Behavioral changes before lockdown and decreased retail and recreation mobility during lockdown contributed most to controlling COVID-19 in Western countries

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Abstract

Background

The COVID-19 pandemic has prompted a lockdown in many countries to control the exponential spread of the SARS-CoV-2 virus, hereby reducing the time-varying basic reproduction number (R_t) to below one. Governments are looking for evidence to balance the demand of their citizens to ease some of the restriction, against the fear of a second peak in infections. More details on the specific circumstances that promote exponential spread (i.e. $R_t > 1$) are needed.

Methods

Incidence data of cases and deaths from the first wave of infections for 35 Western countries (32 European, plus Israel, USA and Canada) were analyzed using epidemiological compartment models in a Bayesian framework. Mobility data was used to estimate the timing of changes associated with a lockdown, and was correlated with estimated reductions of R_t .

Results

Across all countries, the initial median estimate for R_t was 3.6 (95% IQR 2.4 – 5.2), and it was reduced to 0.78 (95% IQR 0.58 – 1.01) during lockdown. 48% (18% – 65%) of the reduction occurred already in the week before lockdown, with lockdown itself causing the remaining drop in transmission. A lower R_t during lockdown was independently associated with an increased time spent at home (0.21 per 10% more time, $p < 0.007$), and decreased mobility related to retail and recreation (0.07 per 10% less mobility, $p < 0.008$).

Conclusions

In a Western population unaware of the risk, SARS-CoV-2 can be highly contagious with a reproduction number $R_0 > 5$. Our results are consistent with evidence that recreational activities (including restaurant and bar visits) enable super-spreading events. Exiting from lockdown therefore requires continued physical distancing and tight control on this kind of activities.

Full Text

This preprint is available for download as a PDF.

Figures

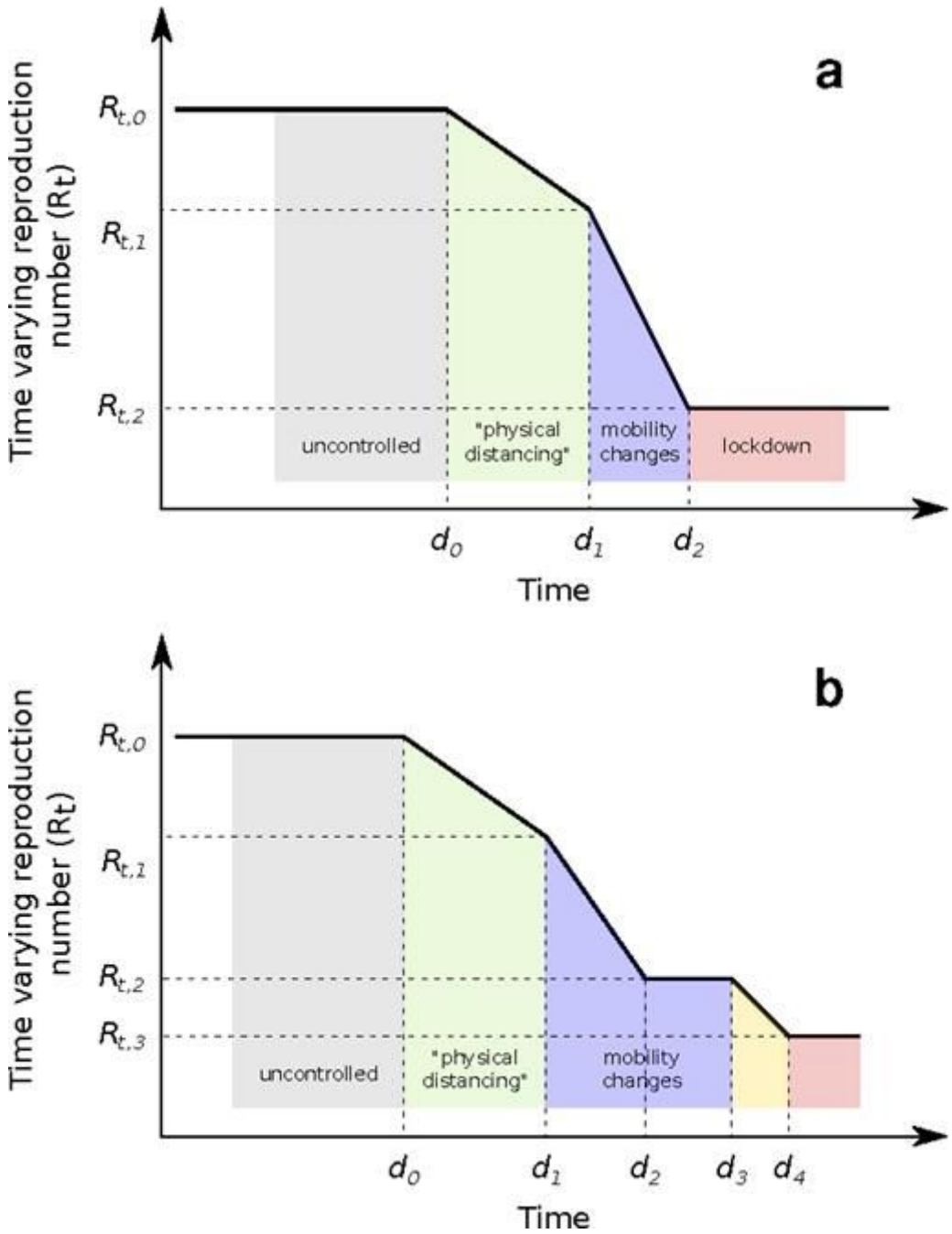

Figure 1

Model for changes of the time-varying reproduction number Rt as a piece-wise linear function. Dates d1 and d2 were estimated from mobility data. Date d0 and values for Rt,0 – Rt,2 were estimated from incidence data on diagnosed cases and deaths. a. model-2 used for all countries; b. model-3p additionally used for Slovakia, which allowed an extra change during lockdown with dates d0, d3 and d4, and values for Rt,0 – Rt,3 estimated from incidence data on diagnosed cases and deaths.

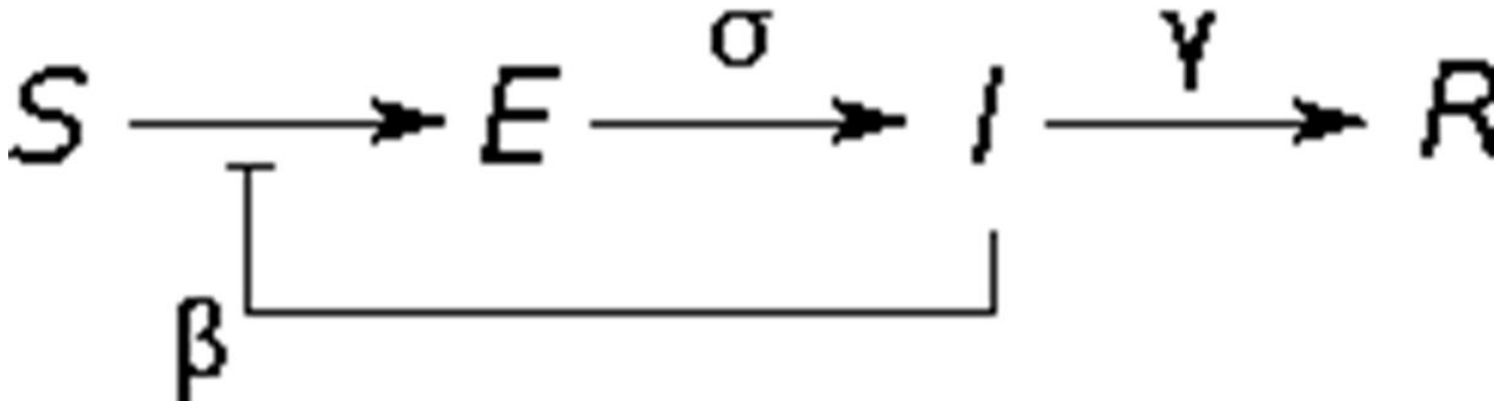

Figure 2

Structure of a standard SEIR compartment model with four compartments: susceptible (S), exposed (E), infectious (I), and removed (recovered or deceased, R). Susceptible individuals become latently infected by infectious individuals, with transmission rate β. Latently infected become infectious at rate σ. Infectious people are removed at rate γ.

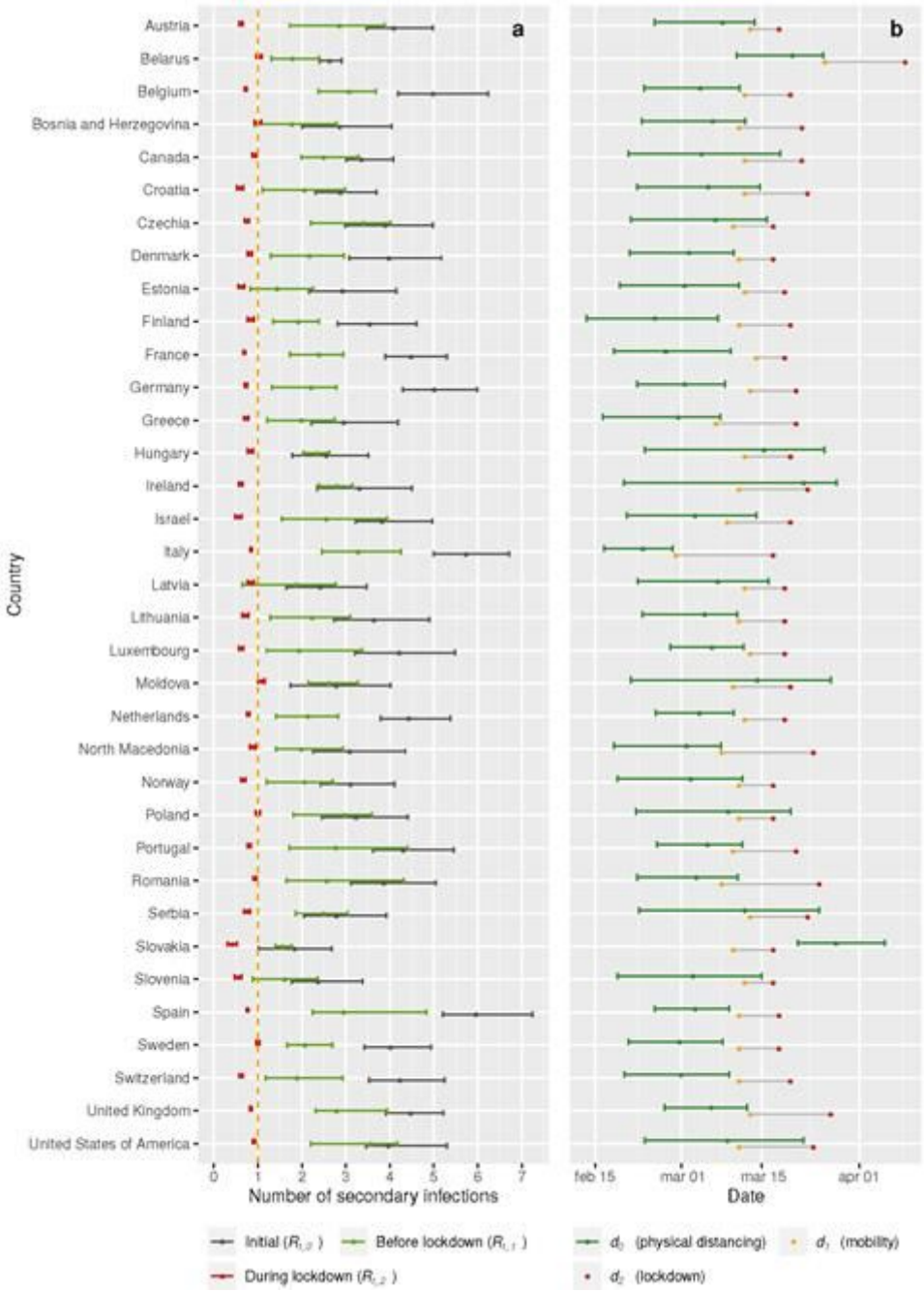

Figure 3

a. Posterior estimates of the initial basic reproduction numbers (Rt,0), the reproduction number at start of lockdown (Rt,1) and during lockdown (Rt,2). b. Estimated median values (95% IQR) for d0 (date of first reduction in transmission, presumably due to physical distancing, estimated from incidence data of deaths and diagnosed cases); and lockdown transition start and end dates d1 and d2, estimated from mobility data (see also Suppl 1).

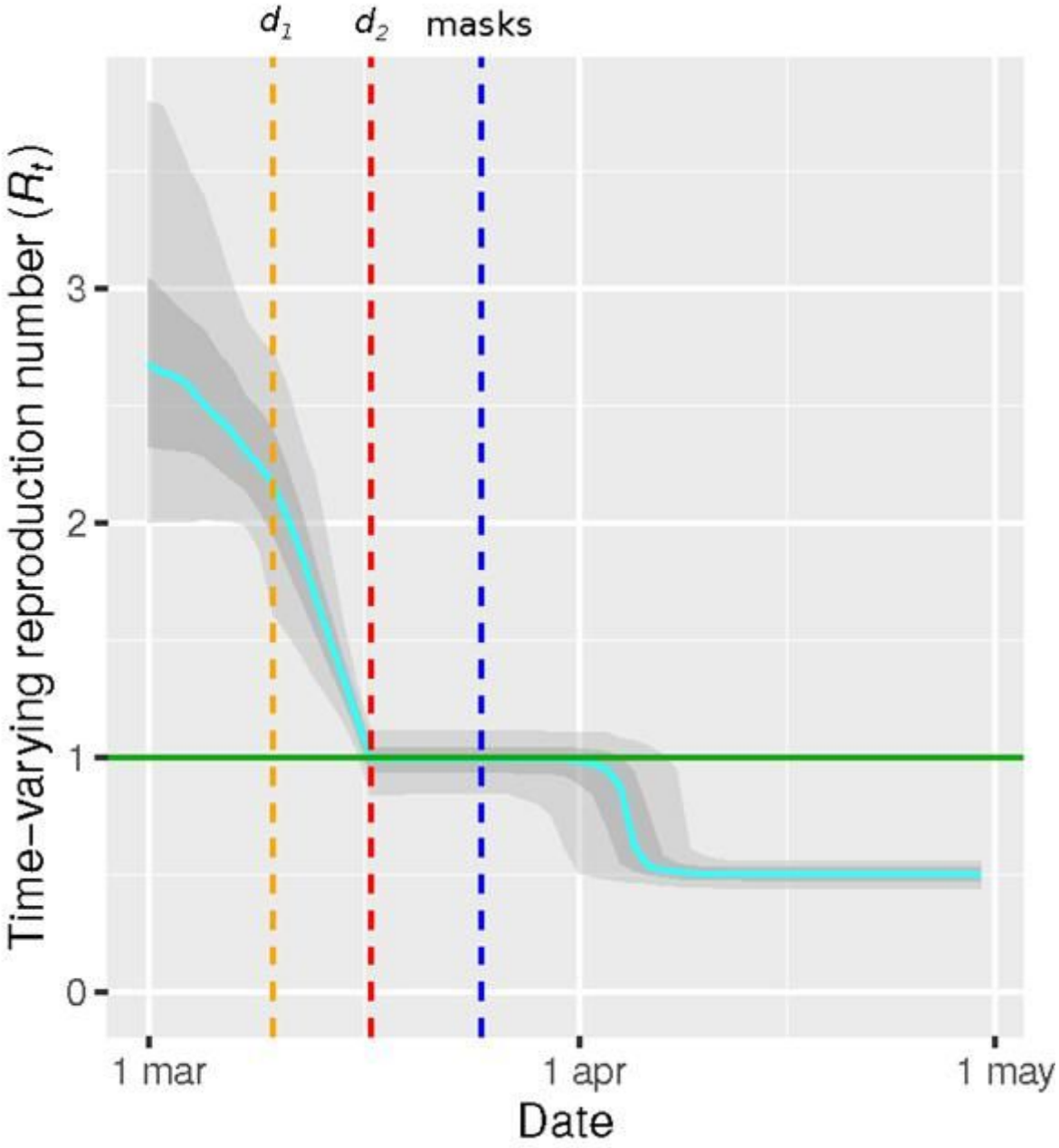

Figure 4

Estimated time-varying basic reproduction number Rt for Slovakia using a model that allowed an additional reduction of transmission rate at a co-estimated date during lockdown. The orange and red lines mark d1 and d2 as estimated from google mobility data. For reference, the date at which mandatory mask wearing was introduced (25 March) is indicated in blue.

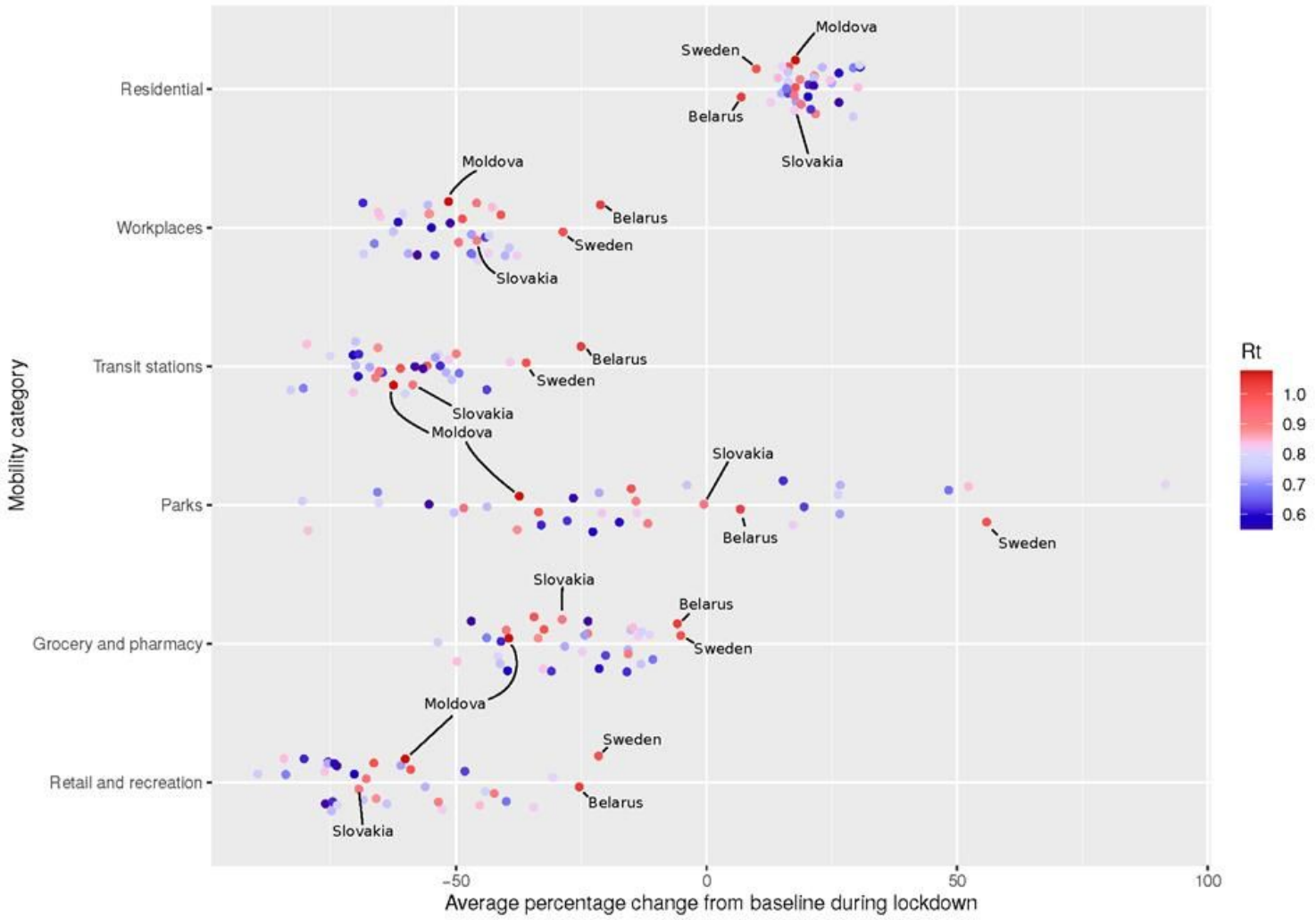

Figure 5

Average percentage change in mobility, compared to baseline, for six location Google mobility categories. Color reflects basic reproduction number Rt during lockdown. Retail and Recreation: restaurants, cafes, shopping centers, theme parks, museums, libraries, and movie theaters; Grocery and Pharmacy: grocery markets, food warehouses, farmers markets, specialty food shops, drug stores, and pharmacies; Parks: local parks, national parks, public beaches, marinas, dog parks, plazas, and public gardens; Transit Stations: public transport hubs such as subway, bus, and train stations; Workplaces: places of work; Residential: places of residence.

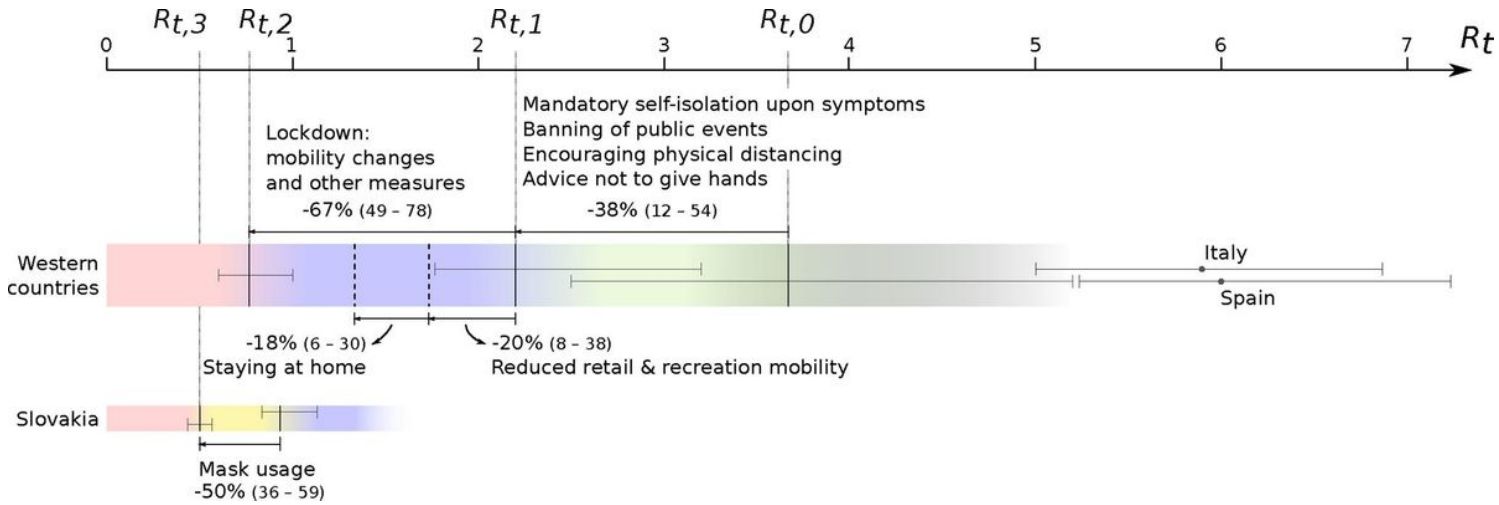

Figure 6

Summary of estimated contributions to the reduction of transmission in 35 Western countries. Initial basic reproduction numbers (Rt,0), the reproduction number at start of lockdown (Rt,1) and during lockdown (Rt,2), and percentage reductions are shown as median values and 95% IQR. Estimates for individual countries (Italy, Spain and Slovakia) are shown as median posterior value and 95% cri.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- suppl4.pdf
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- suppl2.pdf
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