2021-04-30

Ranking effectiveness of worldwide COVID-19 government interventions



N Haug, L Geyrhofer, A Londei, E Dervic, A Desvars-Larrive, V Loreto, B Pinior, S Thurner, P Klimek

1. N Haug, L Geyrhofer, A Londei, E Dervic, A Desvars-Larrive, V Loreto, B Pinior, S Thurner, P Klimek, *Ranking the effectiveness of worldwide COVID-19 government interventions.* Nature Human Behavior 4 (2020) 1303–1312

2. A Desvars-Larrive, E Dervic, N Haug, T Niederkrotenthaler, J Chen, A Di Natale, J Lasser, D S Gliga, A Roux, A Chakraborty, A Ten, A Dervic, A Pacheco, D Cserjan, D Lederhilger, D Berishaj, E Flores Tames, H Takriti, J Korbel, J Reddish, J Stangl, L Hadziavdic, L Stoeger, L Gooriah, L Geyrhofer, M R Ferreira, R Vierlinger, S Holder, S Alvarez, S Haberfellner, V Ahne, V Reisch, V D P Servedio, X Chen, X M Pocasangre-Orellana, D Garcia, S Thurner,

A structured open dataset of government interventions in response to COVID-19. Scientic Data 7 (2020) 285



What are the NPIs taken in the world?



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Austria

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Austria (AUT)





Name of implemented government measure

- Case identification, contact tracing and related measures
 Environmental measures
- Healthcare and public health capacity
- Resource allocation
- Returning to normal life
- Risk communication
- Social distancing
- Travel restriction

Number of specific implemented government measures per day



Special measures

National Lockdown Cordon sanitaire

Smoothed daily-new confirmed COVID-19 cases per million people (Source: Our World in Data)



Countries

	es - [A]	All Countries	; - [B]	All Coun	tries -	[C] All	Countries	- [D] A	bania	Aust	ria	Belgi	ium	Bosnia	and He	erzeg	jovina	Brazil
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Data structure

SCIENTIFIC DATA

OPEN A structured open dataset of

Check for updates

DATA DESCRIPTOR government interventions in

- Hierarchically coded NPIs divided into
- 8 themes (e.g., social distancing) divided into
- **response to COVID-19** Amélie Desvars-Larrive^{1,2,53}, Elma Dervic^{5,3}, Nils Haug^{5,3}, Thomas Niederkrotenthaler^{2,4}, Jiaying Chen^{5,3}, Anna Di Natale^{2,3}, Jana Lasser^{2,3}, Diana S. Gliga¹⁶, Alexandra Roux^{5,6}, Johannes Sorger², Abhijit Chakraborty^{2,7}, Alexandr Ten⁹, Alija Dervic⁵, Andrea Pacheco¹⁰, Ania Jurczak¹¹, David Cserjan², Diana Lederhilger¹⁶, Dominika Bulska¹², Dorontinë Berishaj¹⁶, Erwin Flores Tames⁶, Francisco S. Álvarez¹³, Huda Takriti², Jan Korbel⁶,^{2,3}, Jenny Reddish^{2,14}, Joanna Grzymała-Moszczyńska¹¹, Johannes Stangl¹⁶, Lamija Hadziavdic¹⁶, Laura Stoeger², Leana Gooriah⁵⁰, Lukas Geyrhofer⁵⁰, Marcia R. Ferreira², Marta Bartoszek¹¹, Rainer Vierlinger⁴⁶, Samantha Holder¹⁶, Simon Haberfellner¹⁶, Verena Ahne², Viktoria Reisch¹⁶, Vito D. P. Servedio², Xiao Chen¹⁶, Xochilt María Pocasangre-Orellana⁵¹³, Zuzanna Garncarek¹¹, David Garcia^{2,3} & Stefan Thurmer^{2,3,15}
- 63 categories (Closure of educational Institutions) divided into
- > 500 subcategories (Closure of kindergardens)



How to measure the effectiveness of NPIs?

- Without vaccines or antiviral medication, non-pharmaceutical interventions (NPIs) are the only option to moderate viral spread
- In the first wave most governments implemented bundles of highly restrictive NPIs under great scientific uncertainty and under rapidly changing epidemiological conditions
- Several trackers started to categorize & document NPIs in numerous countries
- In total, we consider 3 databases with ~50k NPI implementations in >200 countries
- Looking back at March-Mai 2020, what worked? What did not work?



Correlate NPIs across countries with time-dependent effective reproduction number R(t)

with

- 1) Timeseries regression model using LASSO regularization
- 2) Regression model with case-control design
- 3) Random forest
- 4) Transformer deep learning model





- within models (e.g. cross validation, leave-one-out analysis)
- across models by comparison of rankings of significant results
- comparison across 3 different databases (CSH, Oxford, Coronanet)





- Circles are NPI categories
- Size: proportional to effectiveness
- Color: NPI theme (broad classification)
- From bottom to top: epidemic age, time after 30 cases appeared
- Progression from soft NPIs to lockdown
- *The hammer*. bulk of NPIs comes about 10 days after reaching 30 cases



Results first wave



 Most effective: close everything where people meet in smaller groups for extended period of time (offices, schools, restaurants, bars, ...), movement restrictions, increase healthcare capacity

 Also effective: risk communication (toward public & stakeholders), governmental assistance for medically and economically vulnerable populations



Timing does matter!





Regression analysis: population density, GDP, HDI, political stability,...

- Tracing & tracking more effective in high GDP countries with low accountability in governance
- NPIs to increase healthcare capacity (PPE, medical supplies) more effective in countries with high control of corruption, regulatory quality and government effectiveness



Effects of strong lockdowns?

Lockdown defined as a bundle of NPIs including: curfews, individual movement restrictions, closure of public places

In most cases some NPIs were in place before lockdowns were implemented

Typically severe lockdowns added "little delta" on top of measures in place

A suitable combination (including a good sequence and timing of implementation) of a smaller package of NPIs *can* substitute severe lockdowns



Other works



Second wave





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Understanding the effectiveness of government interventions in Europe's second wave of COVID-19

Mrinank Sharma^{*,1,2,3}, Sören Mindermann^{*,4}, Charlie Rogers-Smith⁵, Gavin Leech⁶, Benedict Snodin³, Janvi Ahuja^{7,3}, Jonas B. Sandbrink⁷, Joshua Teperowski Monrad^{8,9,3}, George Altman¹⁰, Gurpreet Dhaliwal^{11,12}, Lukas Finnveden³, Alexander John Norman¹³, Sebastian B. Oehm^{14,15}, Julia Fabienne Sandkühler¹⁶, Thomas Mellan¹⁷, Jan Kulveit³, Leonid Chindelevitch¹⁷, Seth Flaxman¹⁸, Yarin Gal⁴, Swapnil Mishra^{+,17,19}, Jan Markus Brauner^{*,+,04,3}, Samir Bhatt^{+,02,017,19}

*Equal contribution to first authorship +Equal contribution to senior authorship [®]Correspondence: <u>jan.brauner@cs.ox.ac.uk</u>, <u>s.bhatt@imperial.ac.uk</u>

50

20

Reduction in R (%)

30

40



Second wave

B)

-10



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COMPLEXITY SCIENCE HUB VIENNA

Schools

- Deeper analyses (finer catgories) school closures effective for ages12y–18y
- Effects in kindergartens and primary schools are visible but statistically less robust
- Findings in line with contact tracing data: the lowest attack rates in age group <10y



Agent-based model of infections in schools with NPIs



Fig. 5. Agents in the epidemiological model can be in the states (circles) susceptible (S), exposed (E), infectious (I), infectious without symptoms (II), infectious with symptoms (II), infectious with any term in the symptome states, agents can also be quarantined (X), preventing them from interacting with other agents. Transitions between states follow the development of the viral last in the host.





How to sustainably open schools?







It is possible to disentangle effectiveness of individual NPIs

• Significant effectiveness

Small groups and gatherings Gastronomy Education (if school closures necessary – should target age groups 12+)

• Minor

Curfews Culture More strict mask policies





WHO database

Conference on NPI assessments

Wider public attention

Altmetric paper # 36 in 2020

