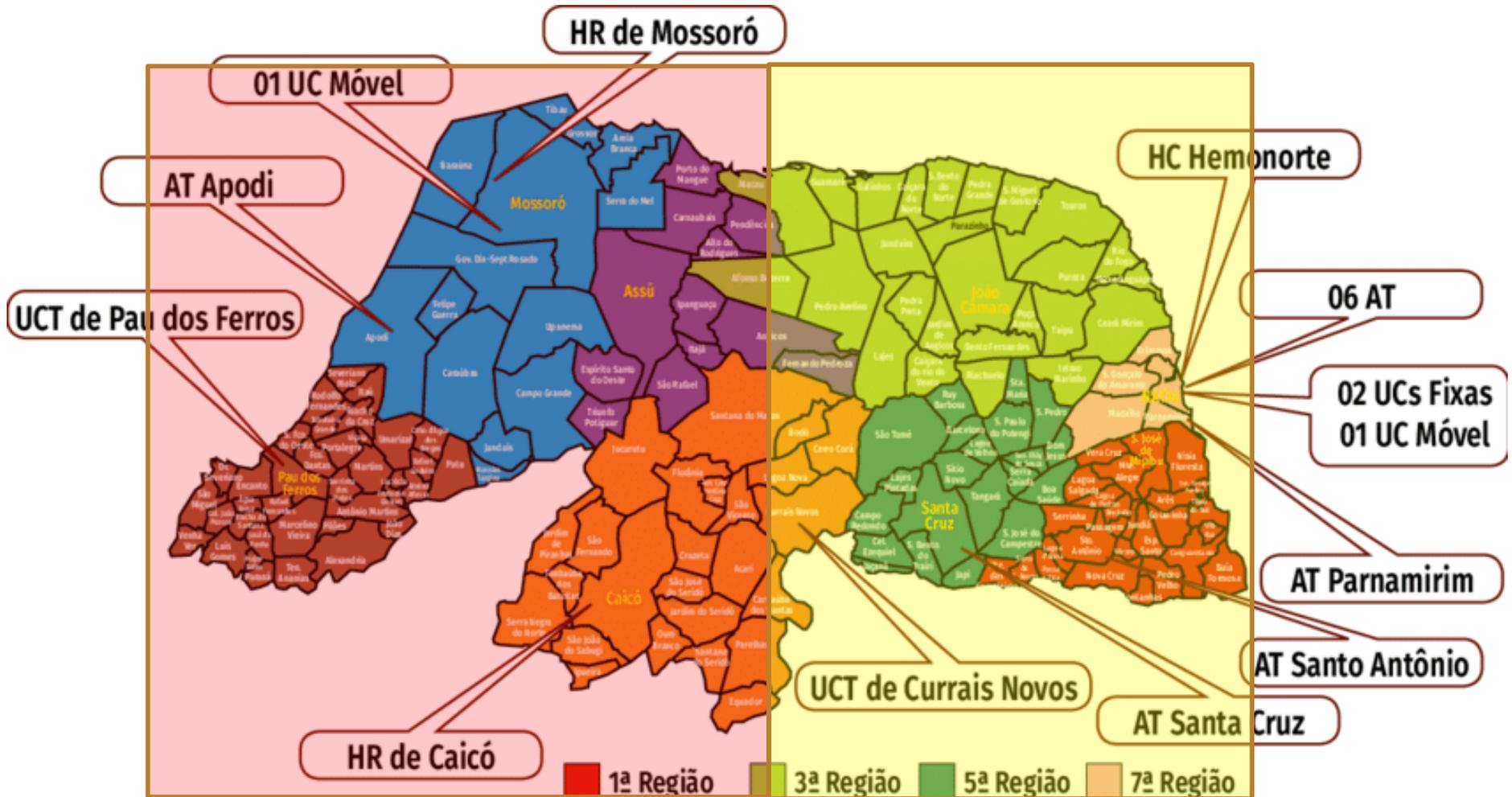
80%
 90% >50 yrs
 99% >50 yrs

80%
 90% >60 yrs
 99% >60 yrs

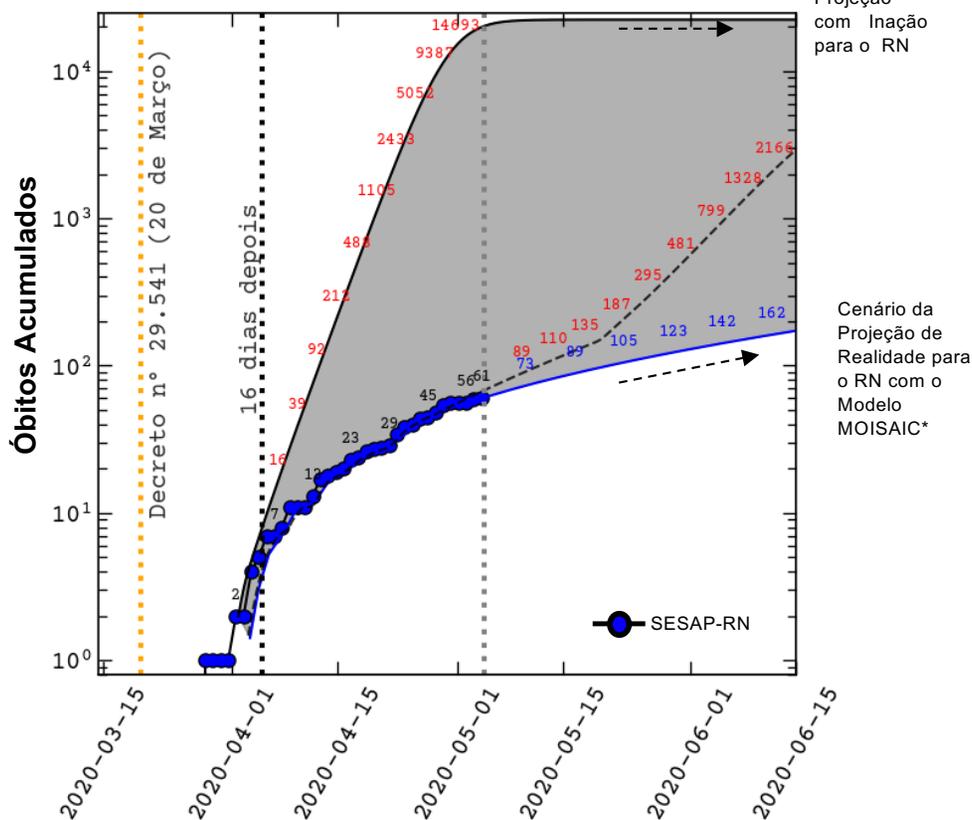
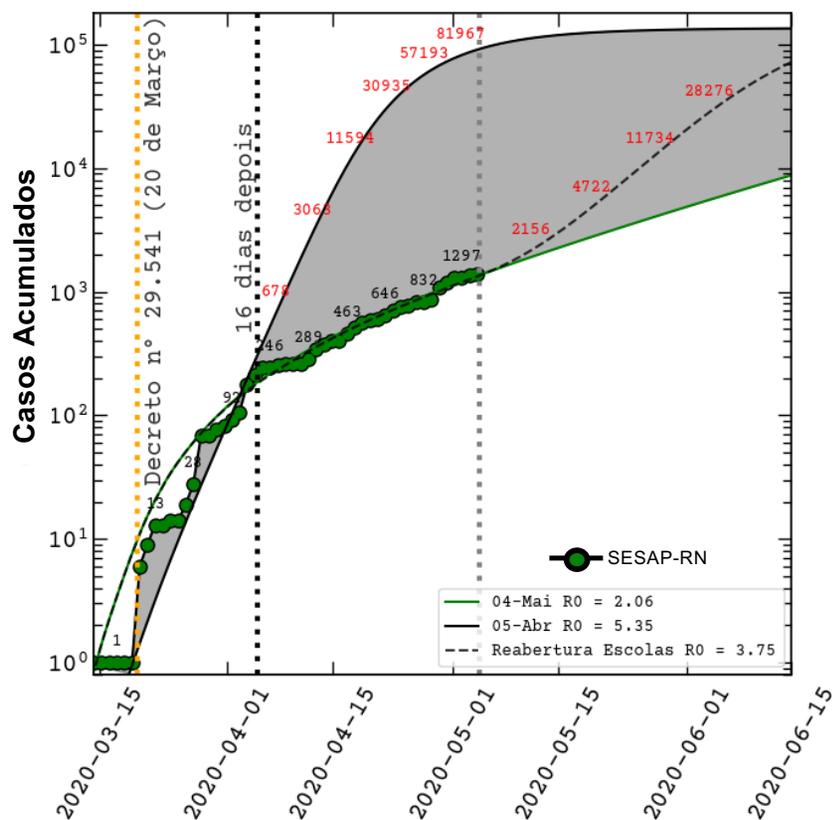
80%
 90% >70 yrs
 99% >70 yrs

População 1

População 2



Projeções do modelo MOSAIC* para o estado do Rio Grande do Norte com **Liberção das Escolas**

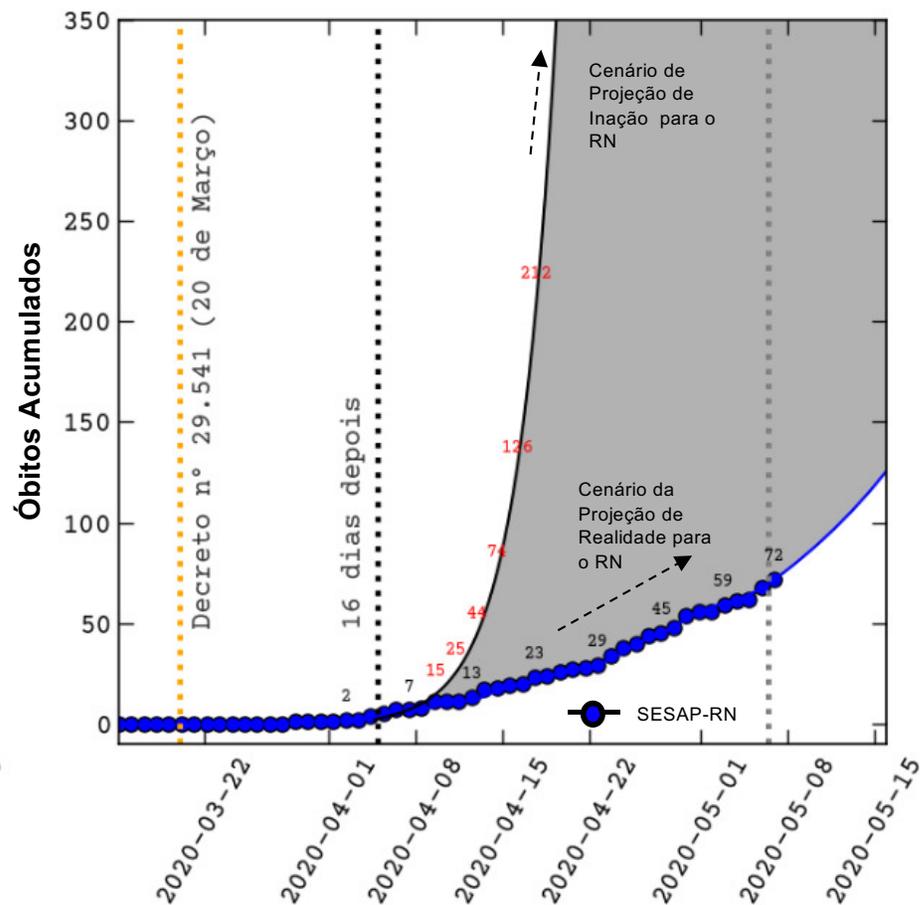
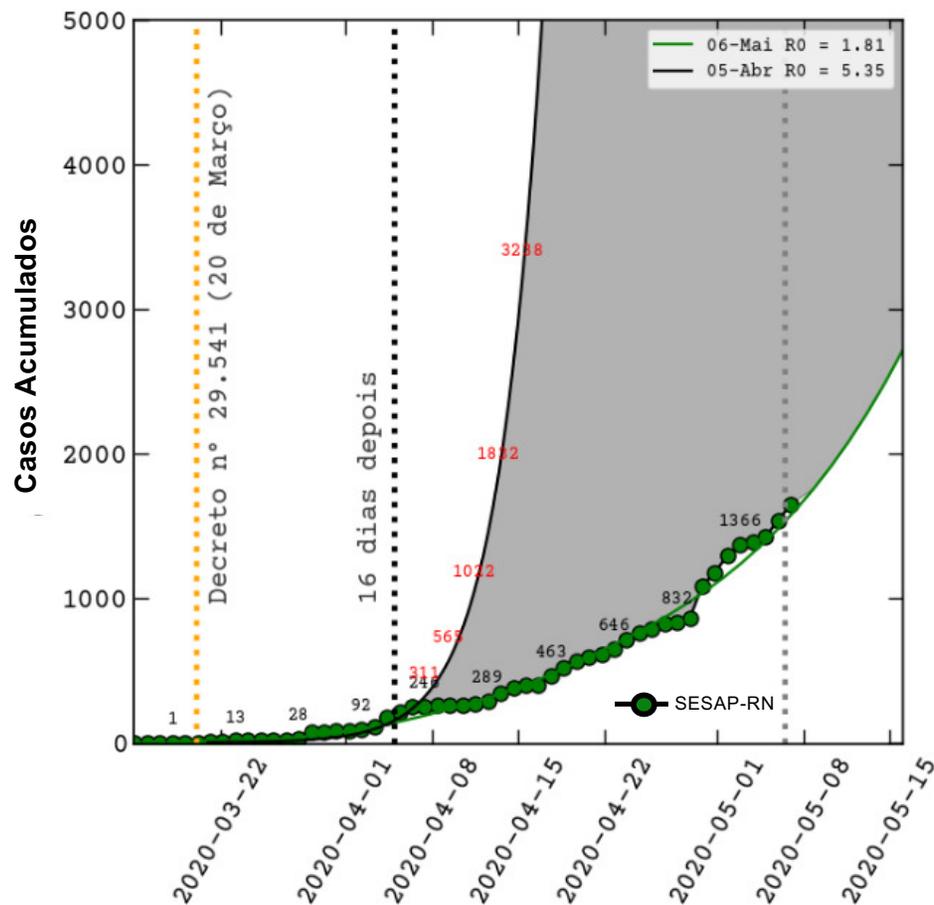


Cenário de Projeção com Inação para o RN

Cenário da Projeção de Realidade para o RN com o Modelo MOSAIC*

*Modelo Epidemic Infectious Disease of Large population Code – MOSAIC (Lyra, do Nascimento et al 2020). Fonte: José Dias do N. (UFRN)

Projeções do modelo MOSAIC* para o estado do Rio Grande do Norte

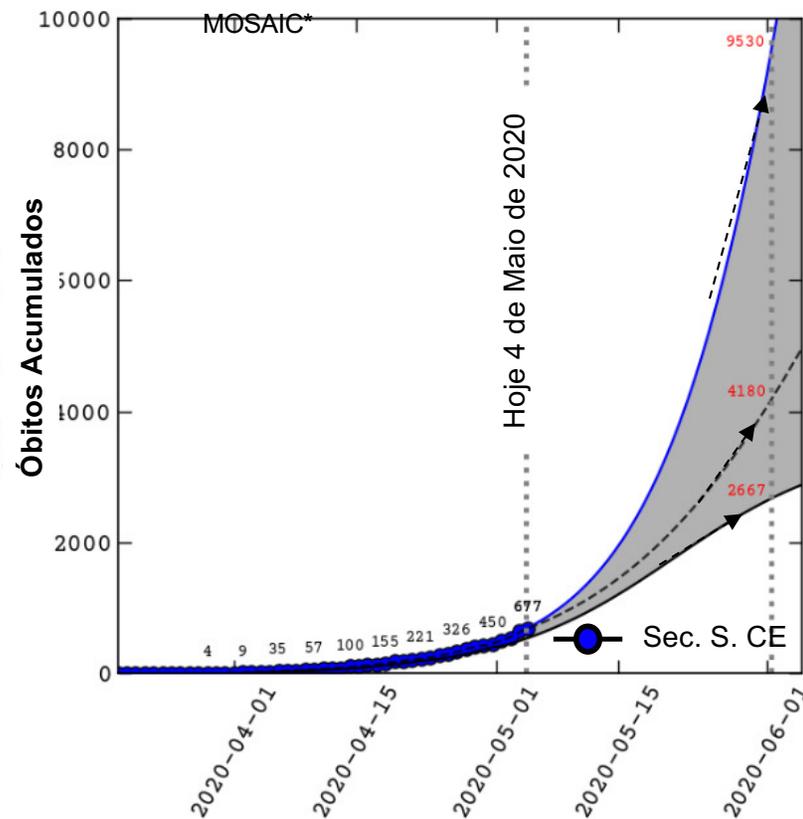
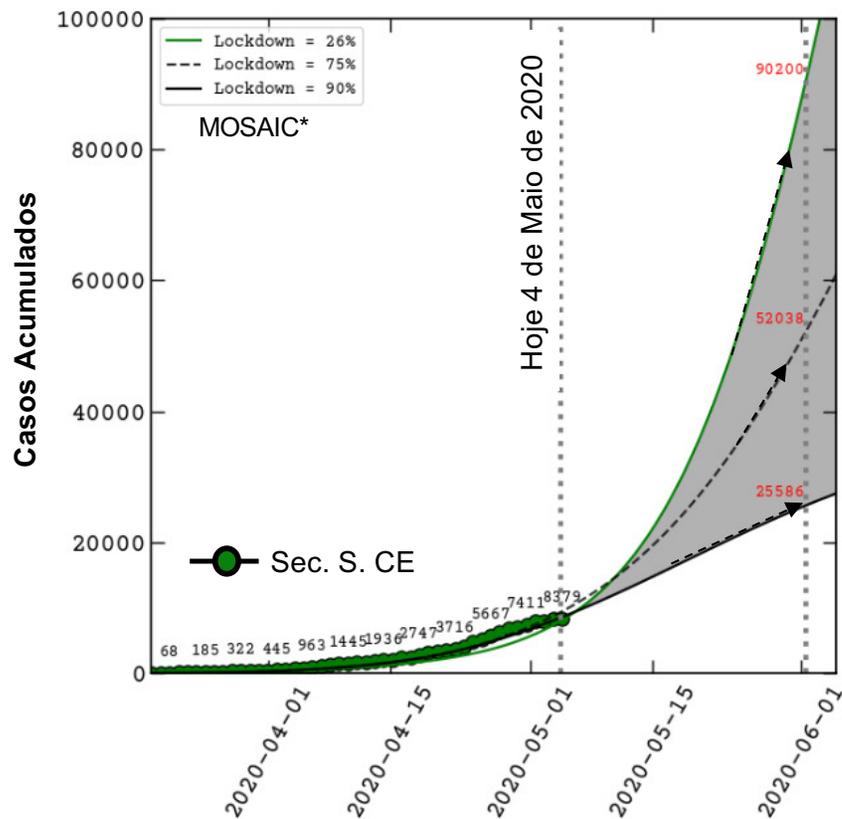


*Modelo Epidemic Infectious Disease of Large population Code – MOSAIC (Lyra, do Nascimento et al 2020). Fonte: José Dias do N. (UFRN)

<https://astro.dfte.ufrn.br/html/Cliente/COVID19.php> & <https://covid.lais.ufrn.br/#projecoes>

06 – 05 - 2020

Projeções do MOSAIC* para a dinâmica COVID-19 no Ceará com Lockdown

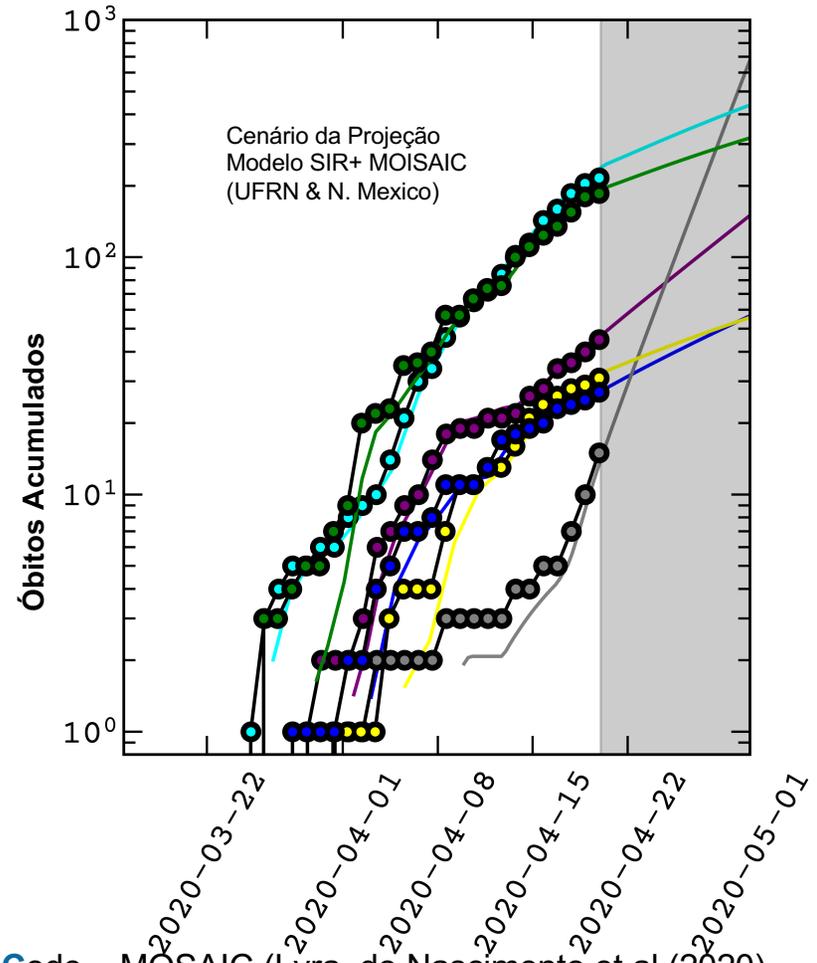
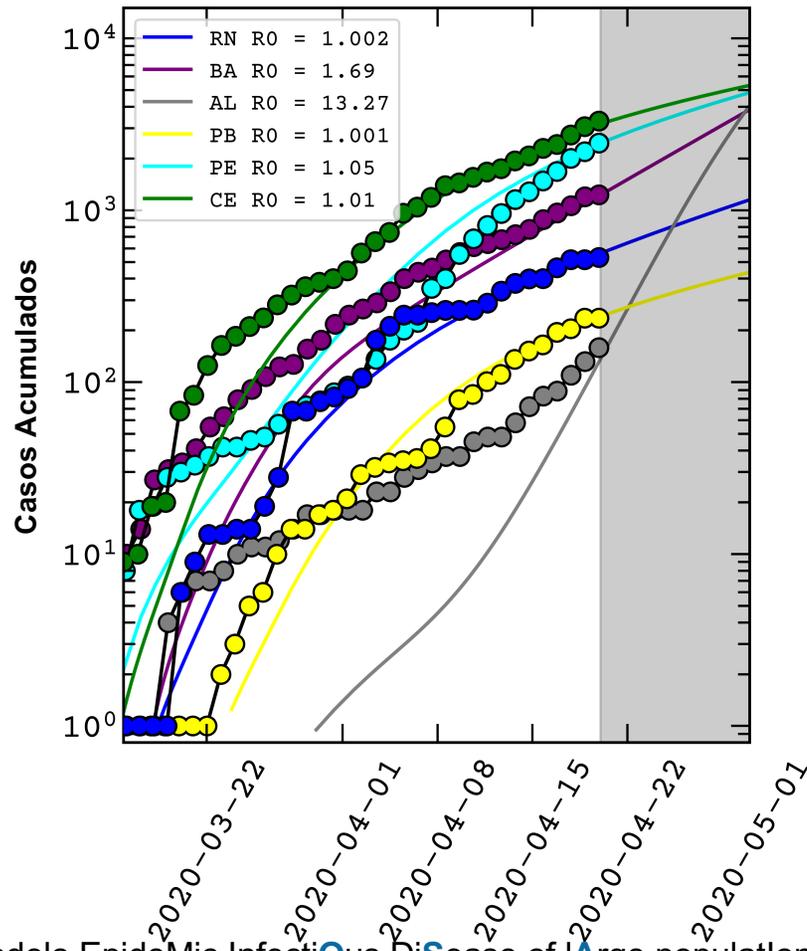


4 modelos para o CE com 26%, 75%, e 90% (Lockdown) de isolamento social.

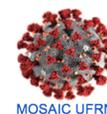
90% (Lockdown)

*Modelo Epidemic Infectious Disease of Large population Code – MOSAIC (Lyra, do Nascimento et al (2020).
 Fonte: José Dias do Nascimento (UFRN)

Projeções do MOSAIC para os Estados do Nordeste

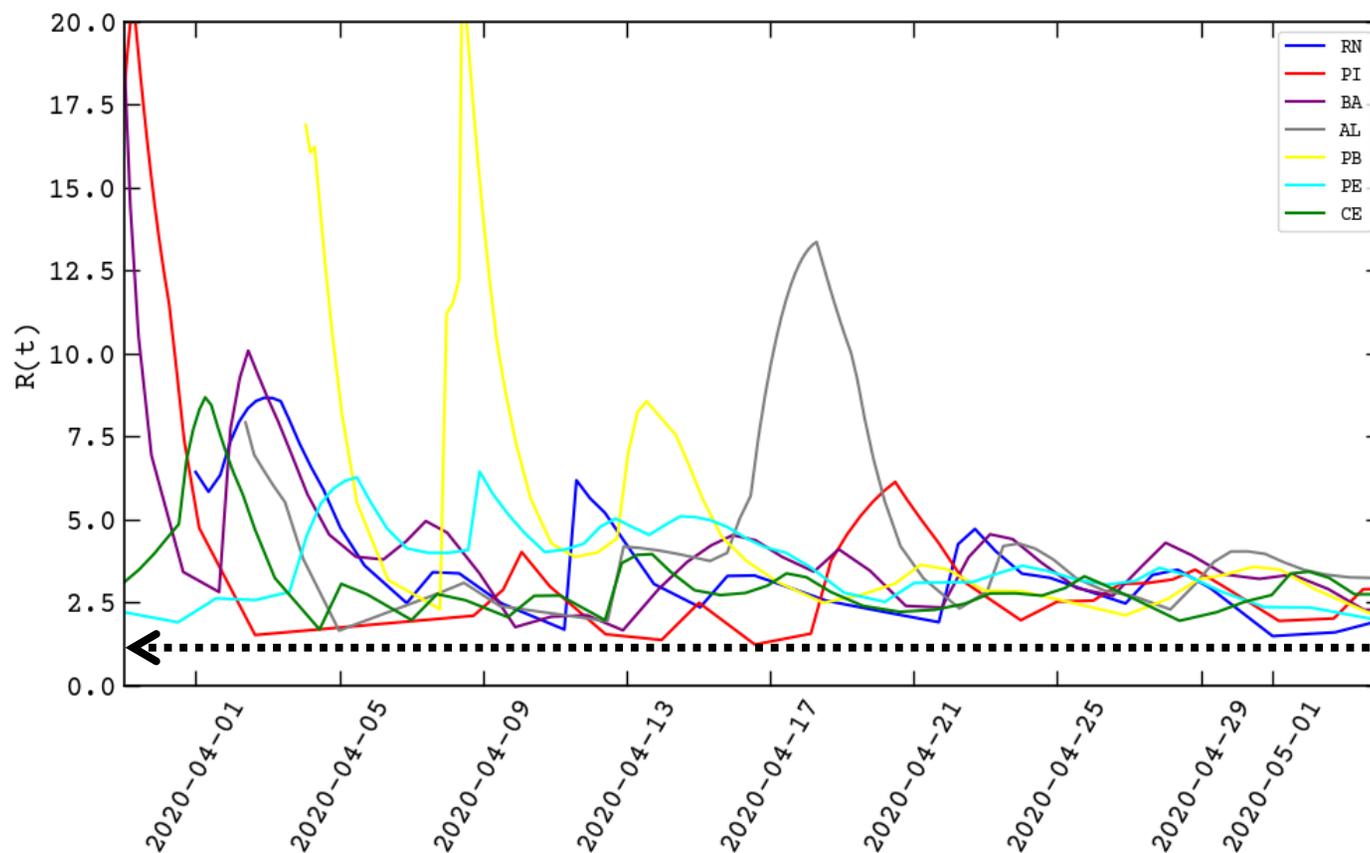


*Modelo Epidemic Infectious Disease of Large population Code – MOSAIC (Lyra, do Nascimento et al (2020).
 Fonte: Prof. José Dias do Nascimento Jr. (UFRN)



Evolução do R0 com MOSAIC para os Estados do Nordeste

Risco de transmissibilidade(Rt)

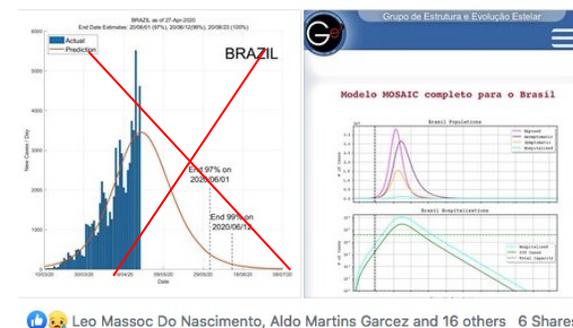
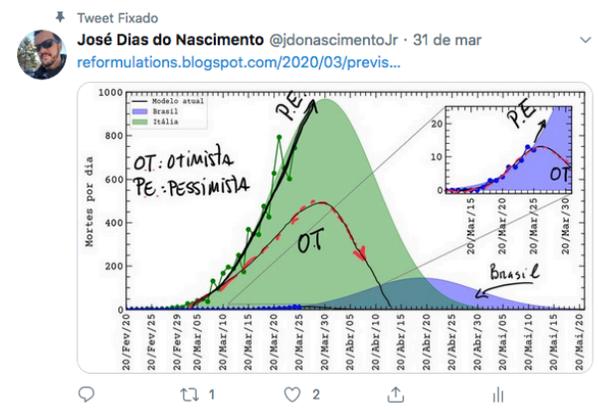
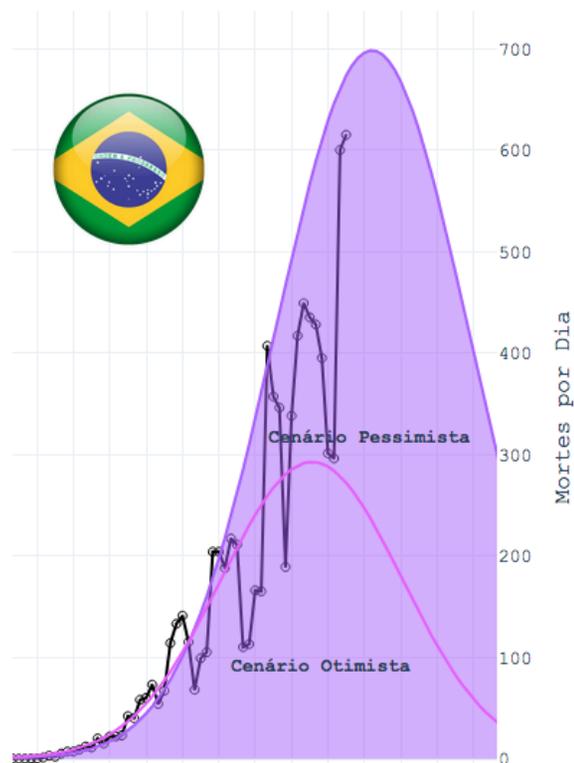
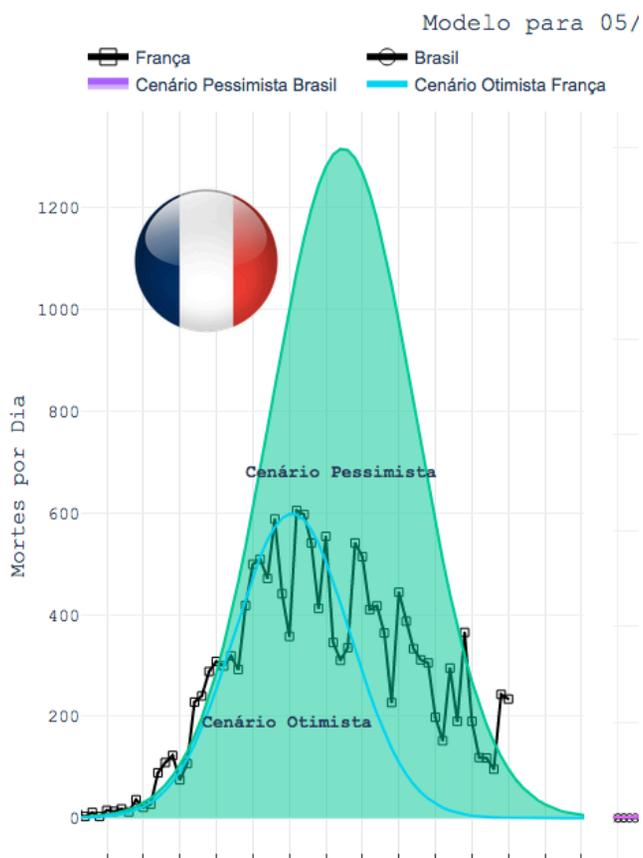


Risco code transmissibilidade(Rt) do MOSAIC representado na Figura é o número de reprodução básica em função do tempo. Como ele é apenas a razão entre a taxa de infecção e a taxa de remoção (dos infectados para a quarentena), representa então diretamente como a taxa de infecção varia no decorrer do tempo. No nosso modelo, essa reprodução básica é lida como a taxa de variação das fatalidades, e pode chegar até zero. Para transformar no R0 e ser a reprodução básica de fato, soma-se 1. Nas figuras que mostramos o R(t) é sempre maior que zero e valores ideais para uma validação da diminuição da epidemia naquela população segundo experiências na China e Itália é um $R(t) < 1$ por pelo menos duas semanas."

Valor Aceitável para Uma possível Reabertura

*Modelo Epidemic Infectious Disease of Large population Code – MOSAIC (Lyra, do Nascimento et al (2020).
Fonte: Prof. José Dias do Nascimento Jr. (UFRN)

[https://twitter.com/: jdonascimentoJr](https://twitter.com/jdonascimentoJr)



<https://covid.lais.ufrn.br/>

*Modelo Epidemic Infectious Disease of Large population Code – MOSAIC (W. Lyra, J.D. do Nascimento et al 2020). Fonte: José Dias (UFRN)

10,91 %

Taxa de Crescimento Hoje no RN

12,25 %

Taxa de Crescimento Ontem no RN

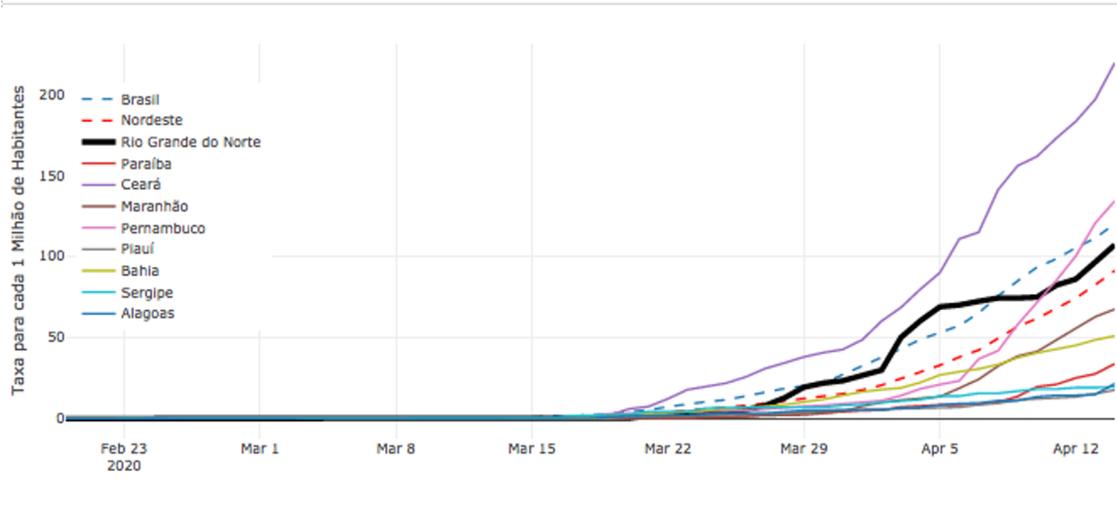
4,50 %

Taxa de Crescimento 3 Dias Atrás no RN

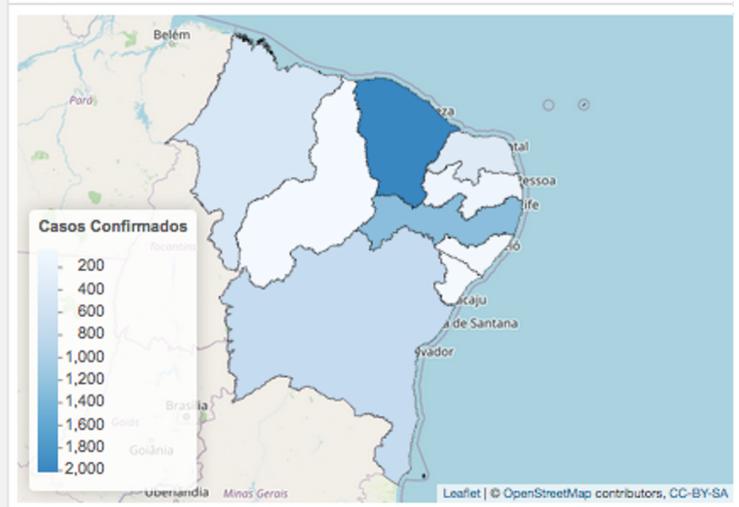
3,25 %

Taxa de Crescimento 1 Semana Atrás no RN

Evolução dos Casos (Brasil e Nordeste)



Situação no Nordeste (Total de Casos Confirmados)



<https://covid.lais.ufrn.br/>

Conclusões e Recomendações

1. Estamos: Simulando confinamento e discriminando grupos (idades). (guardar idosos é muito importante)
2. *A curva epidêmica está pronta para uso em todos os estados do nordeste brasileiro. É uma linha do tempo importante para os governadores e gestores. Entrar em 40, LD? Quando sair da Quarentena? Do LD?*
3. *Lembre-se: modelos são aproximações da realidade, alguns são simples; alguns são úteis. (SBF é um fórum para sondar procedência)*
4. *Tratar as grandes cidades (estados) como populações (útil)*

Obrigado

<https://covid.lais.ufrn.br/>

Obrigado