THE LANCET
Infectious Diseases

Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

Supplement to: Li Y, Campbell H, Kulkarni D, et al. The temporal association of introducing and lifting non-pharmaceutical interventions with the time-varying reproduction number (*R*) of SARS-CoV-2: a modelling study across 131 countries. *Lancet Infect Dis* 2020; published online Oct 22. https://doi.org/10.1016/S1473-3099(20)30785-4.

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Table S1. List of countries included in the analysis

Country	Start Date	End Date
Afghanistan	16/03/2020	20/07/2020
Albania	13/03/2020	20/07/2020
Algeria	05/03/2020	20/07/2020
Andorra	17/03/2020	09/06/2020
Angola	19/04/2020	20/07/2020
Argentina	07/03/2020	20/07/2020
Australia	04/03/2020	20/07/2020
Austria	04/03/2020	20/07/2020
Azerbaijan	15/03/2020	20/07/2020
Bahrain	26/02/2020	20/07/2020
Bangladesh	21/03/2020	20/07/2020
Belarus	13/03/2020	20/07/2020
Belgium	02/03/2020	20/07/2020
Benin	02/04/2020	14/07/2020
Bolivia	14/03/2020	20/07/2020
Bosnia and Herzegovina	16/03/2020	20/07/2020
Botswana	10/04/2020	20/07/2020
Brazil	06/03/2020	20/07/2020
Bulgaria	13/03/2020	20/07/2020
Cameroon	18/03/2020	20/07/2020
Canada	06/03/2020	20/07/2020
Cape Verde	16/04/2020	20/07/2020
Central African Republic	28/04/2020	14/07/2020
Chad	14/04/2020	26/06/2020
Chile	09/03/2020	20/07/2020
China	01/01/2020	11/07/2020
Colombia	12/03/2020	20/07/2020
Congo	29/03/2020	18/07/2020
Costa Rica	12/03/2020	20/07/2020
Cote dIvoire	21/03/2020	20/07/2020
Croatia	13/03/2020	19/07/2020
Cuba	20/03/2020	26/06/2020
Czechia	07/03/2020	20/07/2020
Democratic Republic of the Congo	19/03/2020	20/07/2020
Denmark	06/03/2020	20/07/2020
Djibouti	26/03/2020	26/06/2020
Dominican Republic	14/03/2020	20/07/2020
Ecuador	02/03/2020	20/07/2020
Egypt	07/03/2020	20/07/2020
El Salvador	29/03/2020	20/07/2020
Estonia	07/03/2020	25/06/2020
Ethiopia	31/03/2020	20/07/2020
Finland	06/03/2020	26/06/2020
France	08/02/2020	11/07/2020
Gabon	01/04/2020	20/07/2020
Gambia	12/04/2020	18/07/2020
Germany	28/02/2020	20/07/2020
Ghana	21/03/2020	20/07/2020
Greece	06/03/2020	20/07/2020
Guatemala	17/03/2020	20/07/2020

Country	Start Date	End Date
Guinea	31/03/2020	20/07/2020
Haiti	30/03/2020	20/07/2020
Hungary	14/03/2020	25/06/2020
Iceland	04/03/2020	26/06/2020
India	05/03/2020	20/07/2020
Indonesia	11/03/2020	20/07/2020
Iran	22/02/2020	20/07/2020
Iraq	01/03/2020	20/07/2020
Ireland	06/03/2020	26/06/2020
Israel	05/03/2020	20/07/2020
Italy	22/02/2020	20/07/2020
Japan	05/02/2020	11/07/2020
Kazakhstan	15/03/2020	20/07/2020
Kenya	23/03/2020	20/07/2020
Kosovo	16/03/2020	20/07/2020
Kuwait	26/02/2020	20/07/2020
Kyrgyzstan	22/03/2020	14/07/2020
Latvia	13/03/2020	26/06/2020
Lebanon	02/03/2020	11/07/2020
Lesotho	24/06/2020	20/07/2020
Libya	30/03/2020	11/07/2020
Lithuania	16/03/2020	26/06/2020
Luxembourg	13/03/2020	11/07/2020
Madagascar	24/03/2020	11/07/2020
Malaysia	04/03/2020	25/06/2020
Mali	29/03/2020	26/06/2020
Mauritania	15/05/2020	11/07/2020
Mexico	13/03/2020	11/07/2020
Moldova	15/03/2020	11/07/2020
Mongolia	15/04/2020	19/06/2020
Morocco	15/03/2020	11/07/2020
Mozambique	09/04/2020	11/07/2020
Namibia	20/06/2020	11/07/2020
Netherlands	01/03/2020	11/07/2020
New Zealand	18/03/2020	25/06/2020
Niger	25/03/2020	26/06/2020
Nigeria	19/03/2020	11/07/2020
Norway	01/03/2020	23/06/2020
Oman	05/03/2020	11/07/2020
Pakistan	10/03/2020	11/07/2020
Palestine	06/03/2020	11/07/2020
Panama	11/03/2020	11/07/2020
Paraguay	21/03/2020	11/07/2020
Peru	09/03/2020	11/07/2020
Philippines	10/03/2020	11/07/2020
Poland	09/03/2020	11/07/2020
Portugal	08/03/2020	11/07/2020
Puerto Rico	28/03/2020	11/07/2020
Qatar	04/03/2020	11/07/2020
Romania	08/03/2020	11/07/2020
Russia	07/03/2020	11/07/2020
Rwanda	21/03/2020	11/07/2020

Country	Start Date	End Date
Saudi Arabia	11/03/2020	11/07/2020
Senegal	14/03/2020	11/07/2020
Serbia	12/03/2020	11/07/2020
Sierra Leone	18/04/2020	26/06/2020
Singapore	05/02/2020	11/07/2020
Slovakia	13/03/2020	26/06/2020
South Africa	12/03/2020	11/07/2020
South Korea	01/02/2020	11/07/2020
South Sudan	29/04/2020	23/06/2020
Spain	26/02/2020	10/07/2020
Sri Lanka	15/03/2020	26/06/2020
Sudan	14/04/2020	11/07/2020
Suriname	01/06/2020	11/07/2020
Sweden	28/02/2020	11/07/2020
Switzerland	28/02/2020	11/07/2020
Tajikistan	01/05/2020	11/07/2020
Thailand	28/01/2020	26/06/2020
Tunisia	13/03/2020	26/06/2020
Turkey	16/03/2020	11/07/2020
Uganda	24/03/2020	26/06/2020
Ukraine	18/03/2020	11/07/2020
United Arab Emirates	28/02/2020	11/07/2020
United Kingdom	01/03/2020	11/07/2020
United States of America	22/02/2020	11/07/2020
Uzbekistan	16/03/2020	11/07/2020
Venezuela	15/03/2020	11/07/2020
Yemen	30/04/2020	26/06/2020
Zambia	26/03/2020	11/07/2020
Zimbabwe	16/04/2020	11/07/2020

Table S2. Details on NPI variables included in the analysis

NPI variable	Levels in the original OxCGRT dataset	Levels re-coded in the present study
School closing	0 – No measures	0 – Not ordered
	1 – recommend closing	0 – Not ordered
	2 – Require closing (only some levels or categories, eg just high school, or just public schools)	1 – Ordered
	3 – Require closing all levels	1 – Ordered
Workplace closing	0 - No measures	0 – Not ordered
	1 - recommend closing (or work from home)	0 – Not ordered
	2 - require closing (or work from home) for some sectors or categories of workers	1 – Ordered
	3 - require closing (or work from home) all-but-essential workplaces (e.g. grocery stores, doctors)	1 – Ordered
Public events ban	0 – No measures	0 – Not ordered
	1 – Recommend cancelling	1 – Ordered
	2 - Require cancelling	1 – Ordered
Restrictions on gatherings	0 - No restrictions	0 – Not ordered
	1 - Restrictions on very large gatherings (the limit is above 1000 people)	0 – Ordered but no restrictions on small (≤10) gatherings
	2 - Restrictions on gatherings between 101-1000 people	0 – Ordered but no restrictions on small (≤10) gatherings
	3 - Restrictions on gatherings between 11-100 people	0 – Ordered but no restrictions on small (≤10) gatherings*
	4 - Restrictions on gatherings of 10 people or less	1 – Ordered with restrictions on small (≤10) gatherings
Public transport closing	0 - No measures	0 – Not ordered
	1 - Recommend closing (or significantly reduce volume/route/means of transport available)	0 – Not ordered
	2 - Require closing (or prohibit most citizens from using it)	1 – Ordered
Stay at home orders	0 - No measures	0 – Not ordered
	1 - recommend not leaving house	0 – Not ordered
	2 - require not leaving house with exceptions for daily exercise, grocery shopping, and 'essential' trips	1 – Ordered
	3 - Require not leaving house with minimal exceptions (e.g. allowed to leave only once a week, or only one person can leave at a time, etc.)	1 – Ordered
Restrictions on internal movement	0 - No measures	0 – Not ordered
	1 - Recommend not to travel between regions/cities	0 – Not ordered

NPI variable	Levels in the original OxCGRT dataset	Levels re-coded in the present study
	2 – internal movement restrictions in place	1 – Ordered
International travel controls	0 - No measures	0 – Not ordered
	1 - Screening	0 – Not ordered
	2 - Quarantine arrivals from high-risk regions	1 – Ordered
	3 - Ban on arrivals from some regions	1 – Ordered

*This is coded as 1 in the sensitivity analysis that used gathering size of 100 as the cutoff.

Text S1. Details of the additional analysis using Google mobility data

Google mobility data were extracted from https://ourworldindata.org/covid-mobility-trends, which was compiled based on Google COVID-19 Mobility Reports (https://www.google.com/covid19/mobility/). These data were aggregated from mobile device location information covering the period between 3rd January 2020 and 20th July 2020. Mobility data of six categories were available: visits to workplace, visits to retail and recreation places, visits to grocery and pharmacy stores, visits to public transit stations, visits to parks and outdoor spaces, and total time of staying at residential areas.

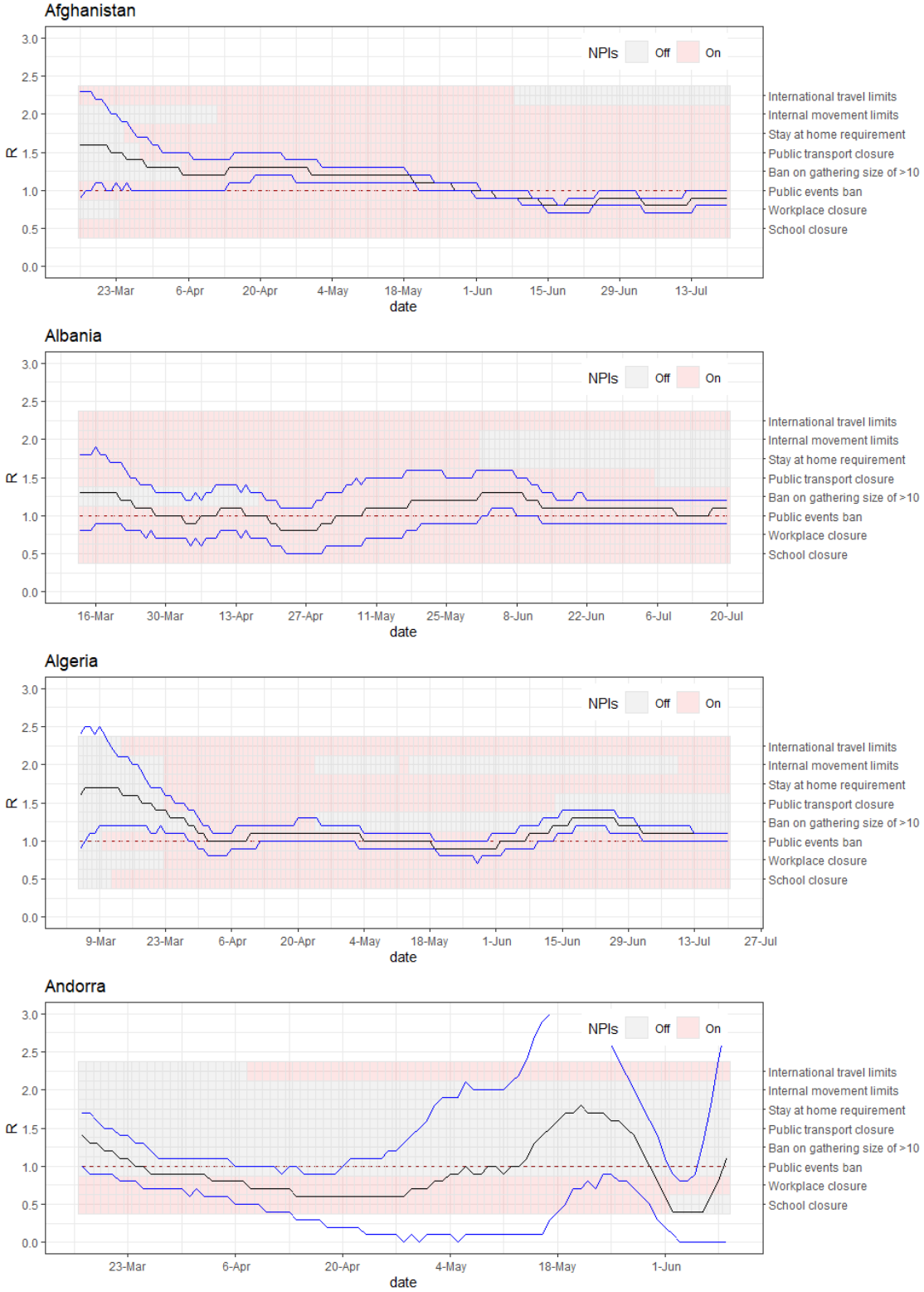
We selected visits to workplace and total time of staying at residential areas as the outcomes for the analysis as the two outcomes are most relevant to workplace closure and requirement to stay at home, respectively. We included a total of 101 countries in this analysis that had available data of both NPIs (from OxCGRT) and mobility: Afghanistan, Angola, Argentina, Australia, Austria, Bahrain, Bangladesh, Belarus, Belgium, Benin, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Cameroon, Canada, Cape, Verde, Chile, Colombia, Costa Rica, Croatia, Czechia, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Finland, France, Gabon, Germany, Ghana, Greece, Guatemala, Haiti, Hungary, India, Indonesia, Ireland, Israel, Italy, Japan, Kenya, Kuwait, Kyrgyzstan, Latvia, Lebanon, Libya, Lithuania, Luxembourg, Malaysia, Mali, Mexico, Moldova, Mongolia, Morocco, Mozambique, Namibia, Netherlands, New Zealand, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Puerto Rico, Qatar, Romania, Russia, Rwanda, Saudi Arabia, Senegal, Serbia, Singapore, Slovakia, South Africa, South Korea, Spain, Sri Lanka, Sweden, Switzerland, Tajikistan, Thailand, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Venezuela, Yemen, Zambia, and Zimbabwe. We used the same log-linear regression model as the main analysis, for each of the two outcomes:

$$\log(Y^t) = \beta_0^t + \beta_1^t X_1^t + \beta_2^t X_2^t + \cdots + \beta_{16}^t X_{16}^t + \beta_{17}^t Z_1^t + \beta_{18}^t Z_2^t$$

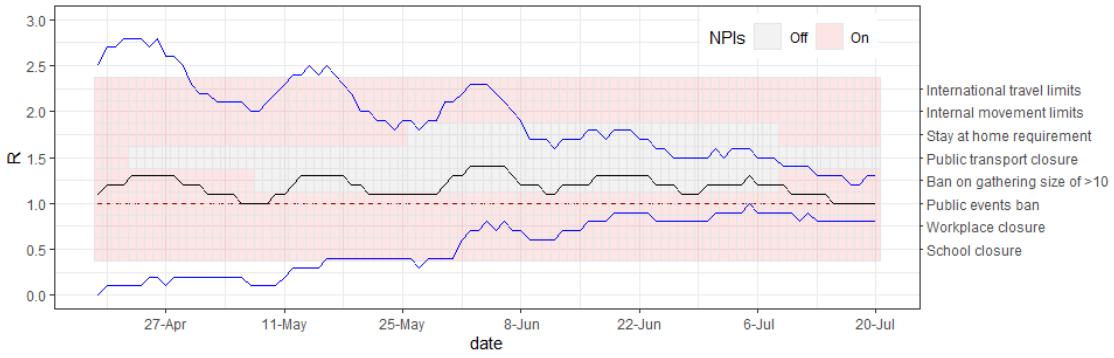
where Y^t represents the ratio of total visits to workplace or total time of staying at residential areas on Day t ($t = 1, 2, \ldots, 28$), over Day *0*; X_1^t to X_{16}^t are binary indicators of whether each of the eight NPIs are introduced and lifted, respectively; Z_1^t and Z_2^t are binary indicators of whether multiple NPIs are introduced and lifted simultaneously, respectively. Hence, β_0^t represents the baseline change in mobility on Day t in the absence of changes in NPI status; β_1^t to β_{16}^t represent the individual effects of introducing and lifting NPIs on Day t; β_{17}^t and β_{18}^t represent the interaction between introducing and lifting multiple NPIs are introduced and lifted simultaneously, respectively.

We reported the effect over time of introducing and lifting workplace closure on the total visits of workplace and the effect over time of introducing and lifting requirement to stay at home on the total time of staying at residential areas. We compared the immediacy of introducing and lifting these two NPIs between using R and using mobility data; immediacy was measured by the time length in days needed to observe 60% of the maximum change in the outcome measures for the first 28 days following introducing/lifting an NPI.

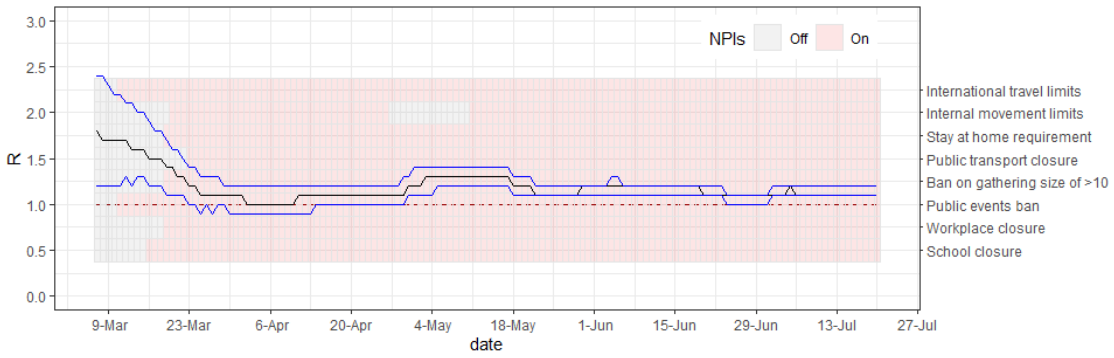
Figure S1. Description of change in R and NPIs over time by country



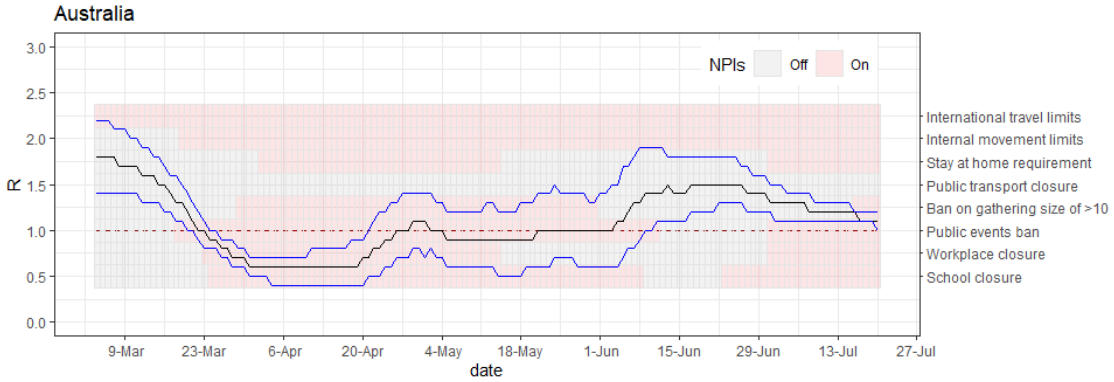
Angola



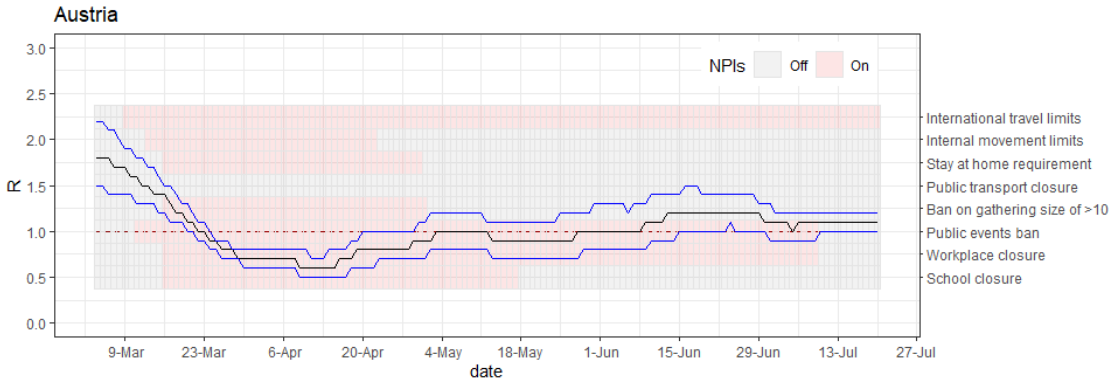
Argentina



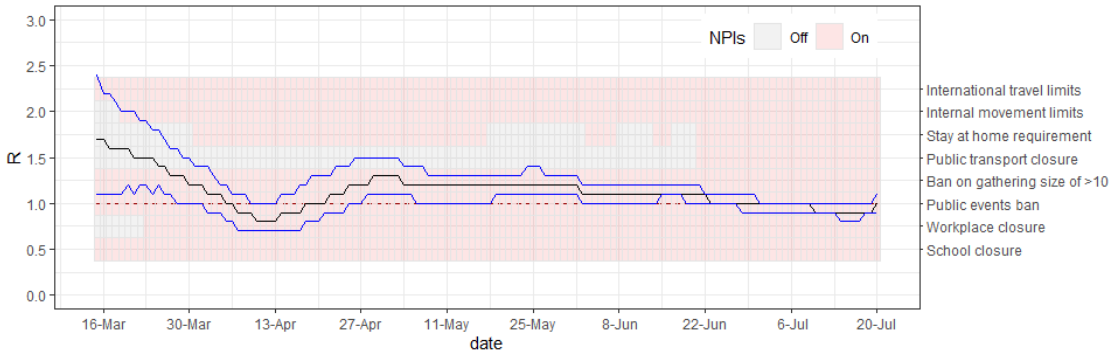
Australia



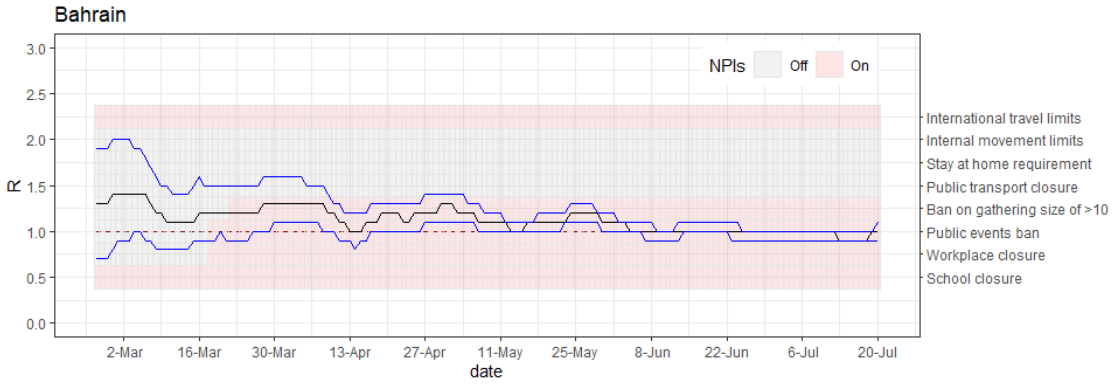
Austria



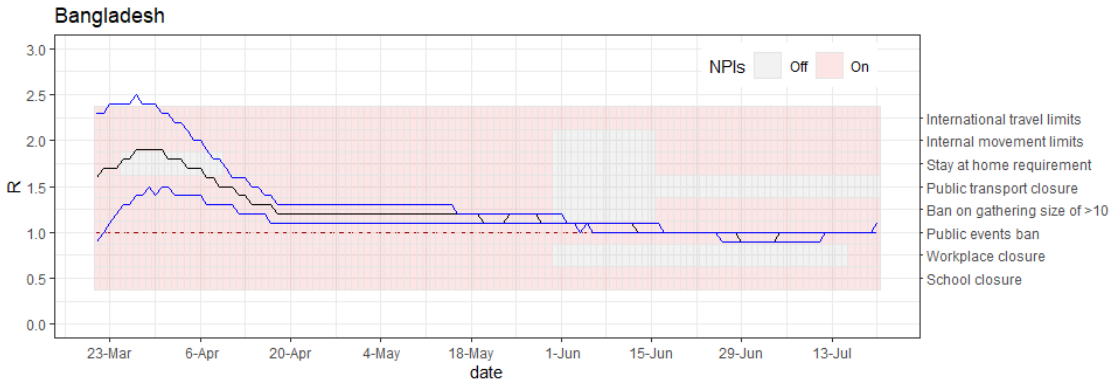
Azerbaijan



Bahrain



Bangladesh



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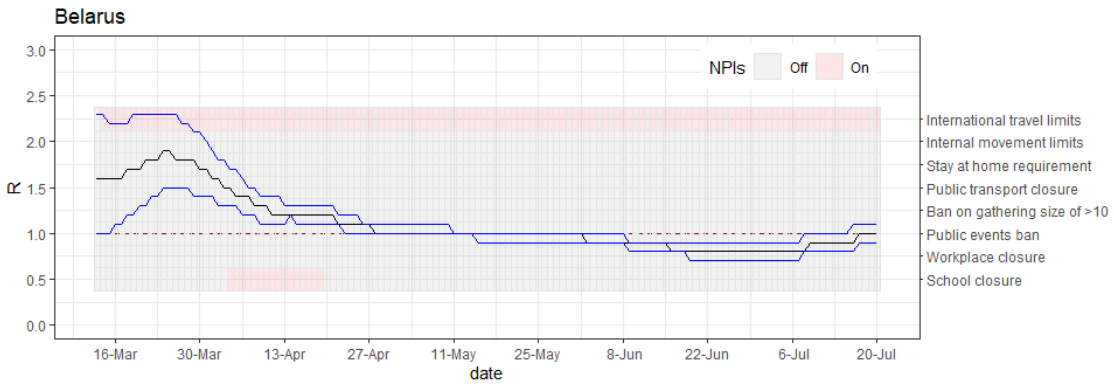
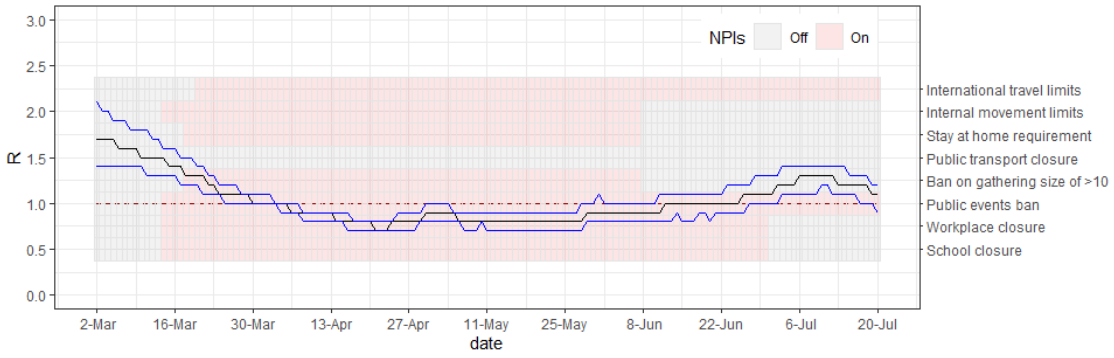
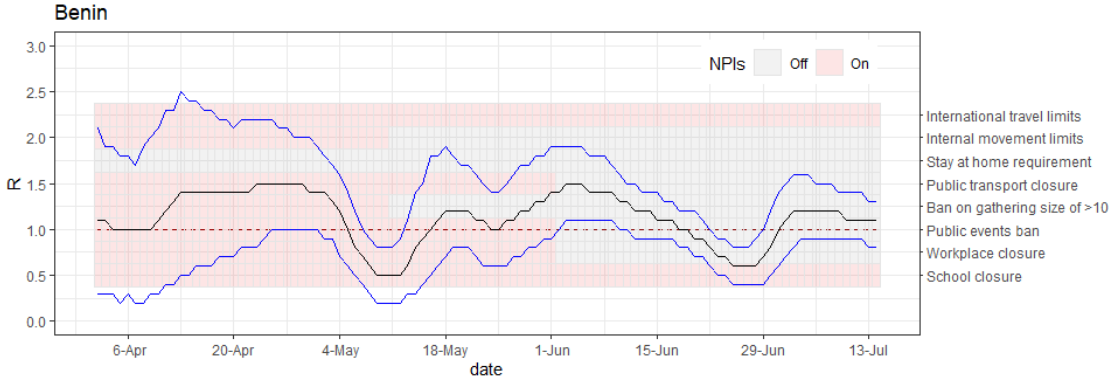


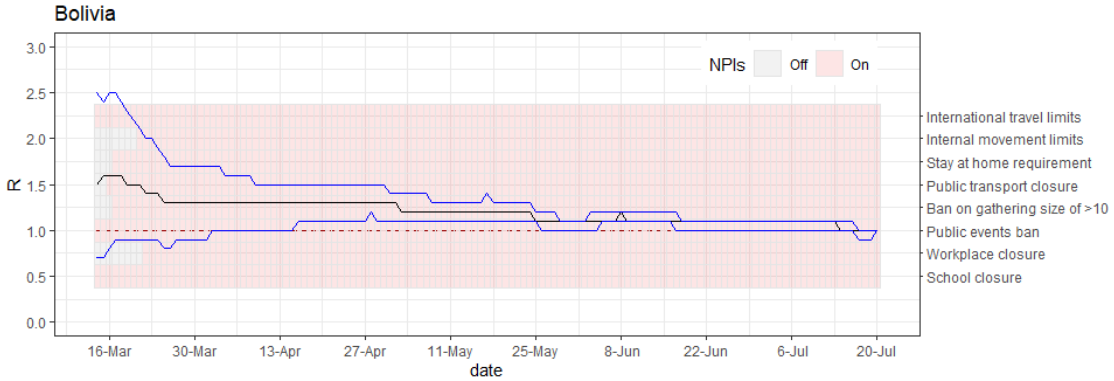
Belgium



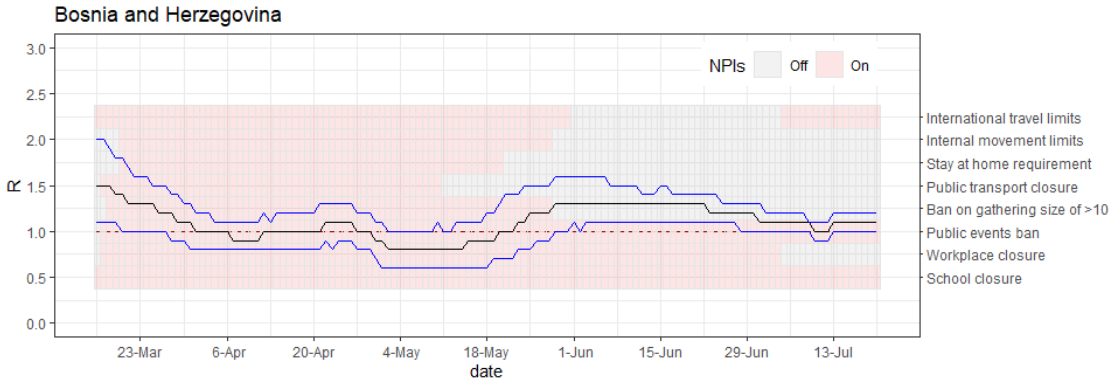
Benin



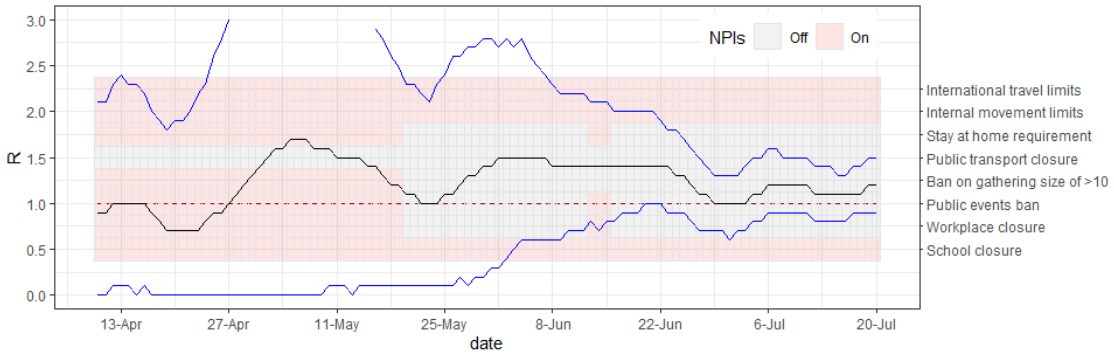
Bolivia



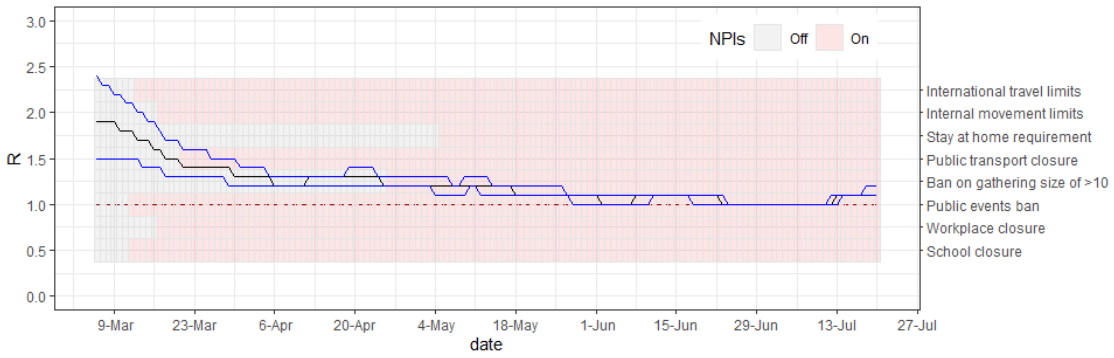
Bosnia and Herzegovina



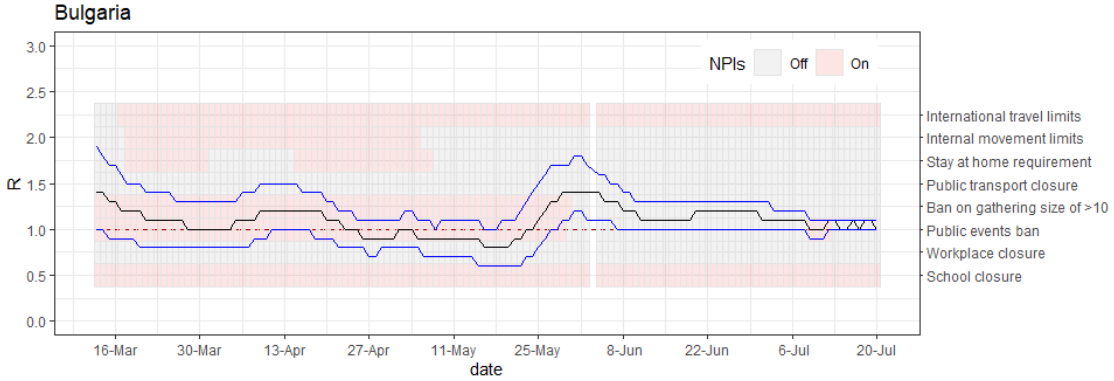
Botswana



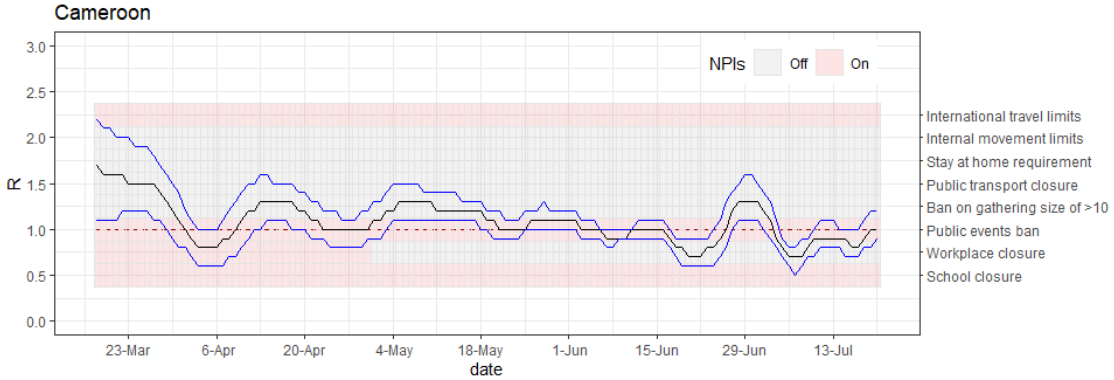
Brazil



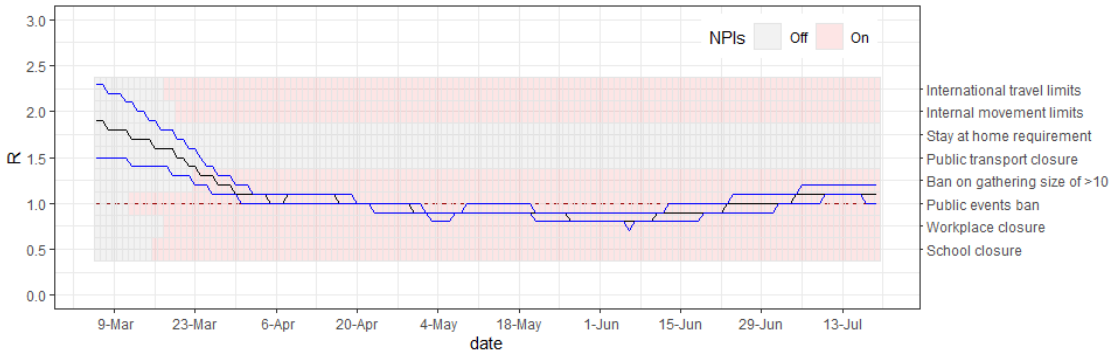
Bulgaria



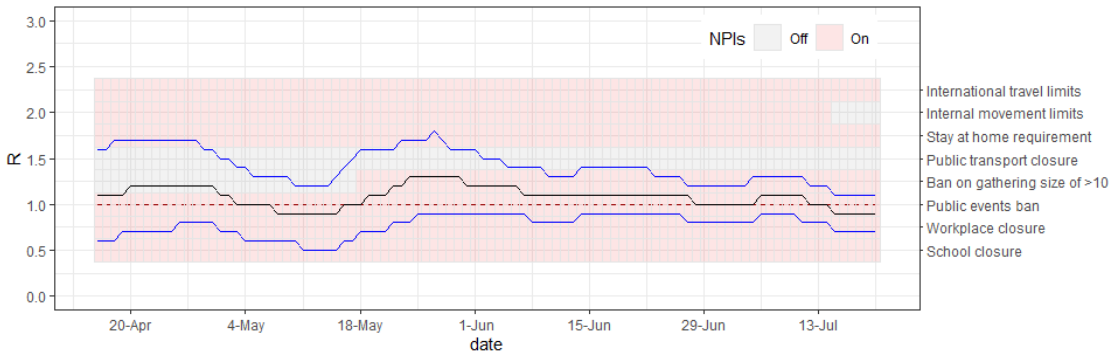
Cameroon



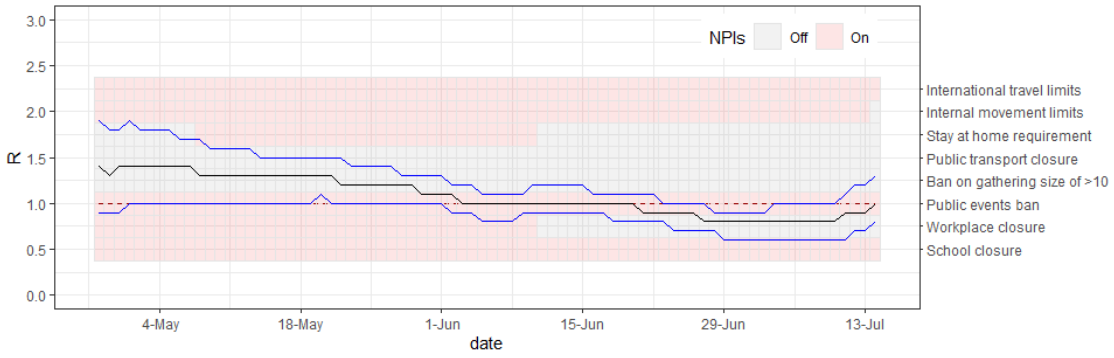
Canada



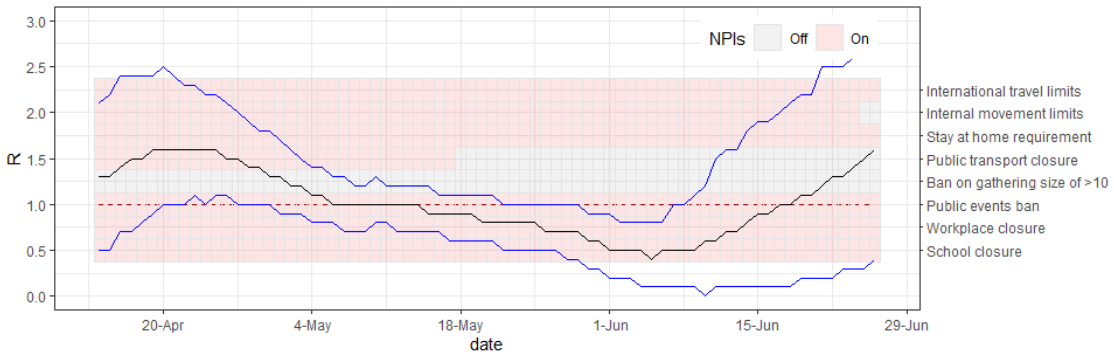
Cape Verde



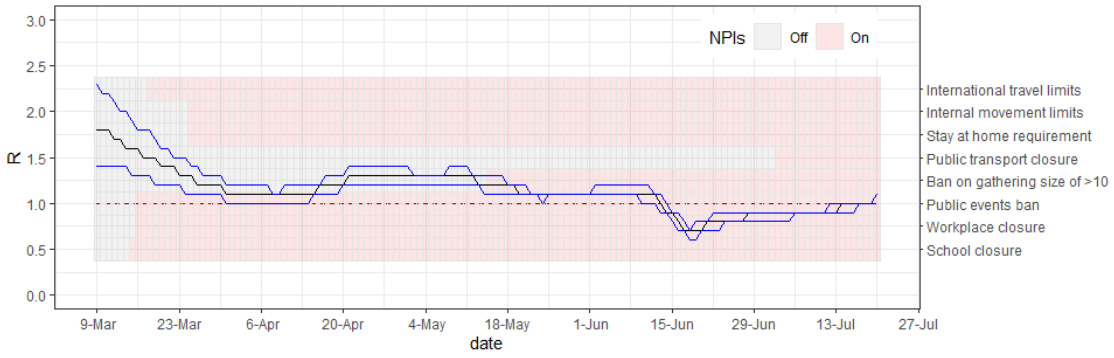
Central African Republic



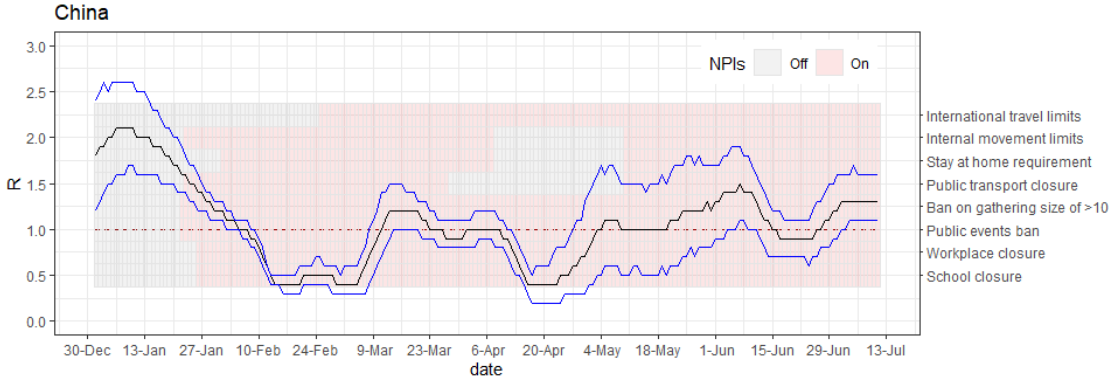
Chad



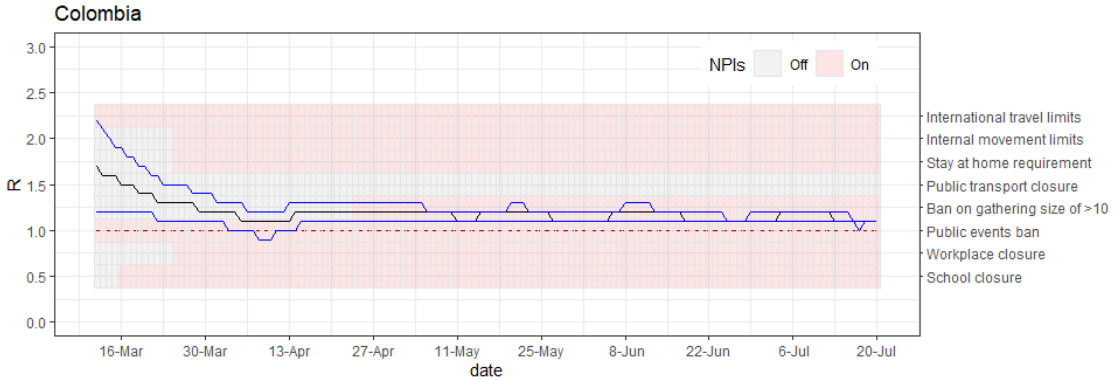
Chile



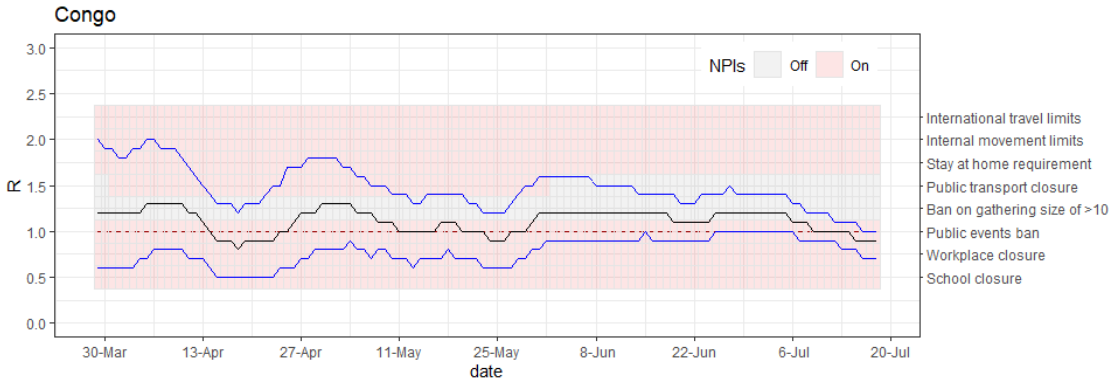
China



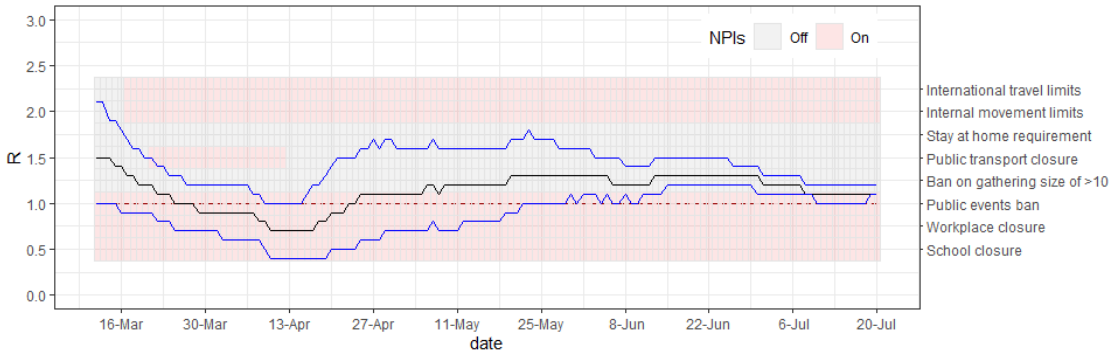
Colombia



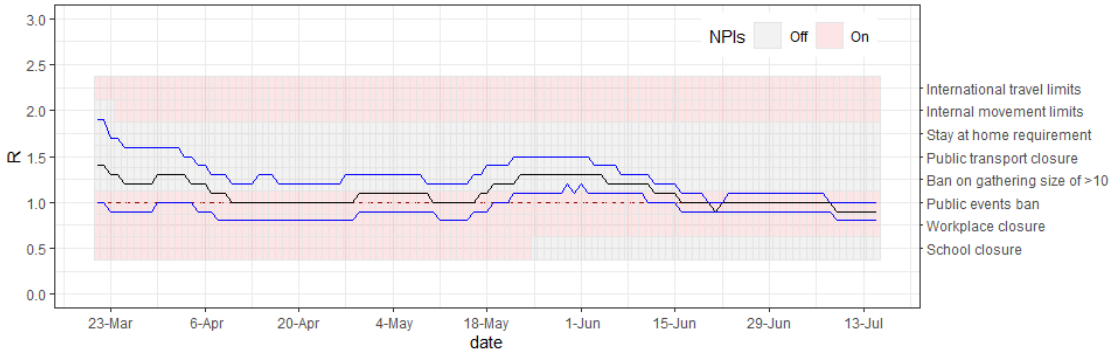
Congo



Costa Rica



Cote dIvoire



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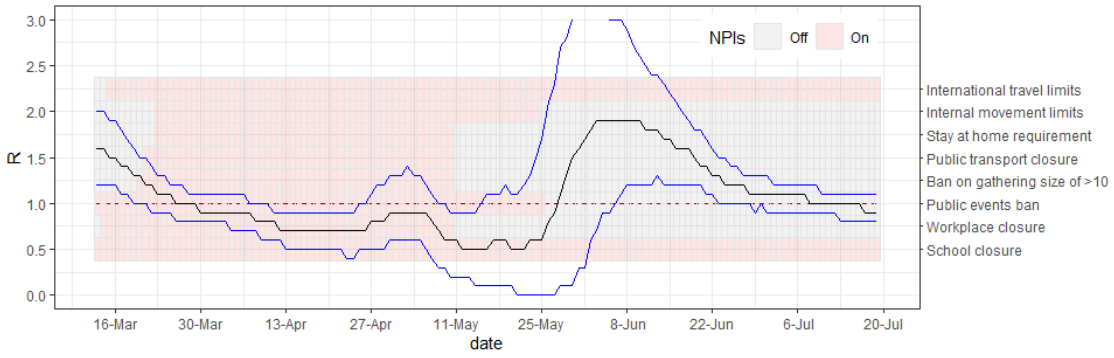

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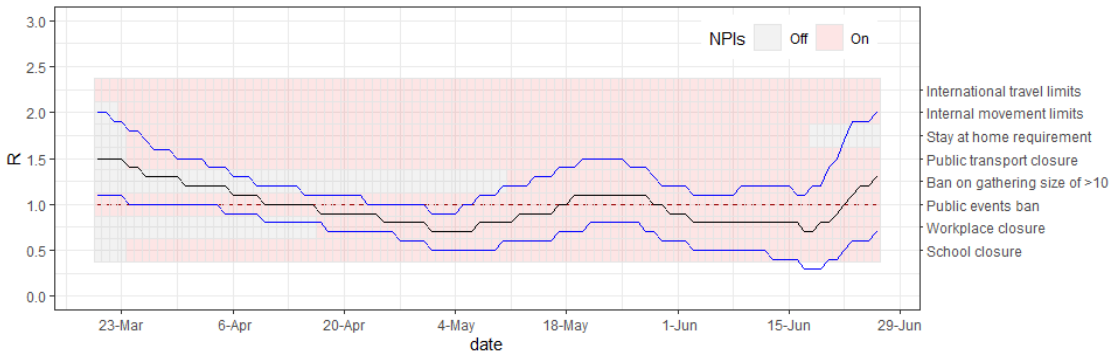

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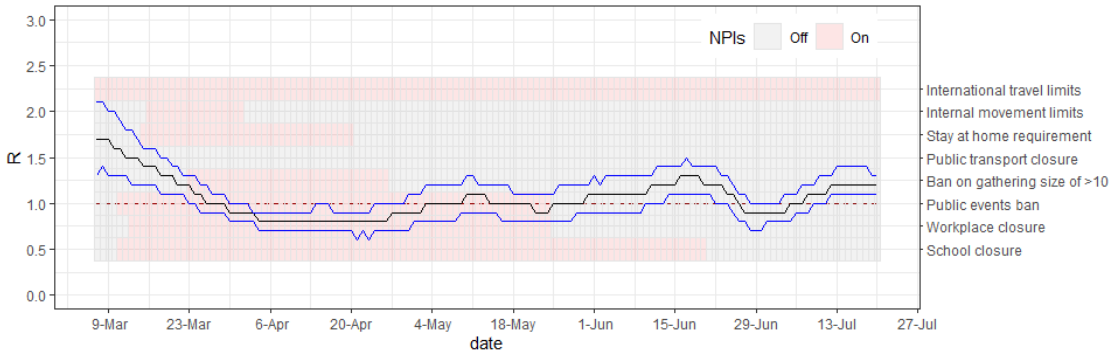

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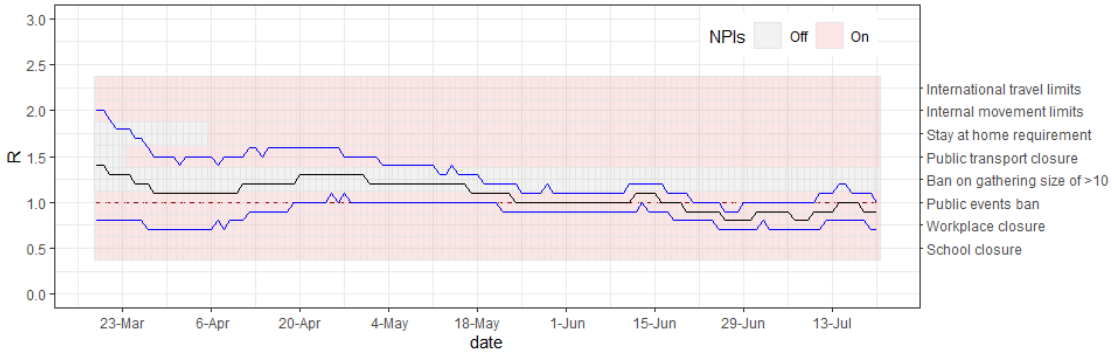

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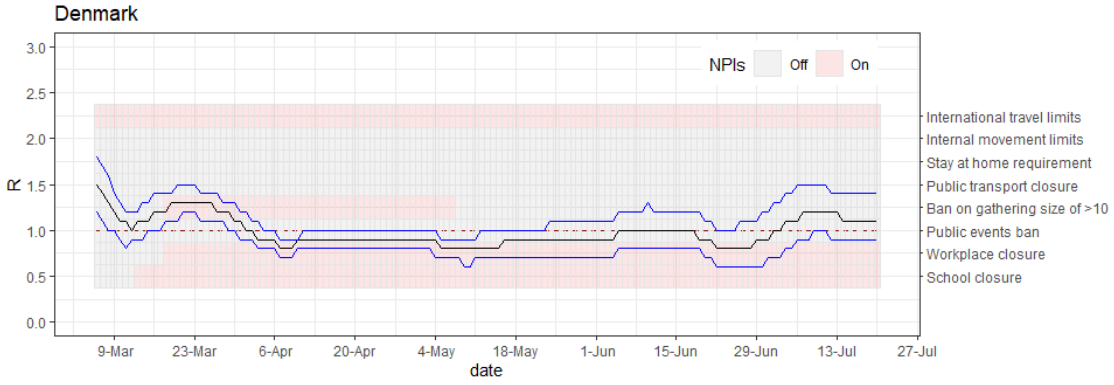

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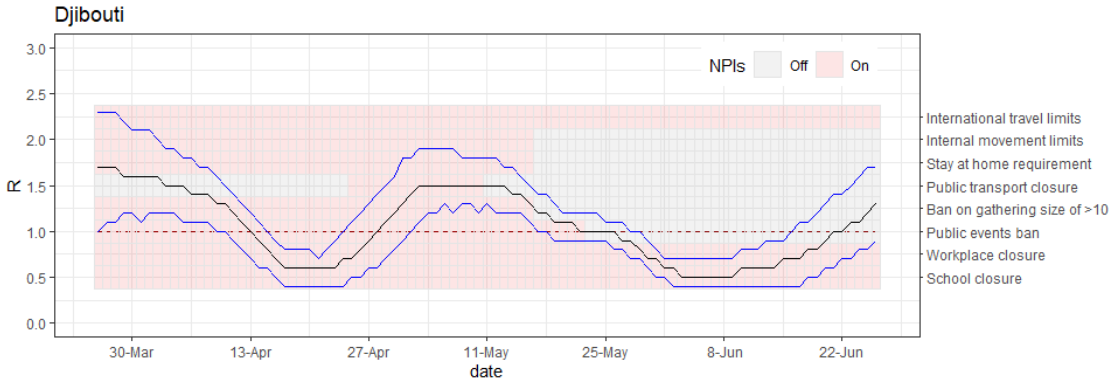

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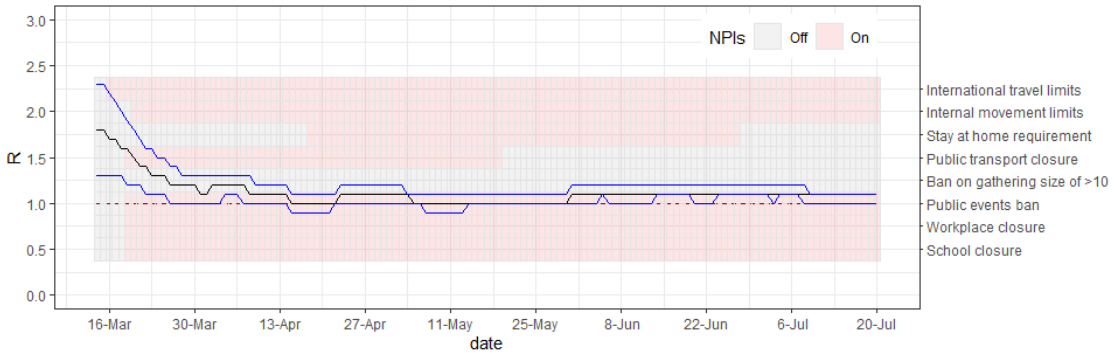

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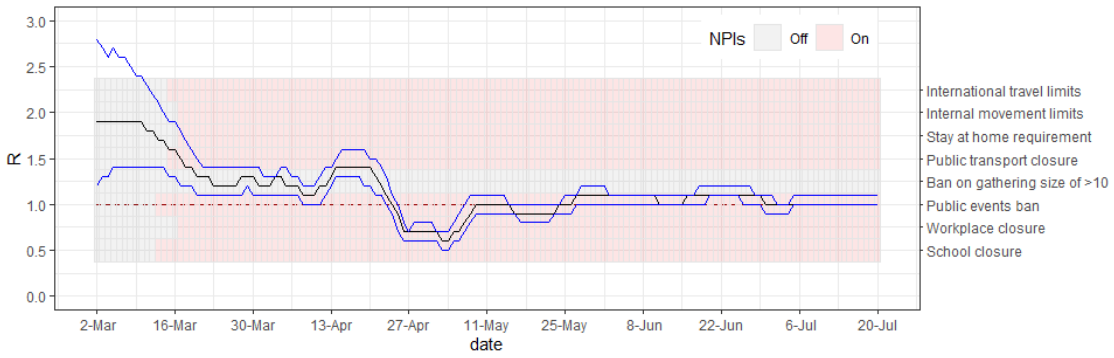

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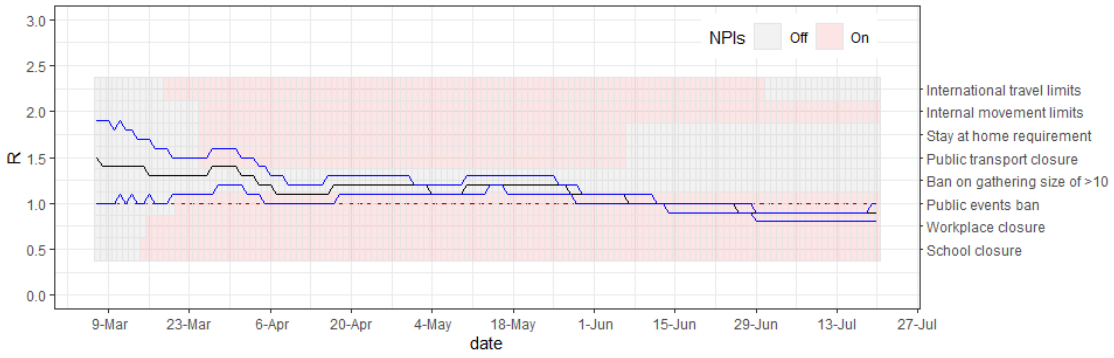

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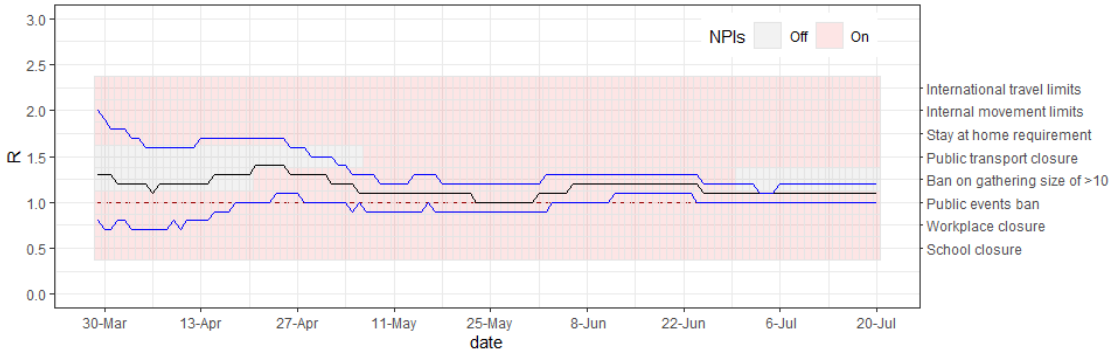

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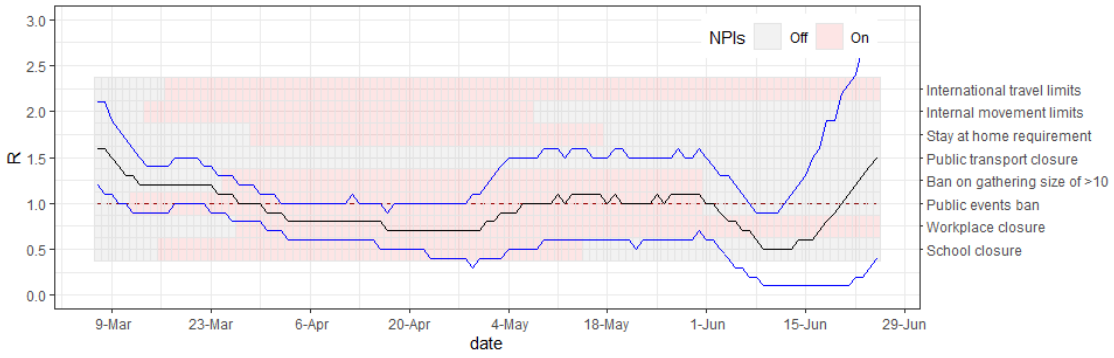

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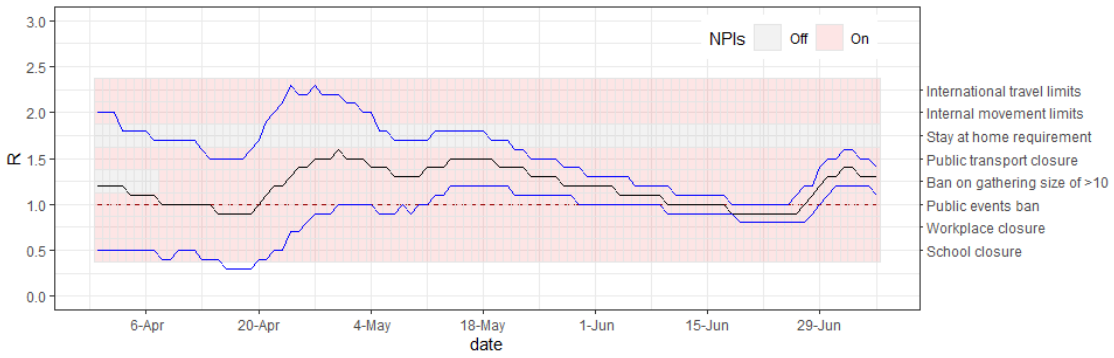

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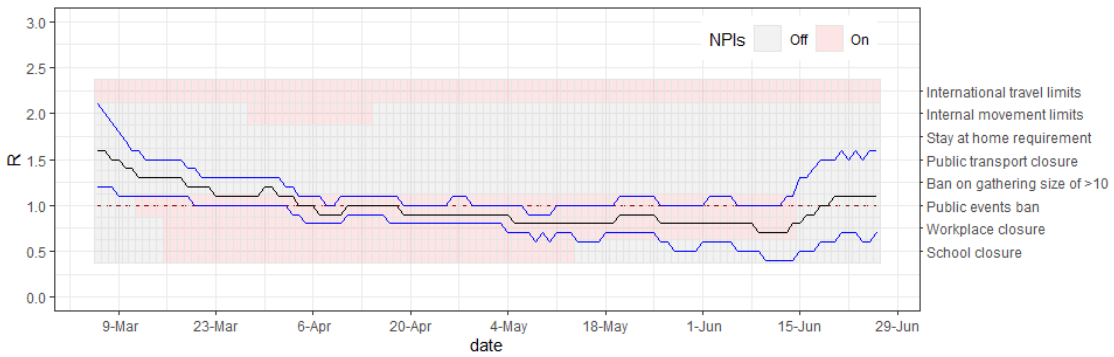

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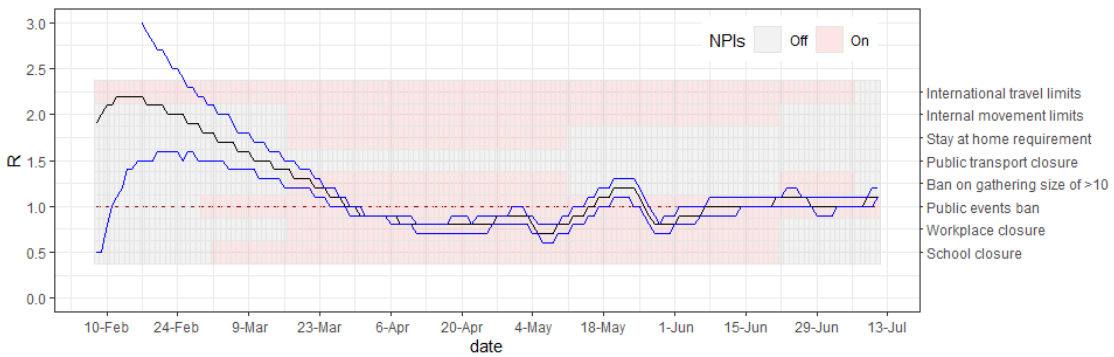

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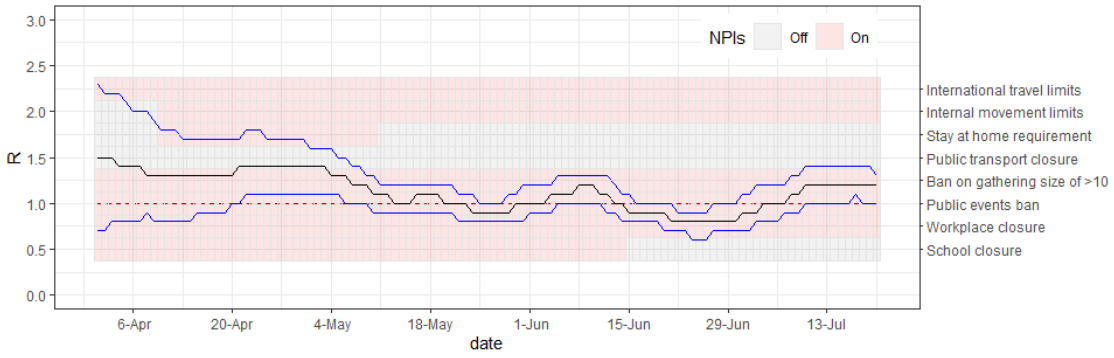

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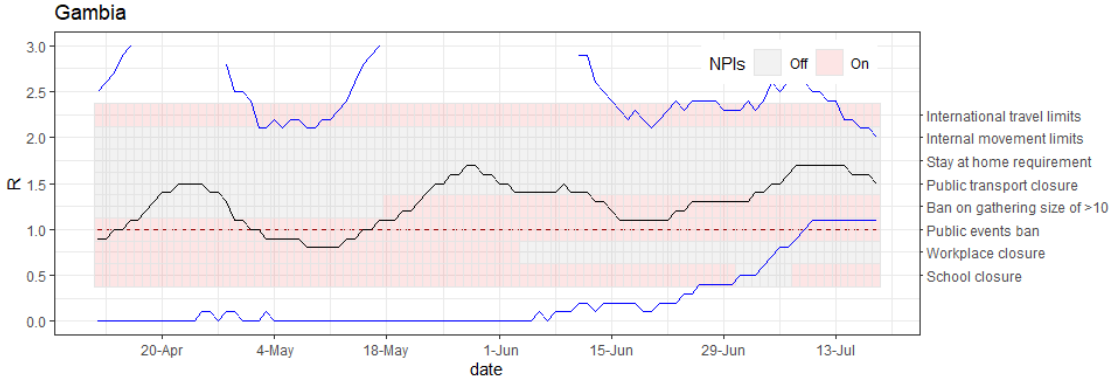

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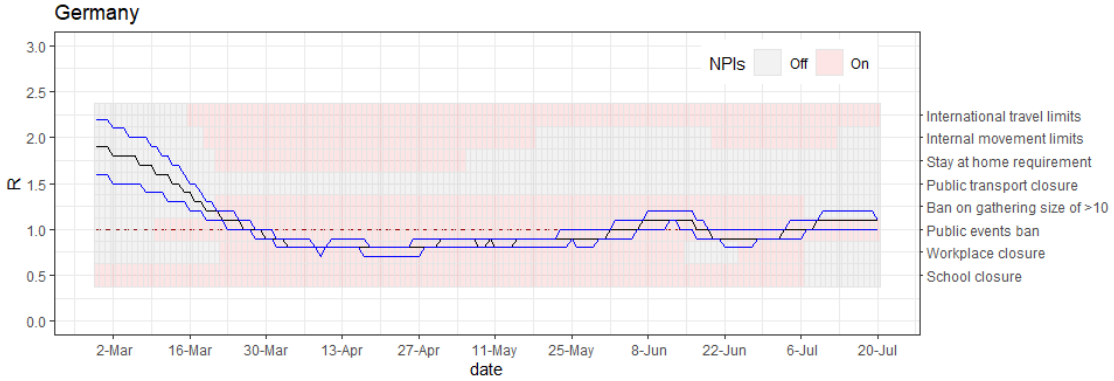

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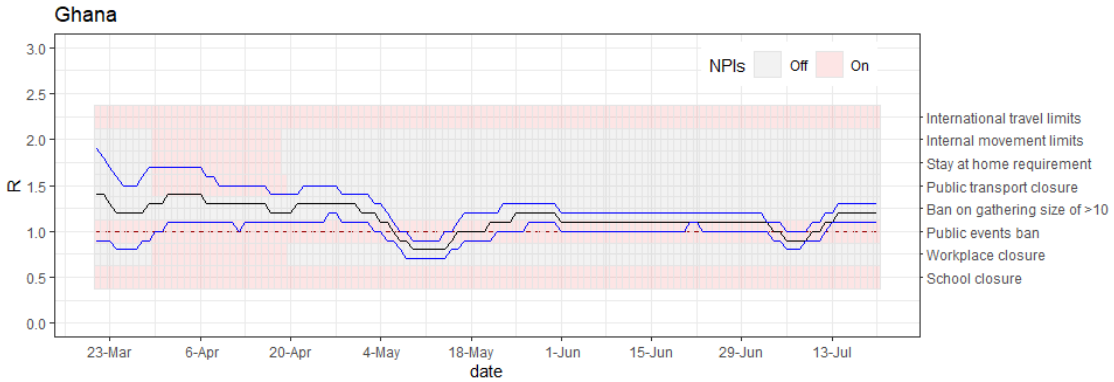

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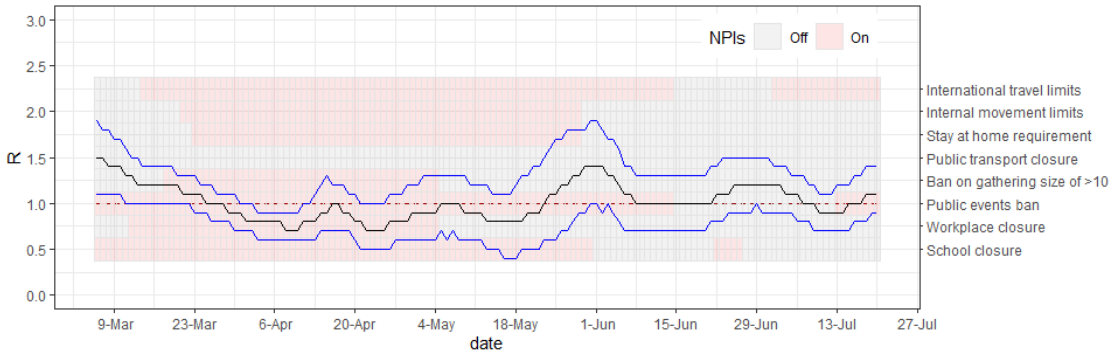

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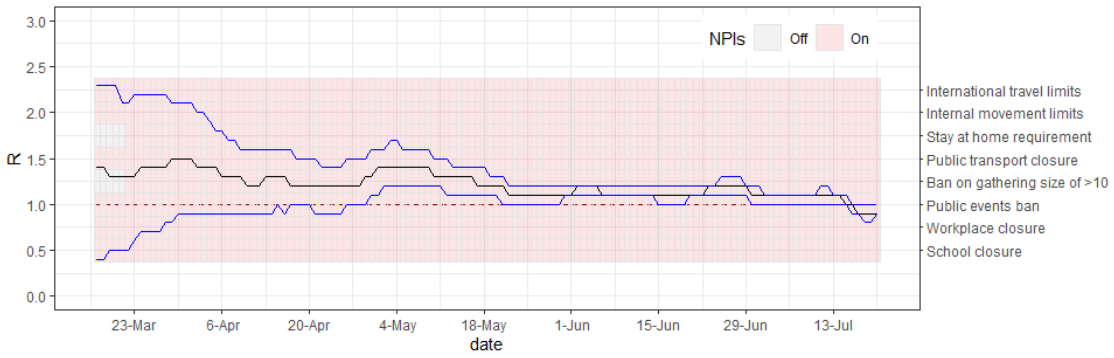

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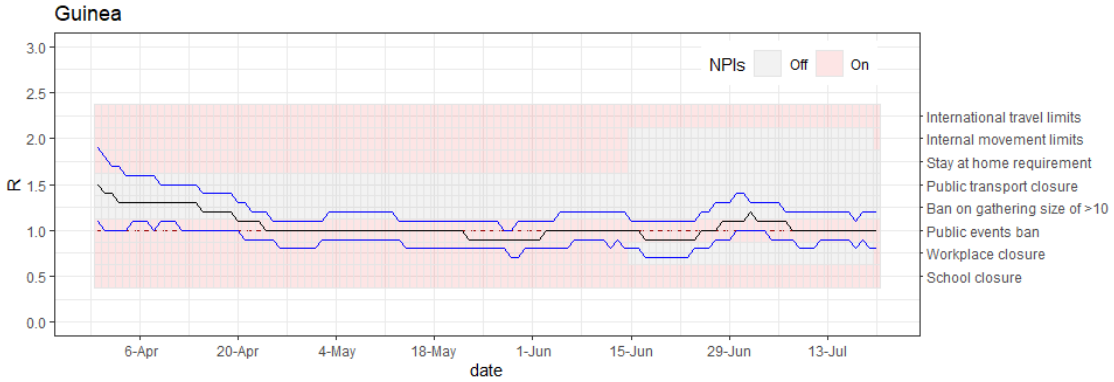

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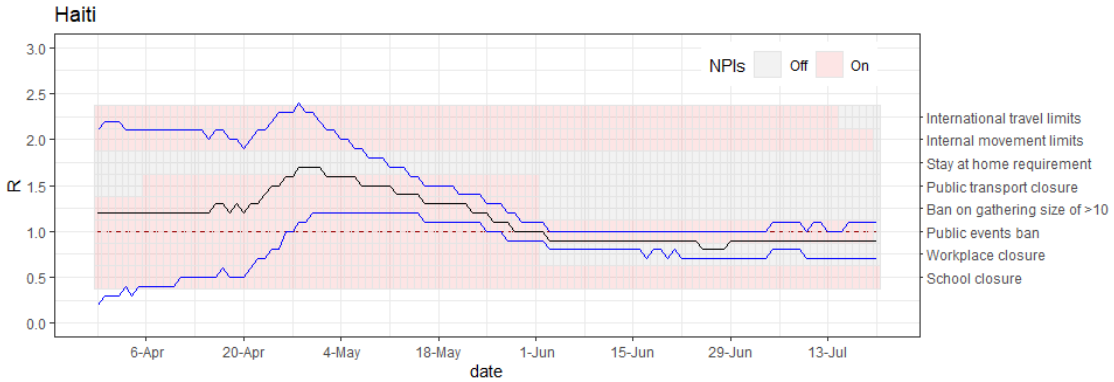

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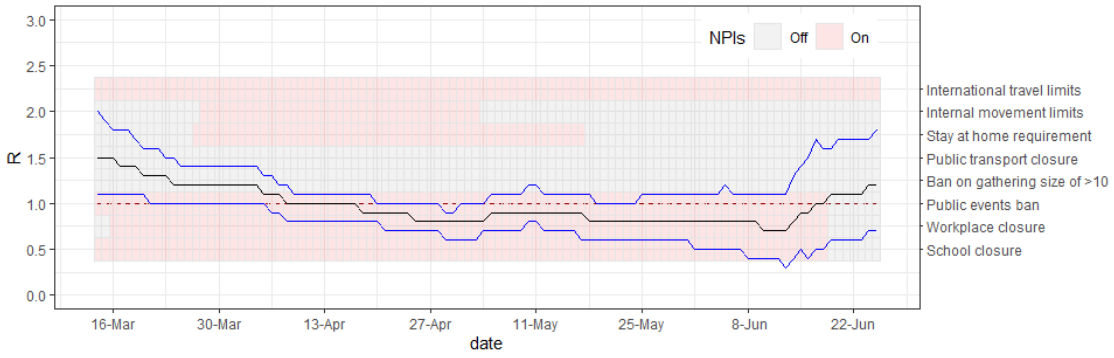

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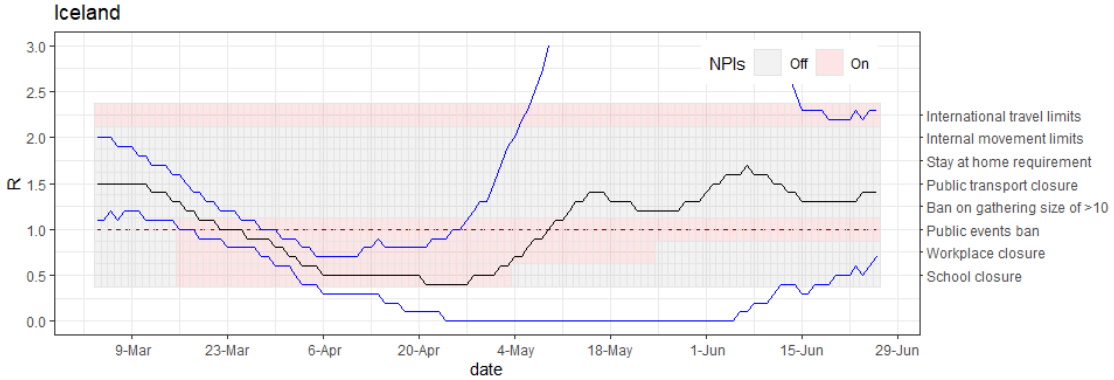

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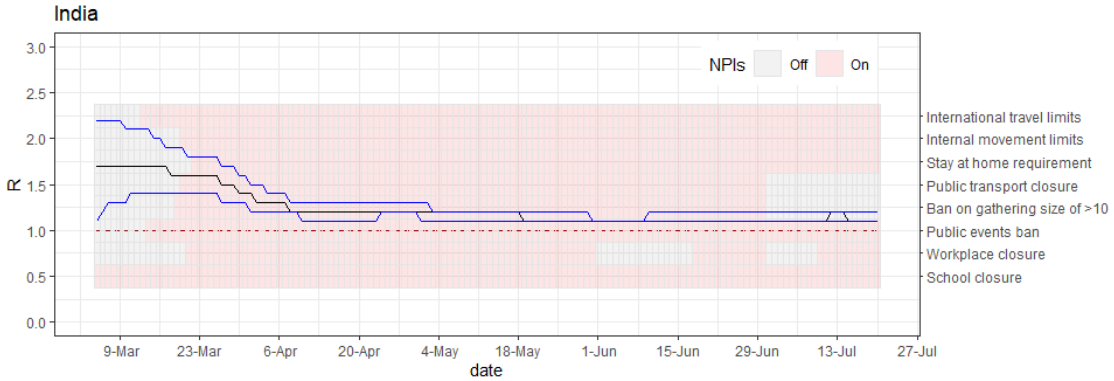

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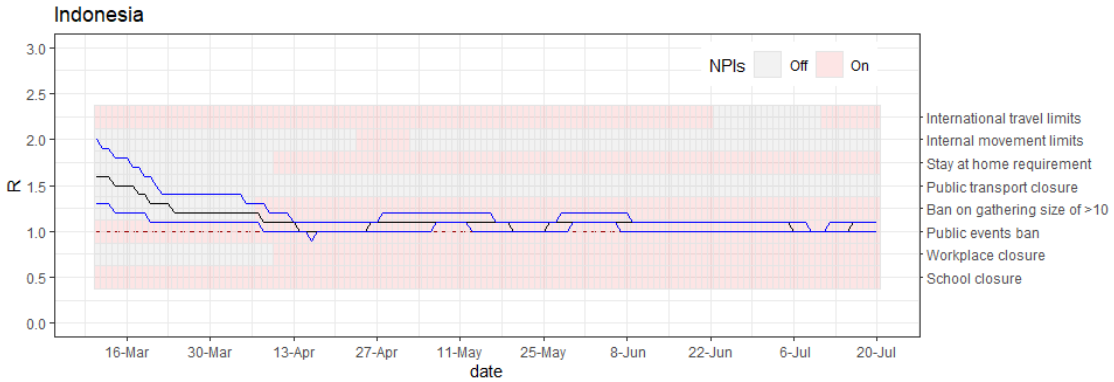

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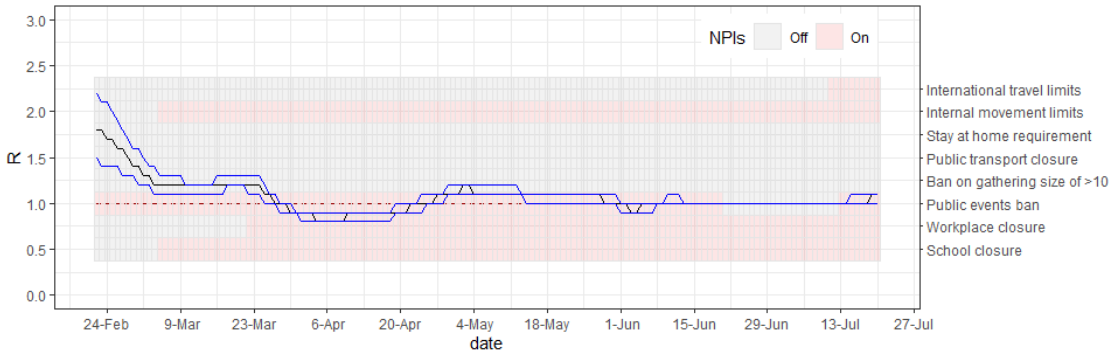

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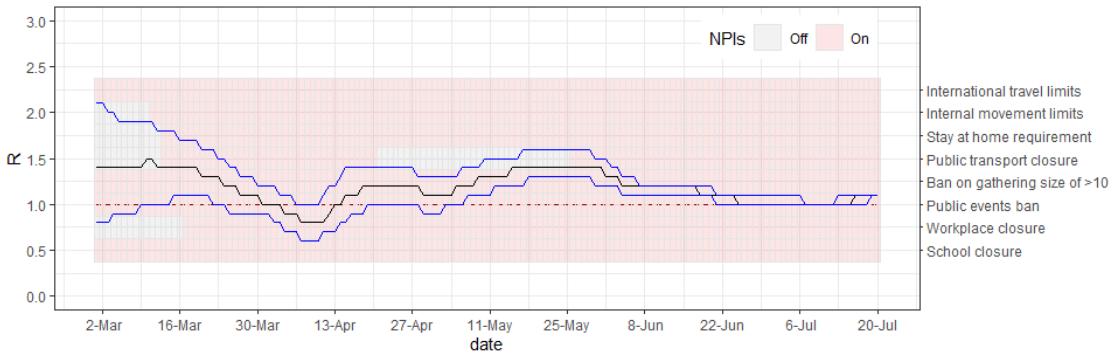

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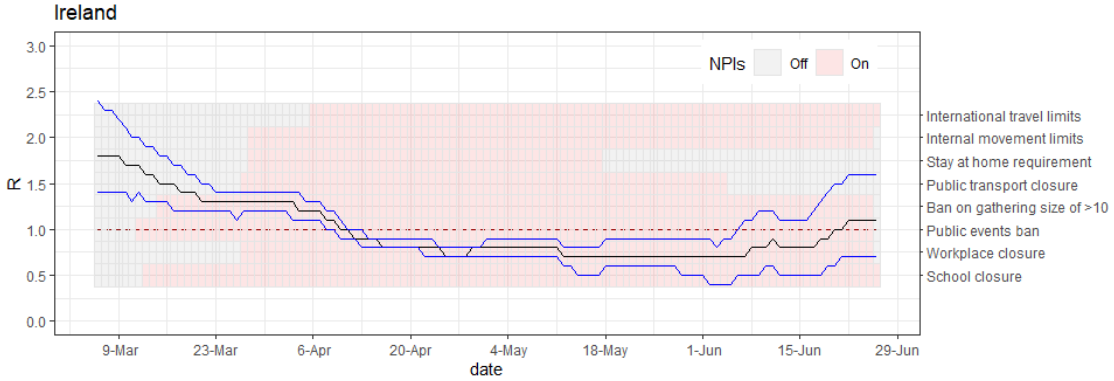

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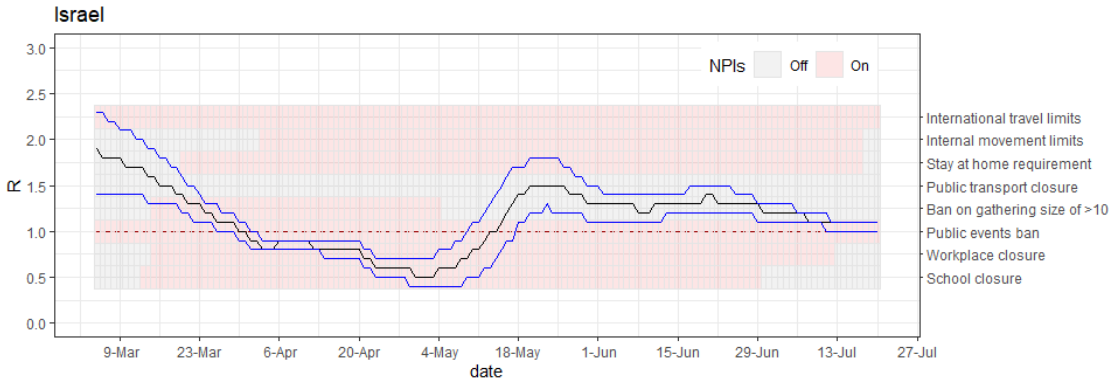

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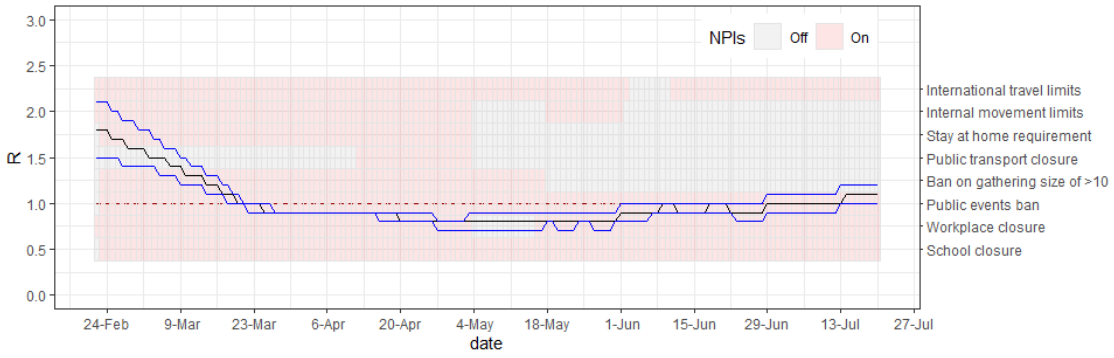

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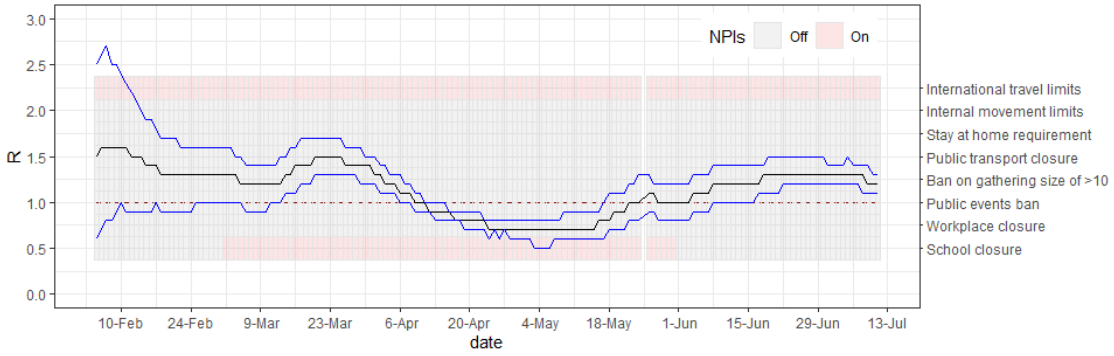

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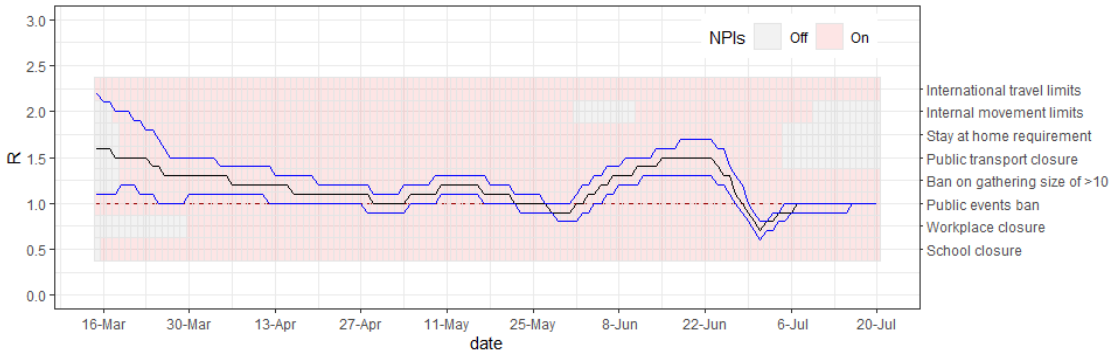

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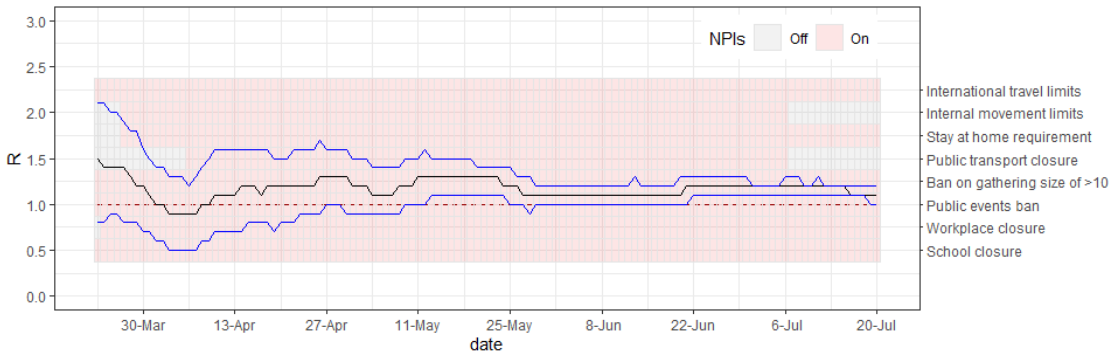

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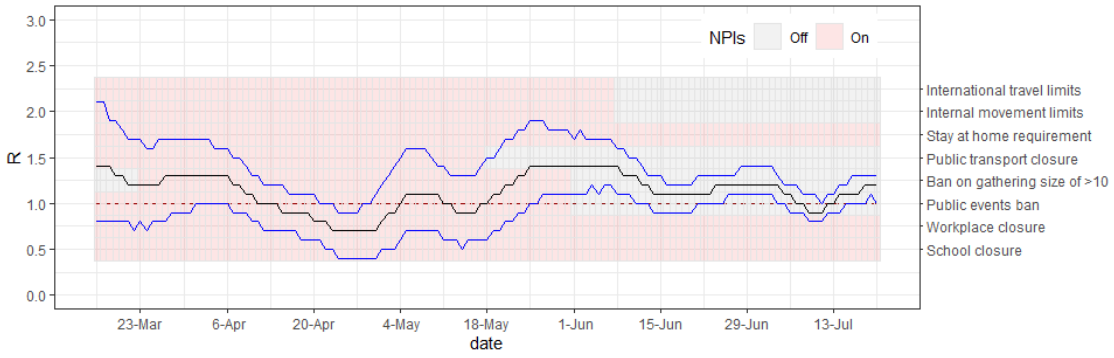

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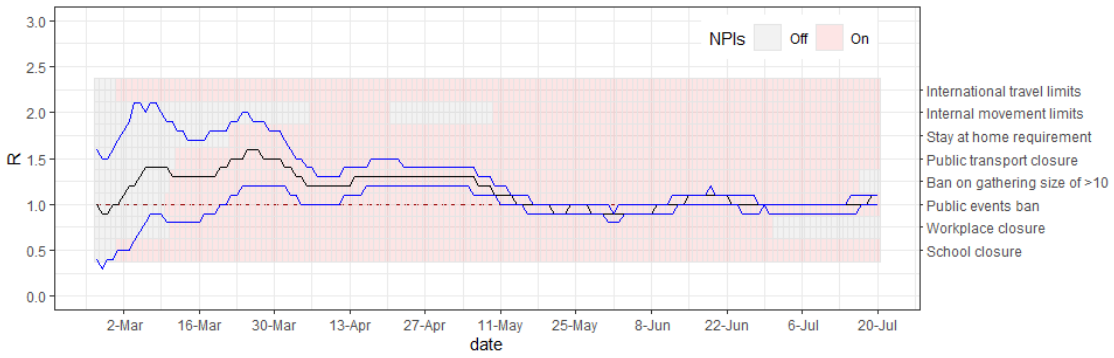

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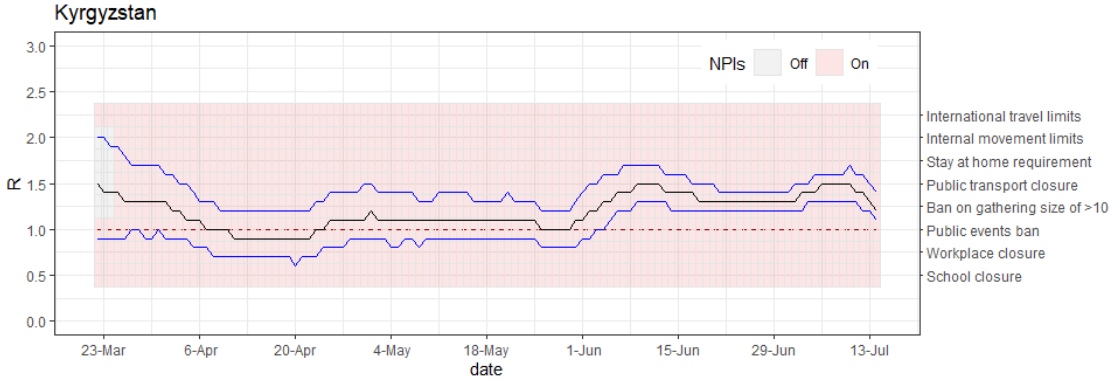

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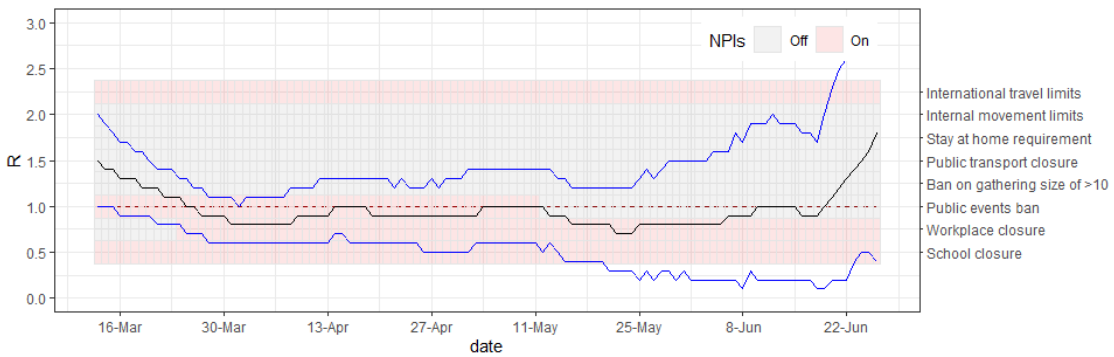

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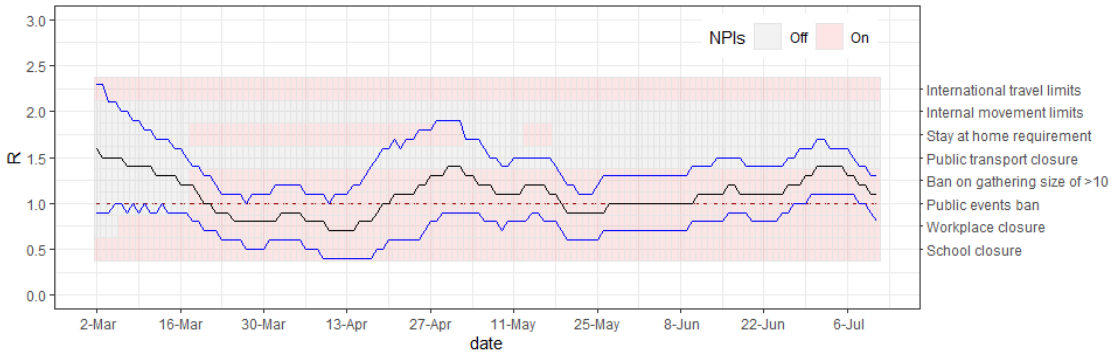

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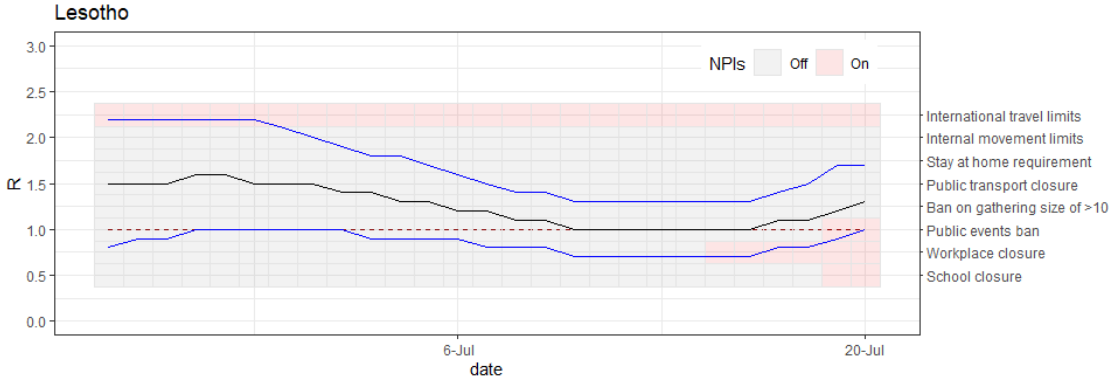

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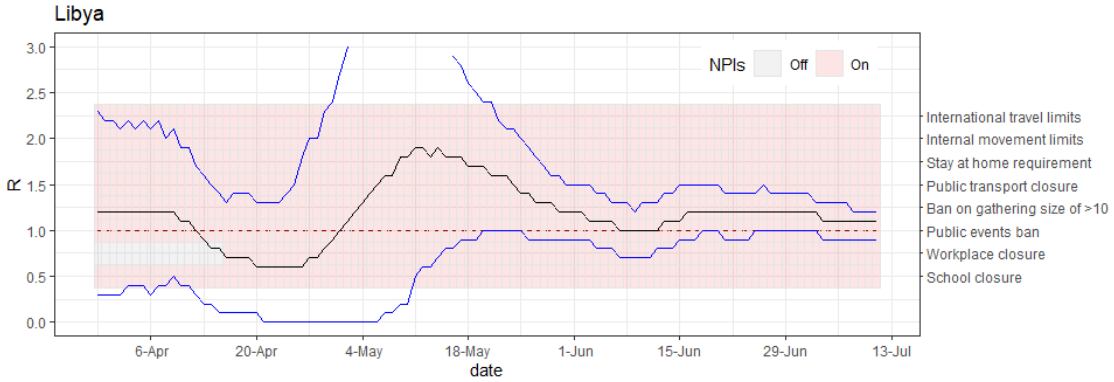

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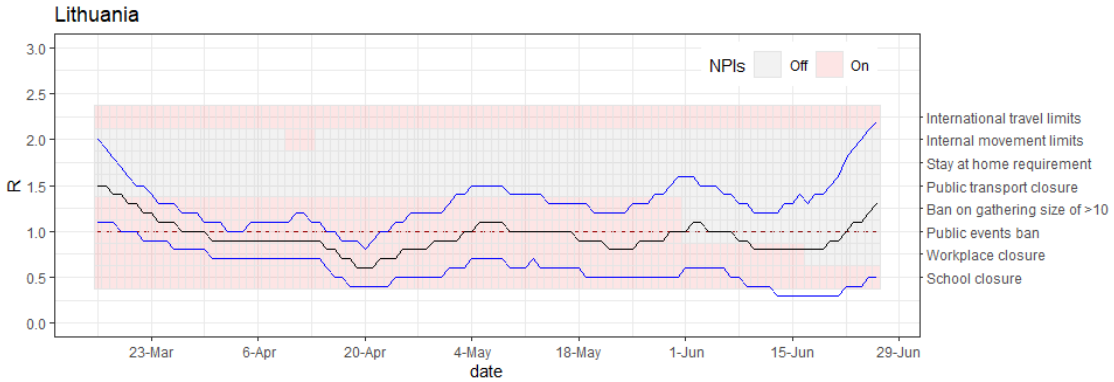

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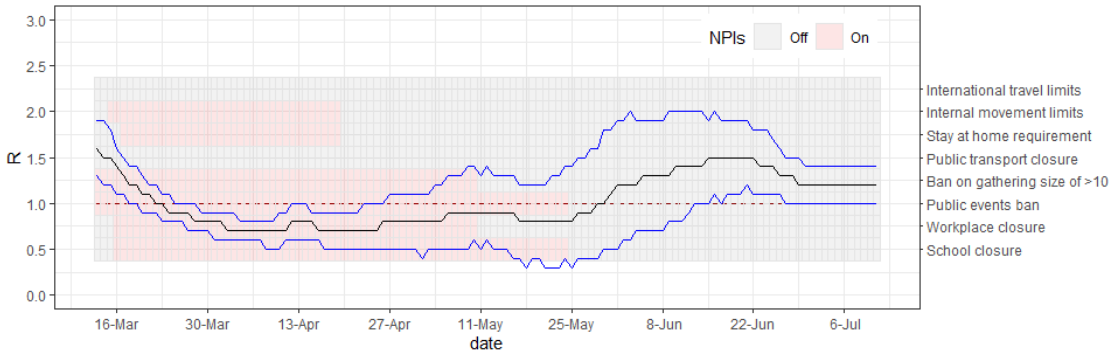

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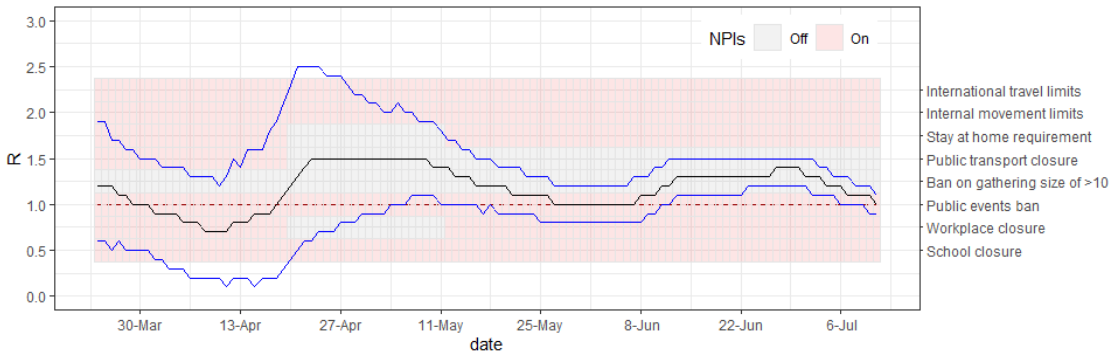

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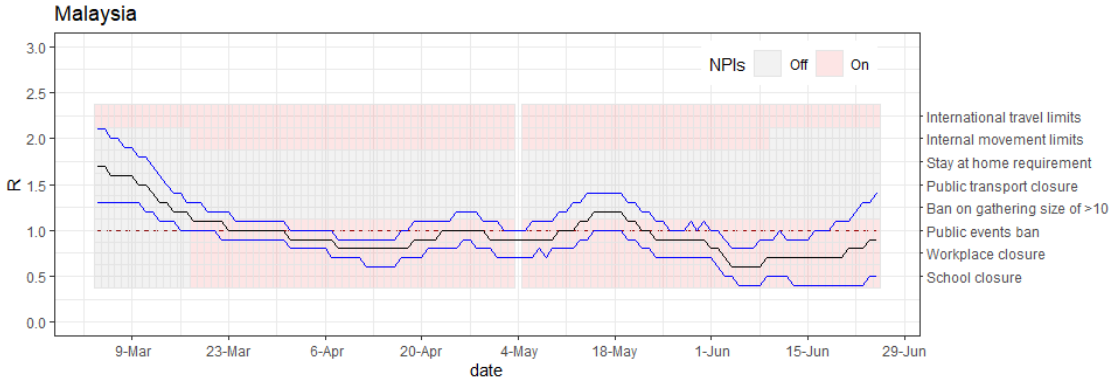

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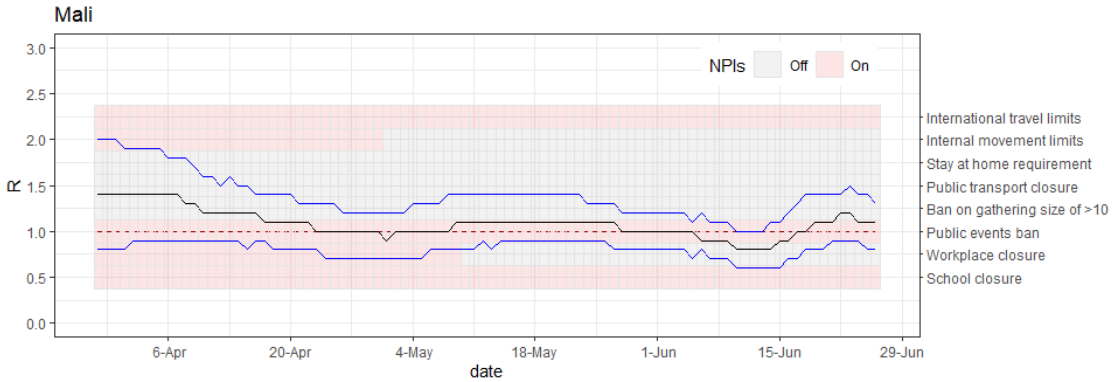

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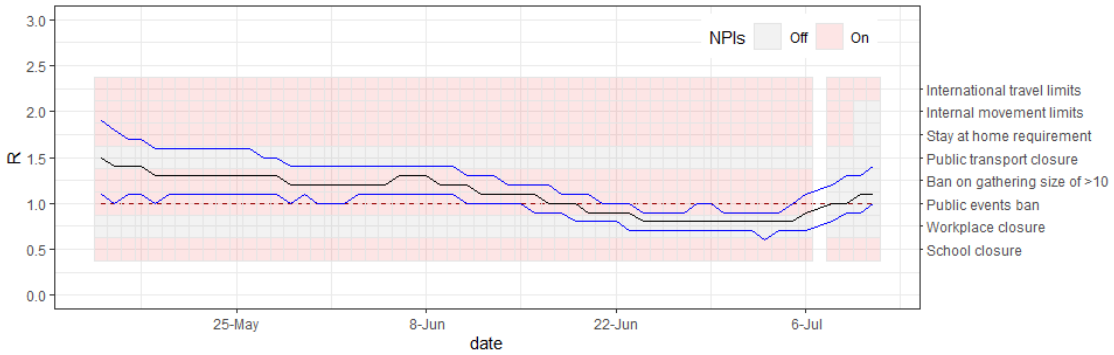

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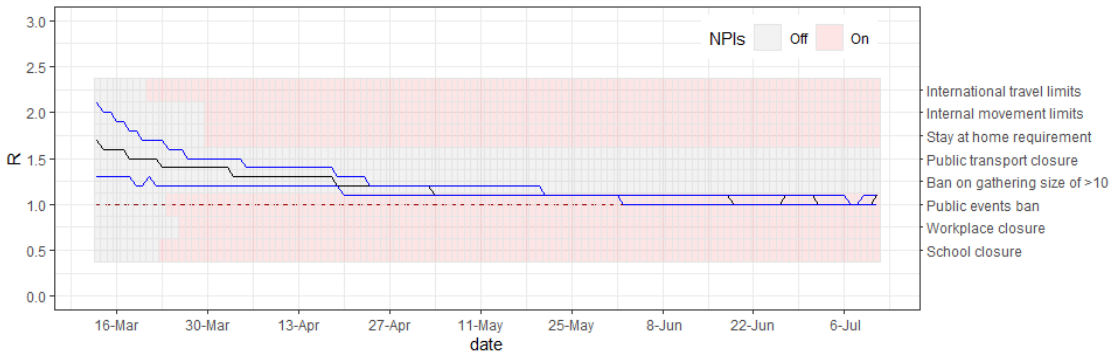

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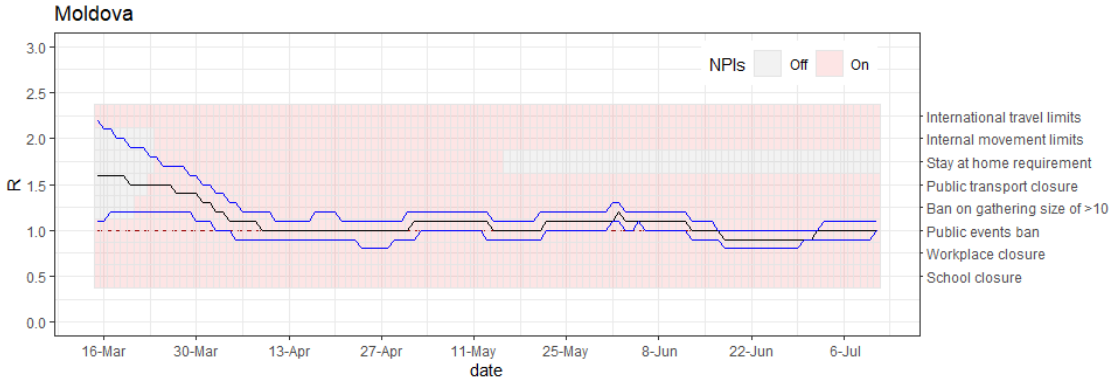

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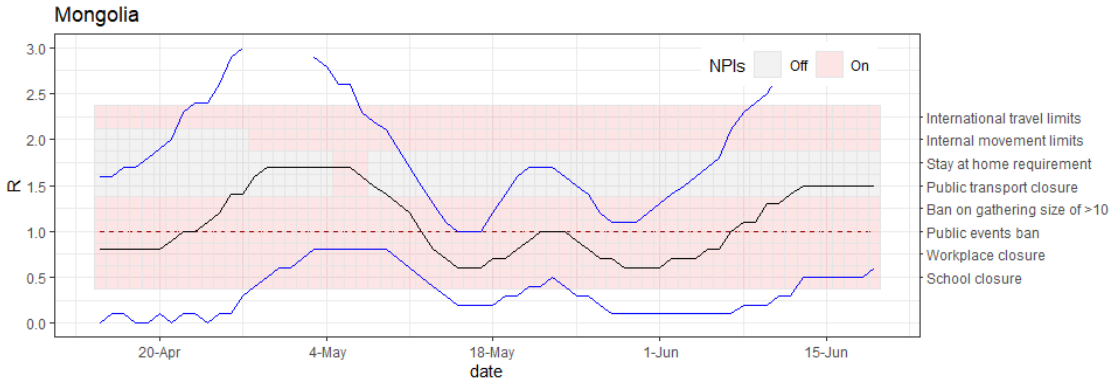

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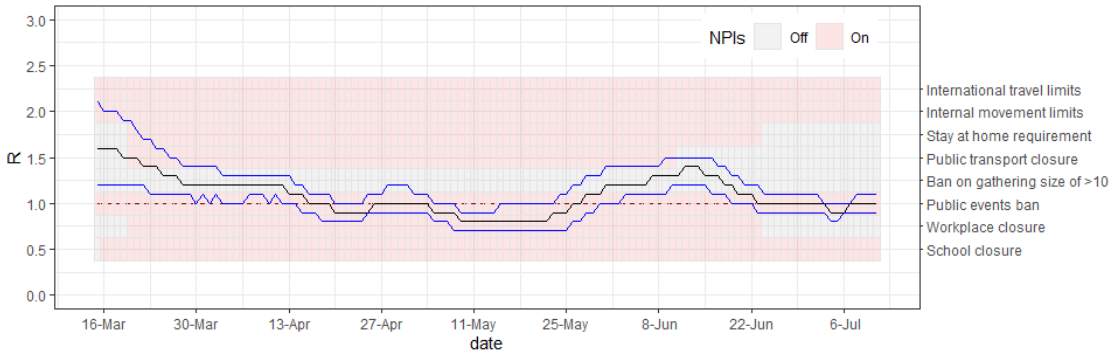

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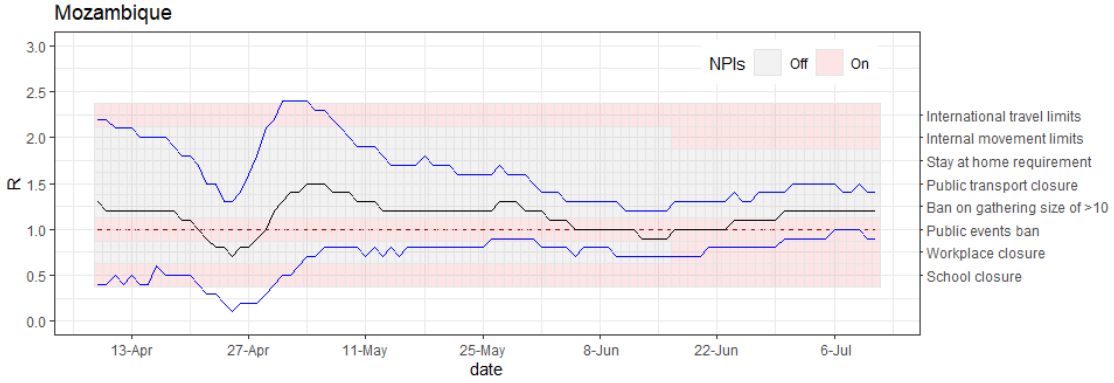

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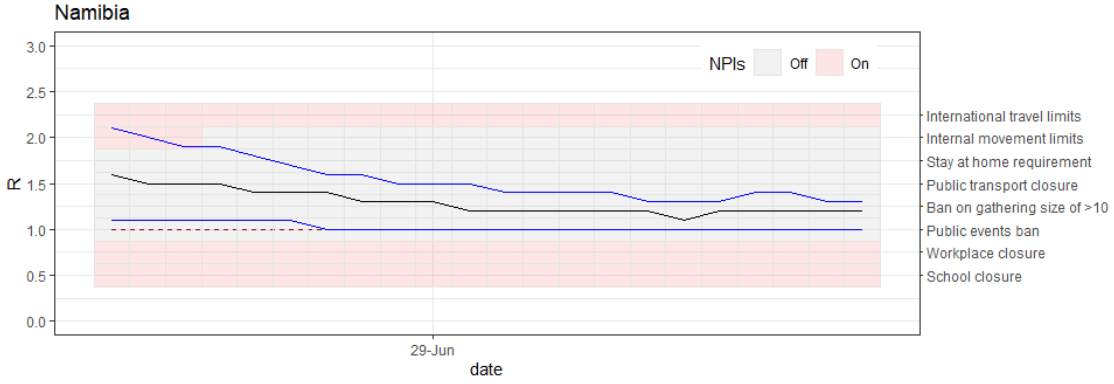

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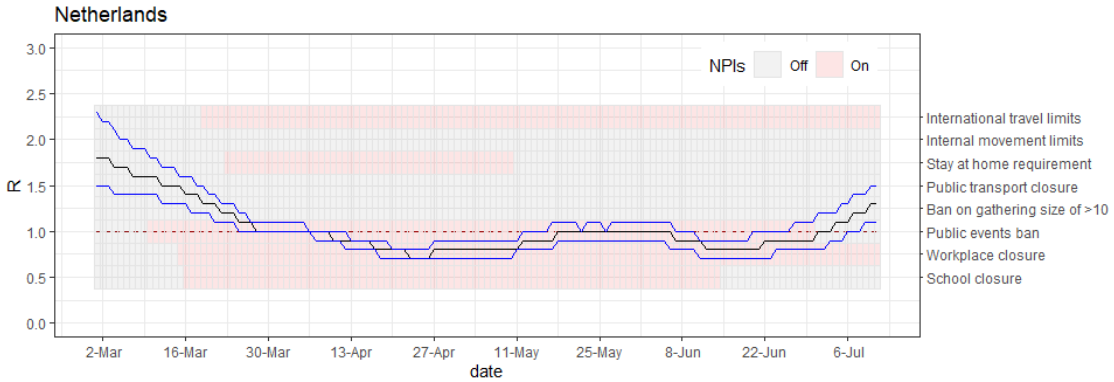

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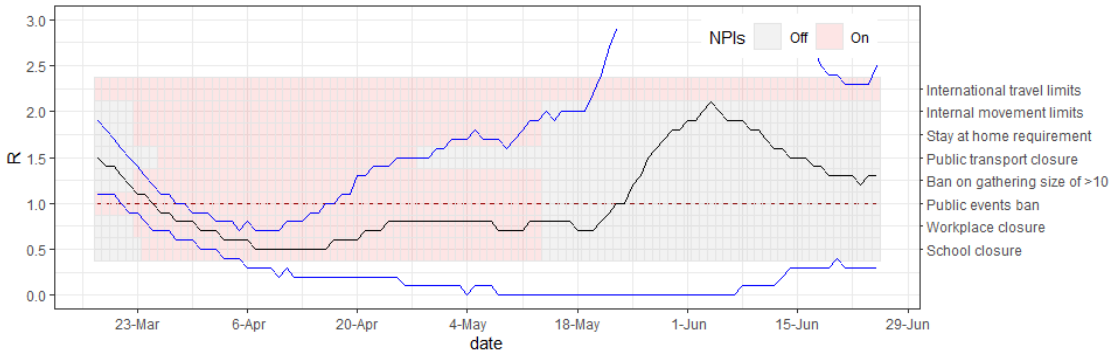

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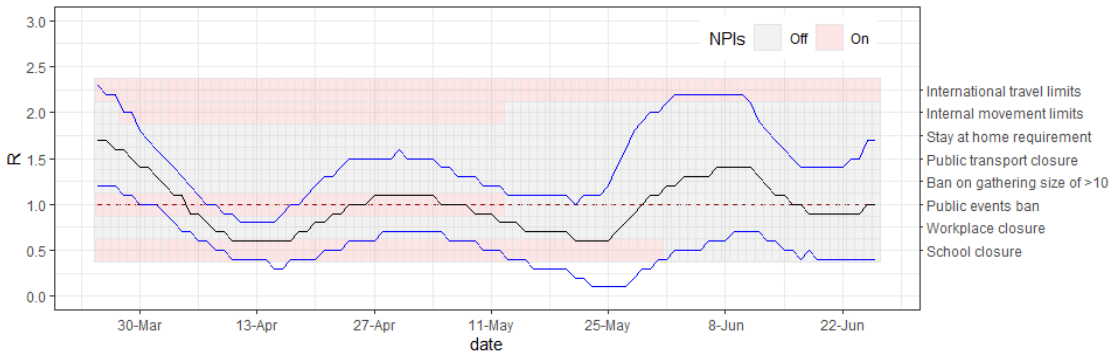

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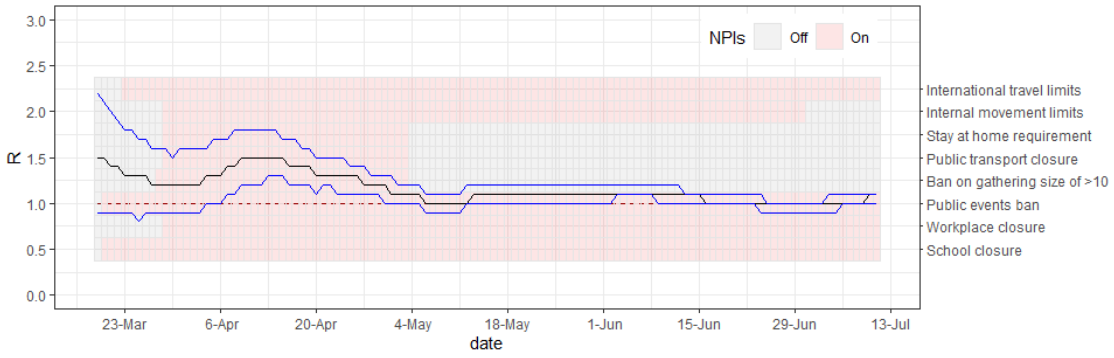

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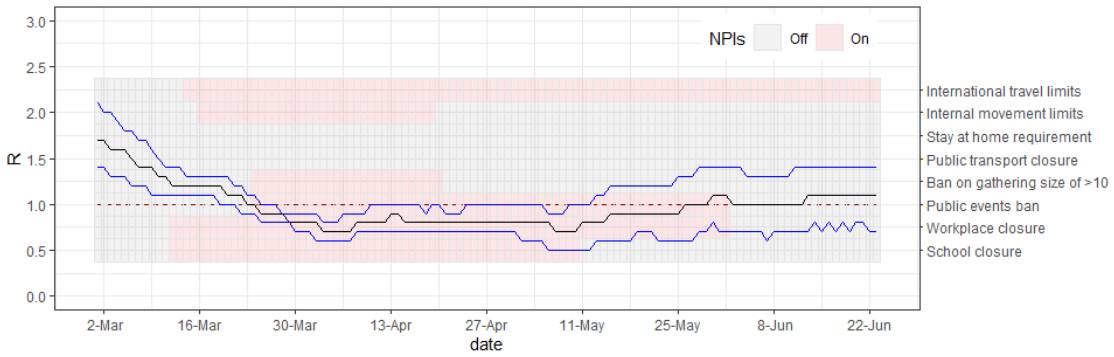

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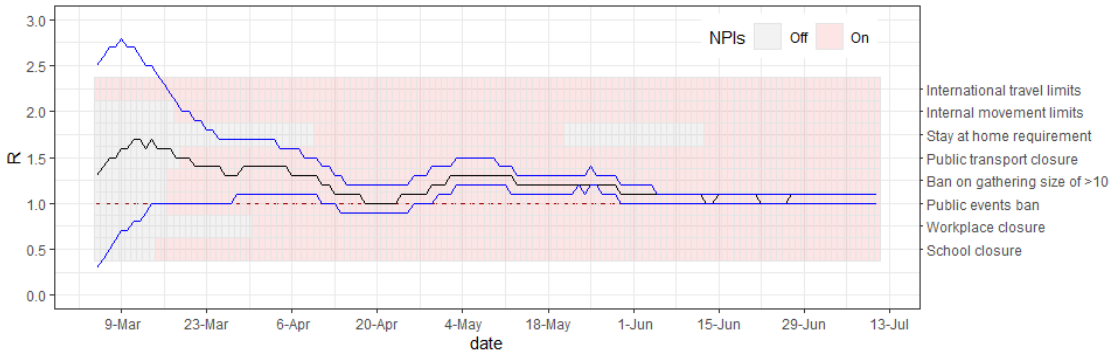

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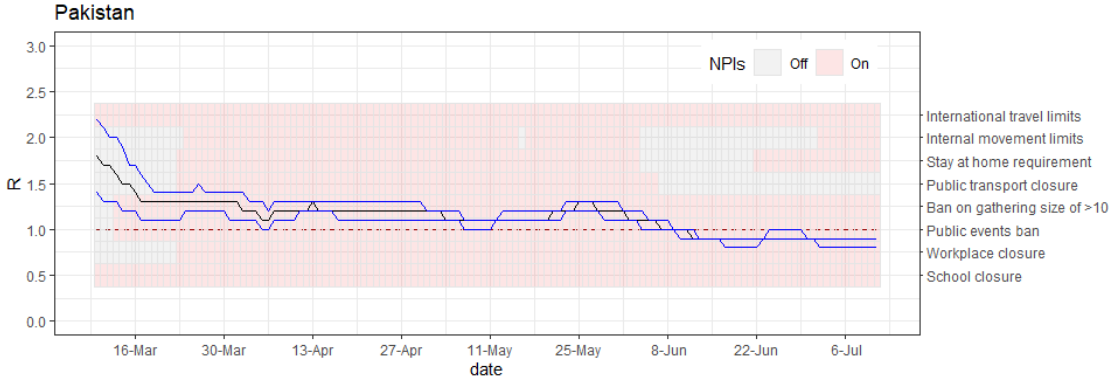

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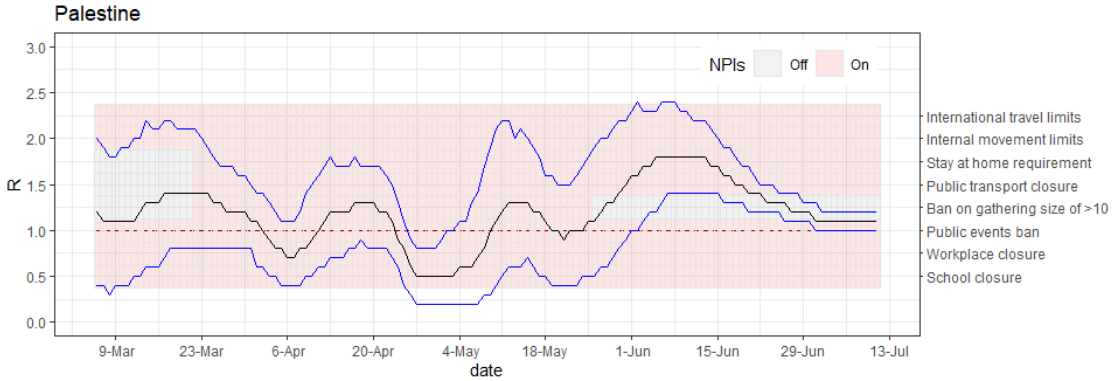

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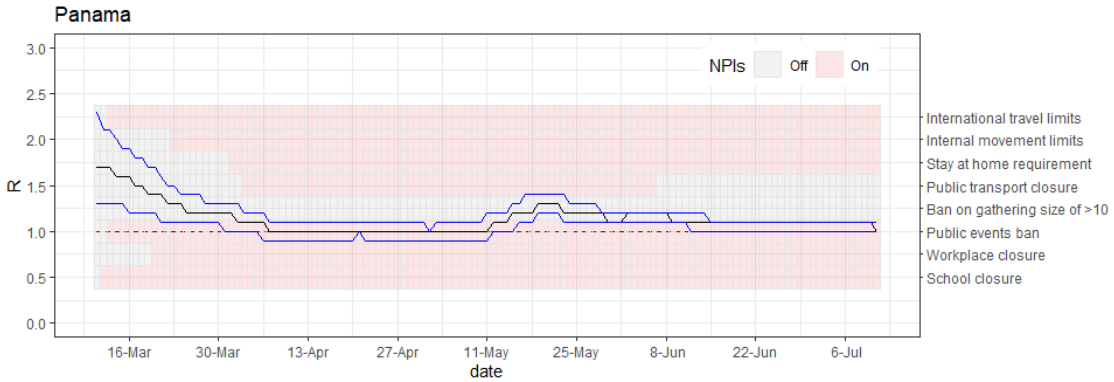

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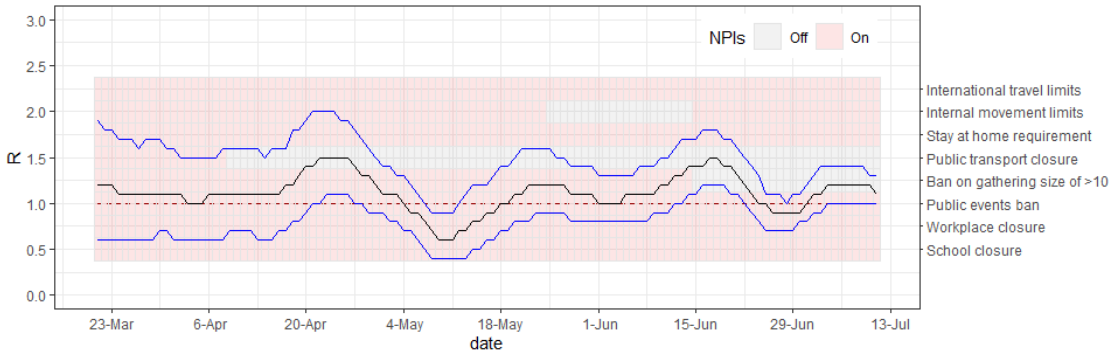

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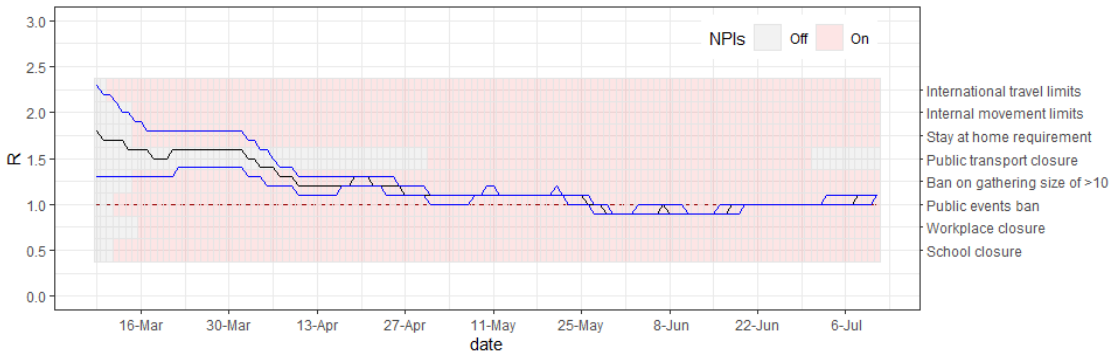

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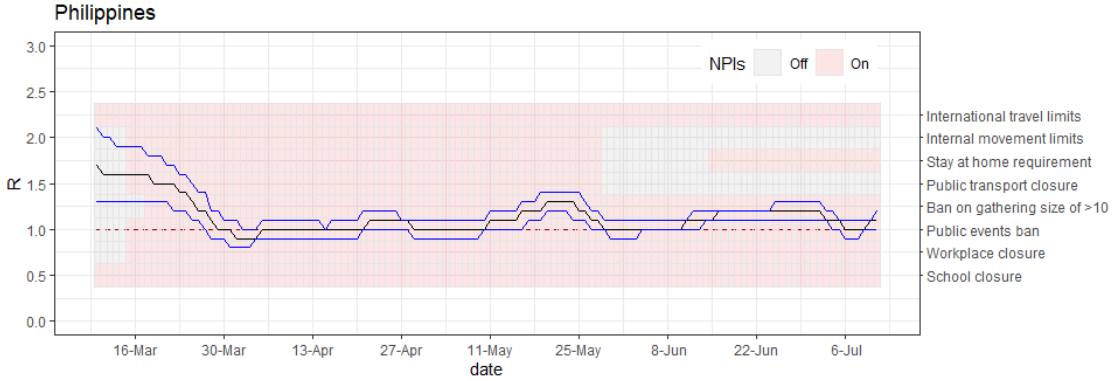

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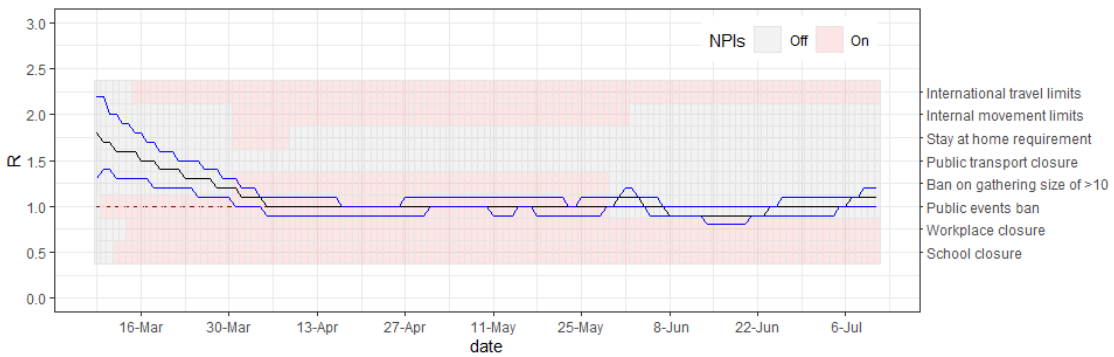

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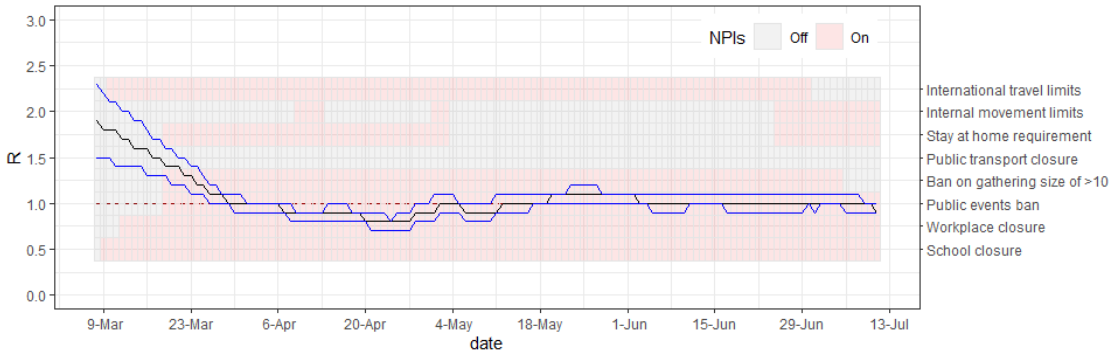

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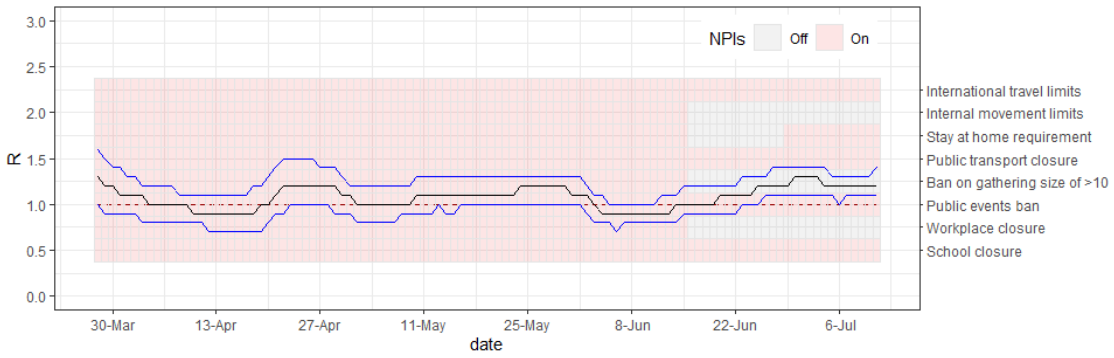

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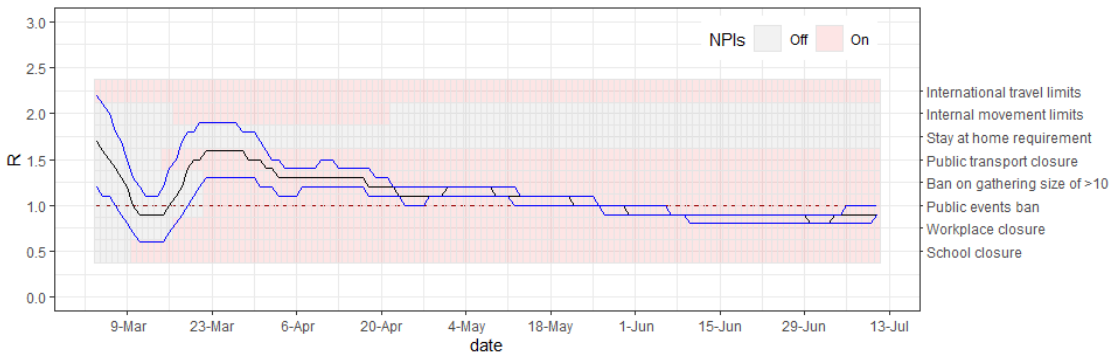

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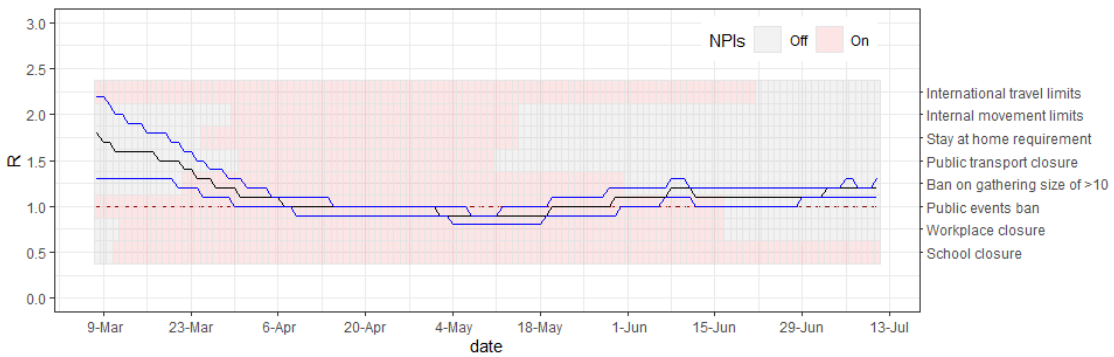

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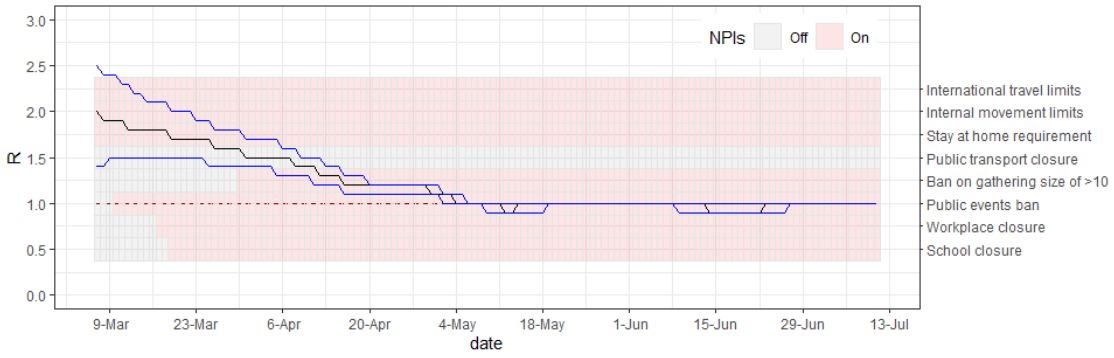

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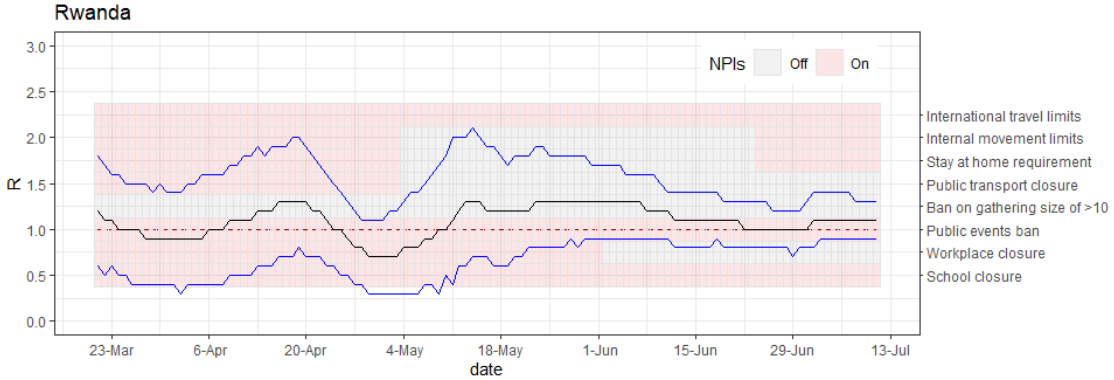

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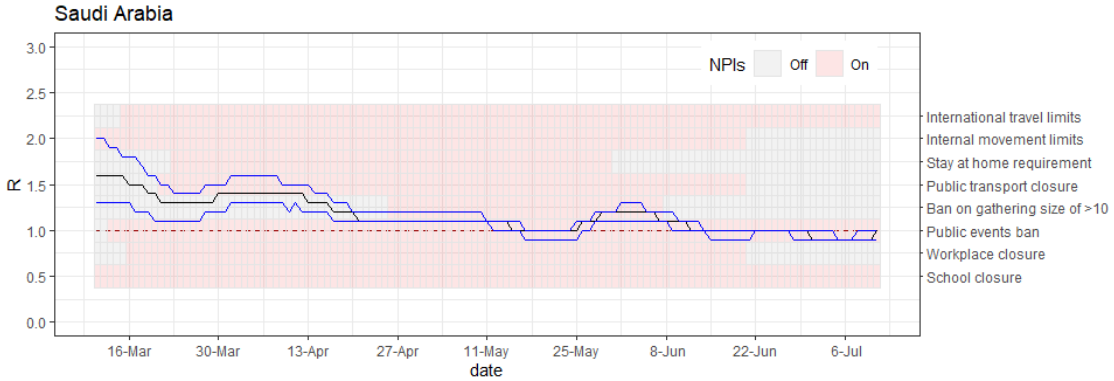

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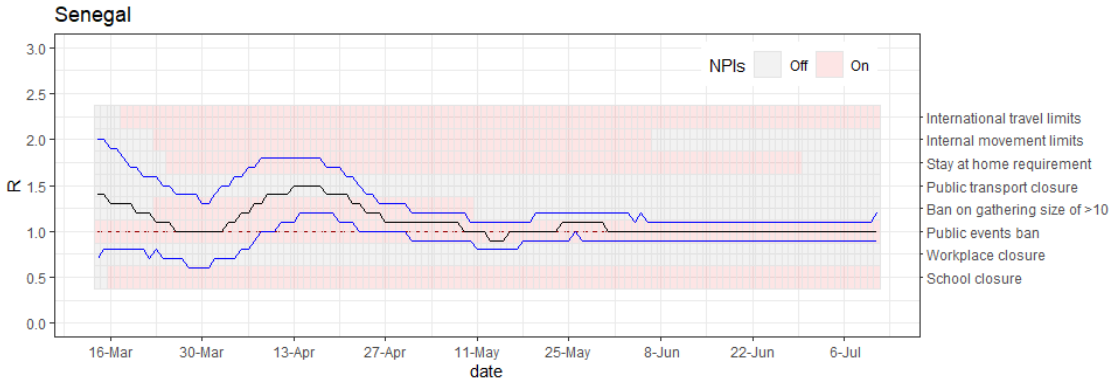

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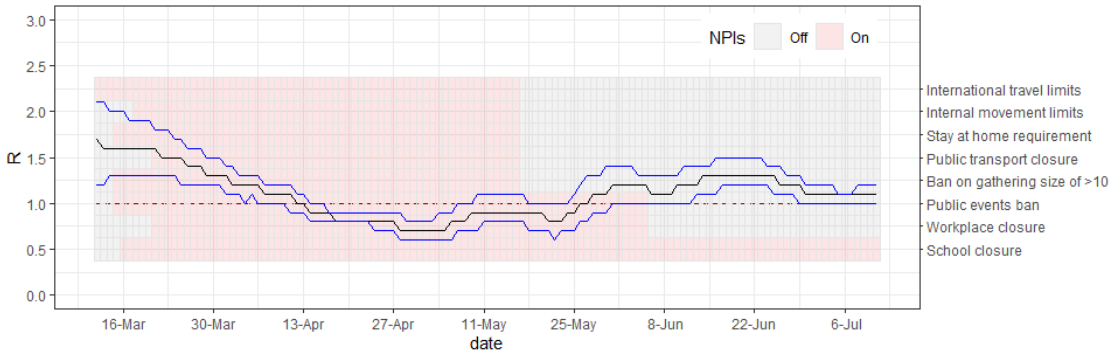

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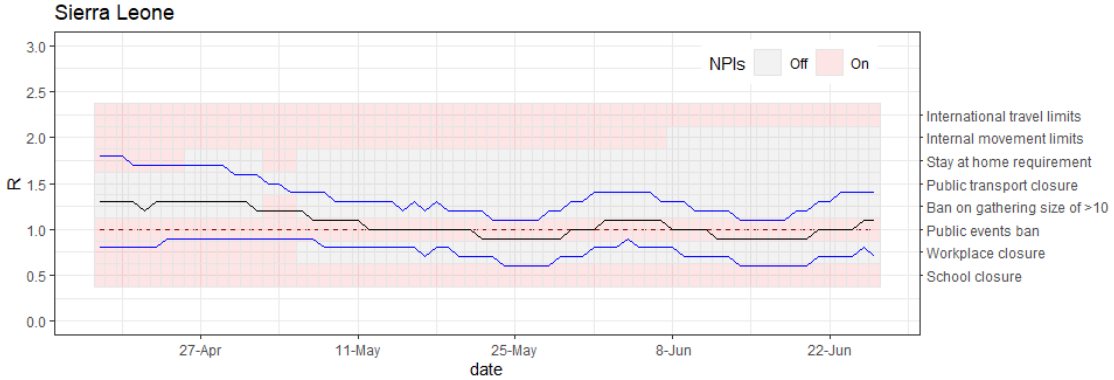

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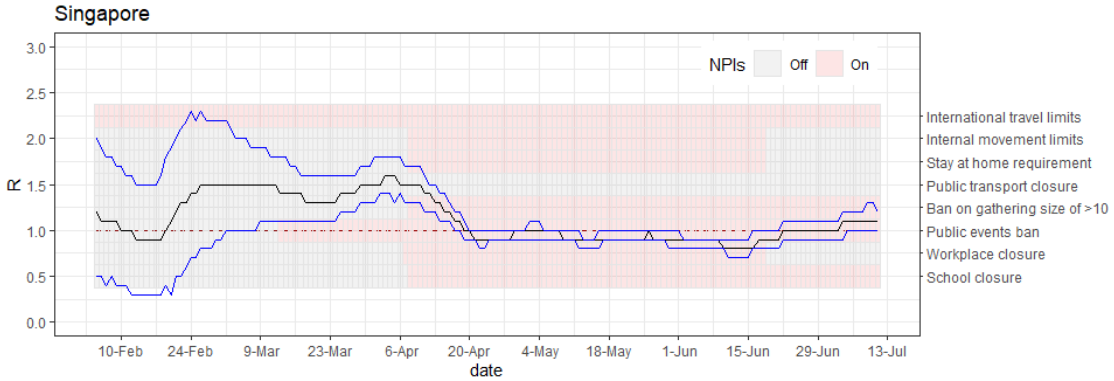

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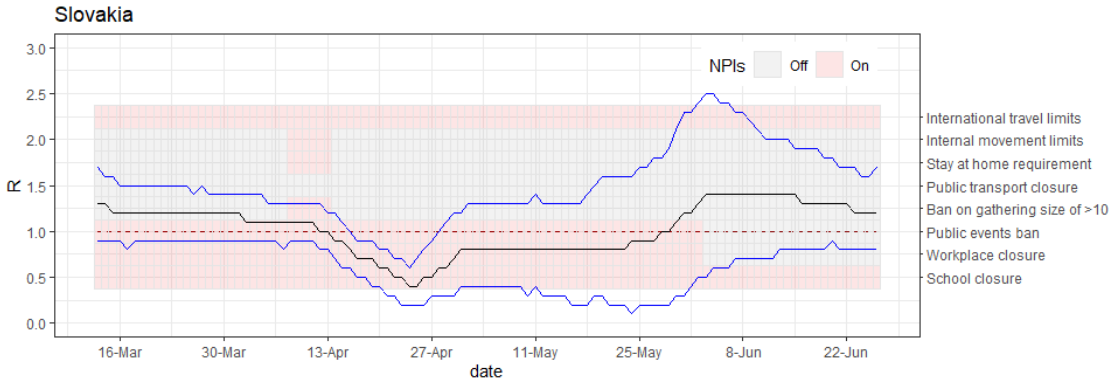

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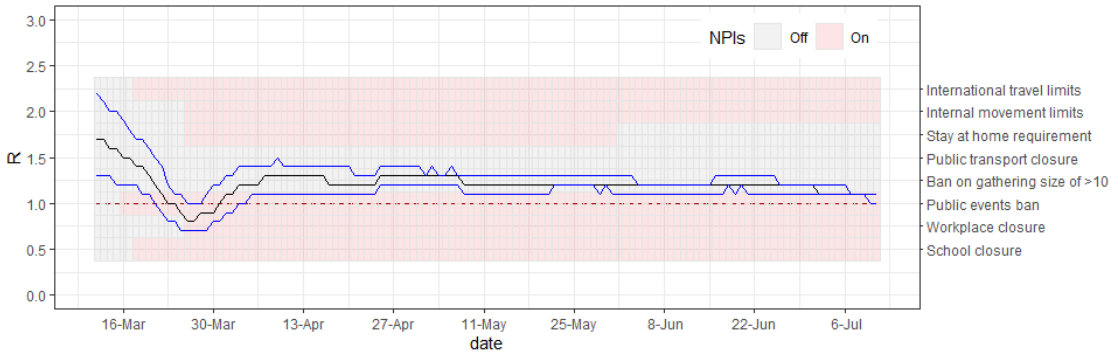

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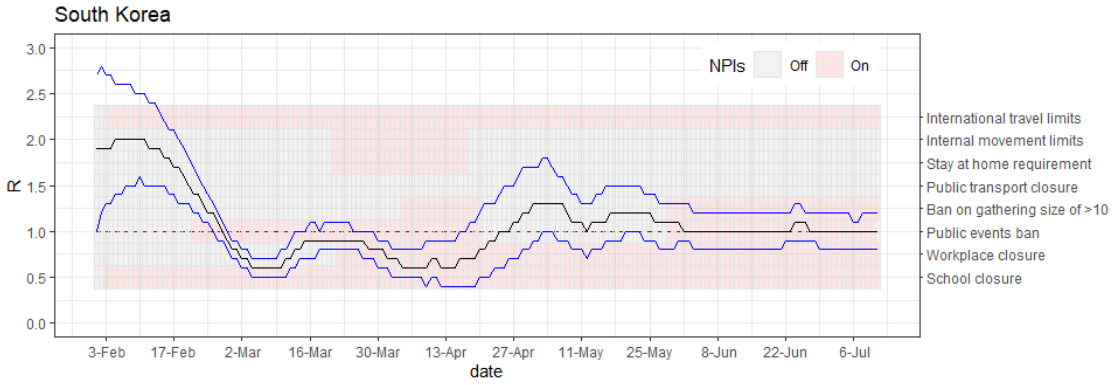

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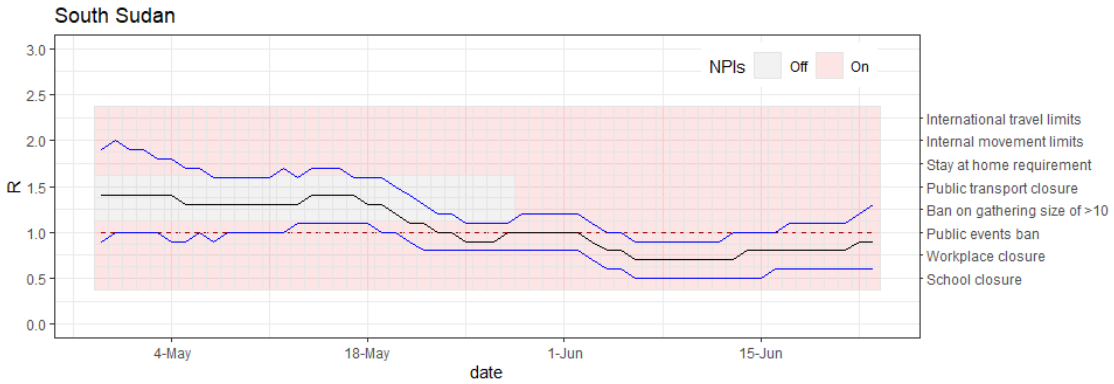

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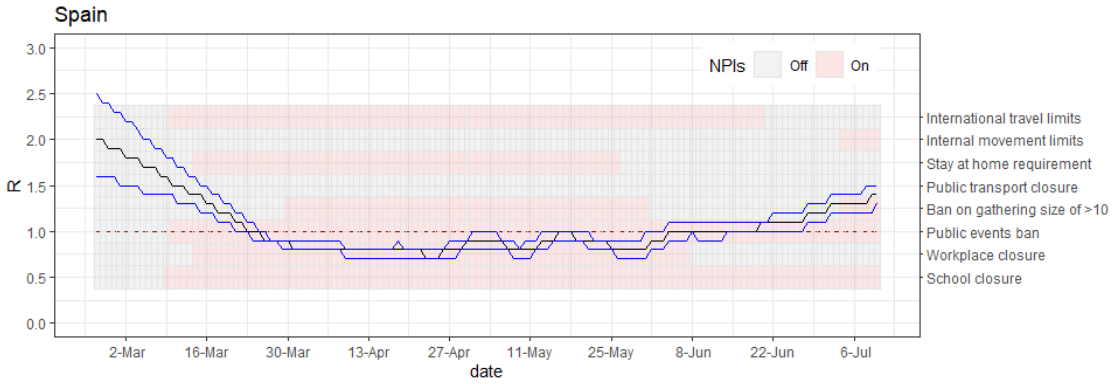

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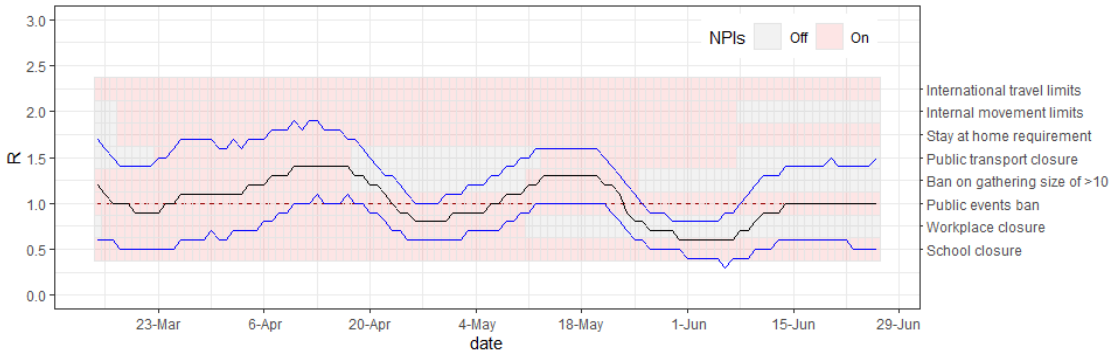

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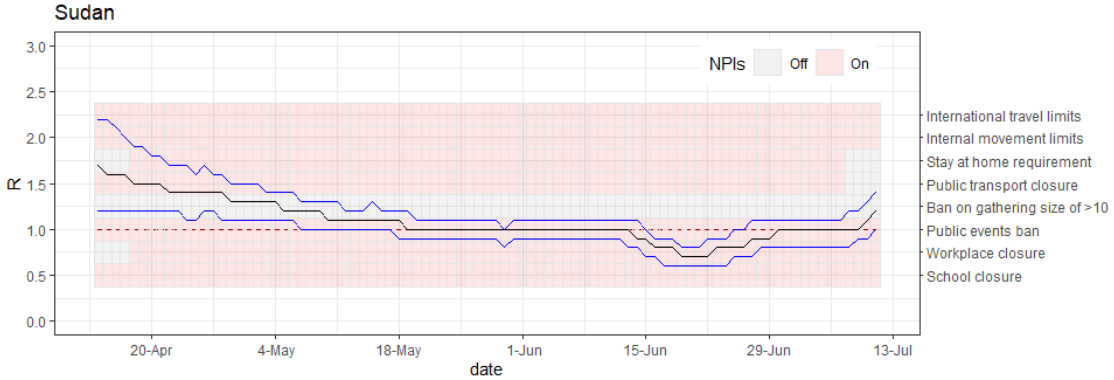

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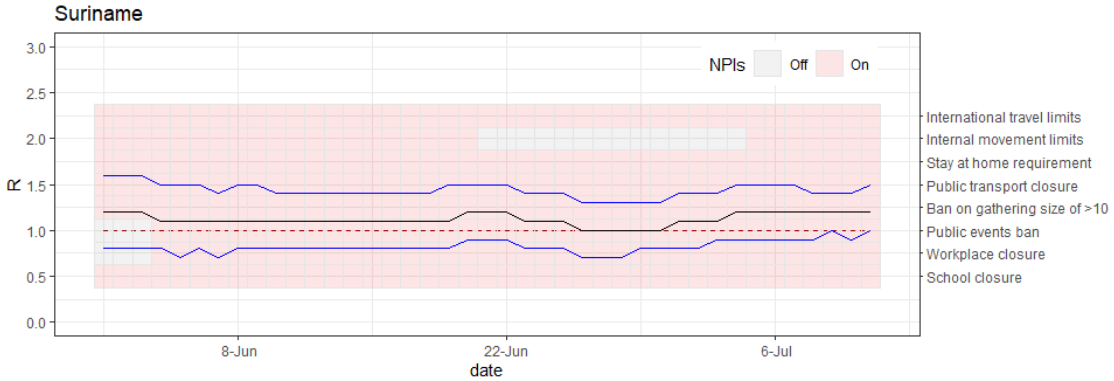

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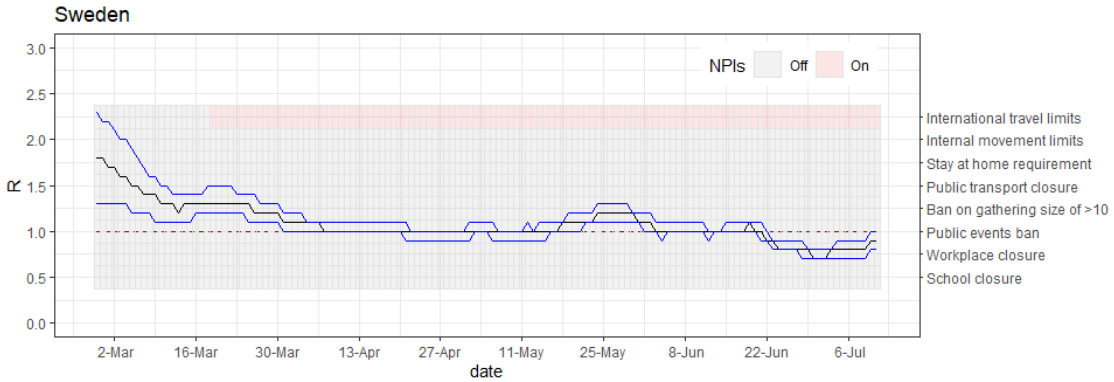

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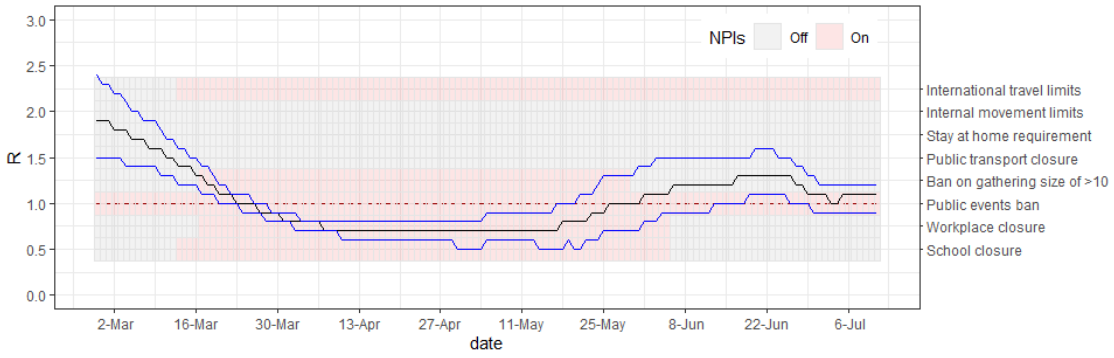

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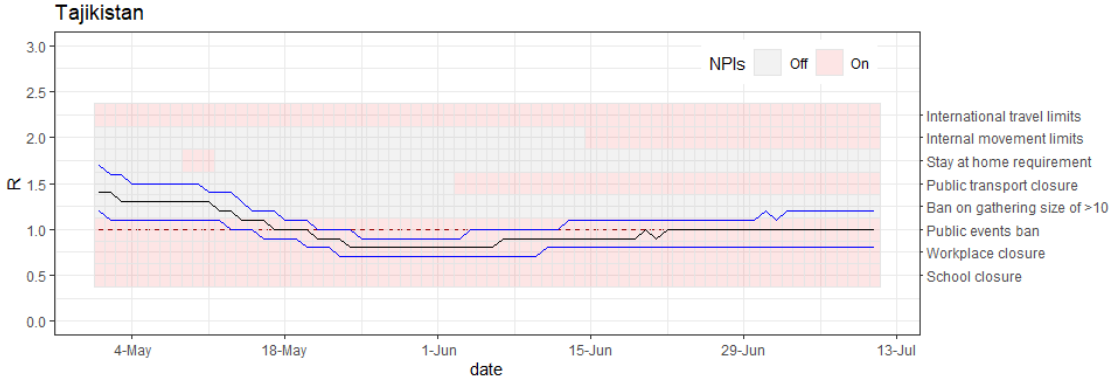

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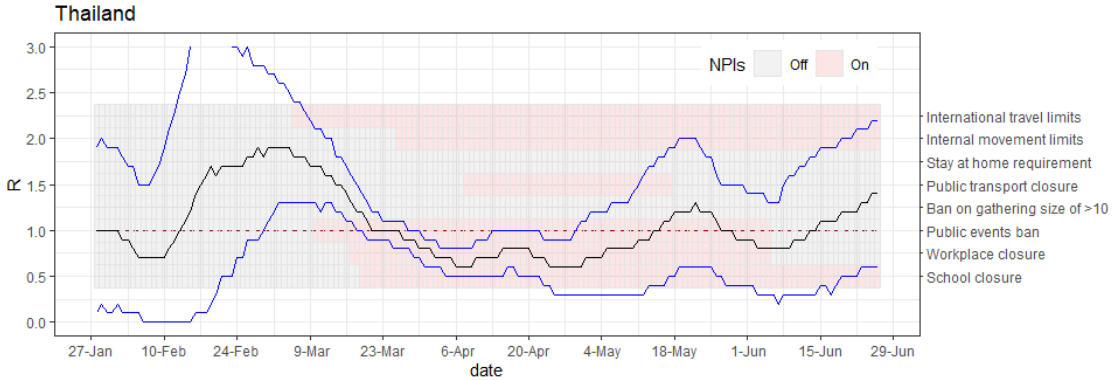

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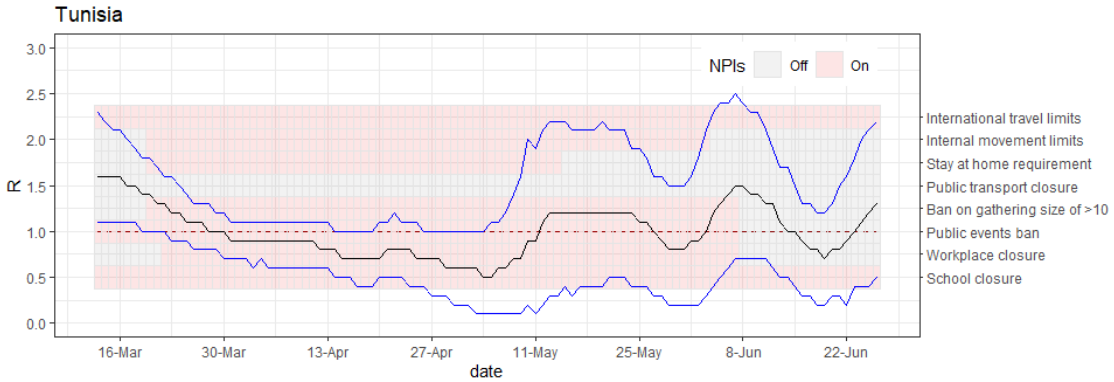

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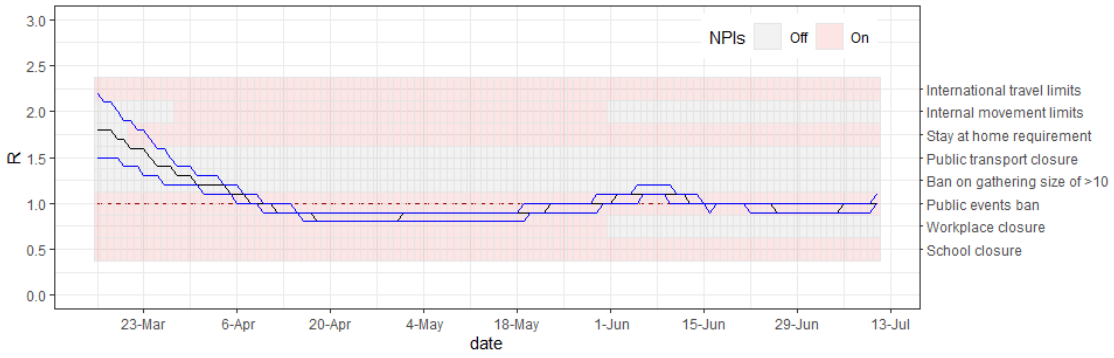

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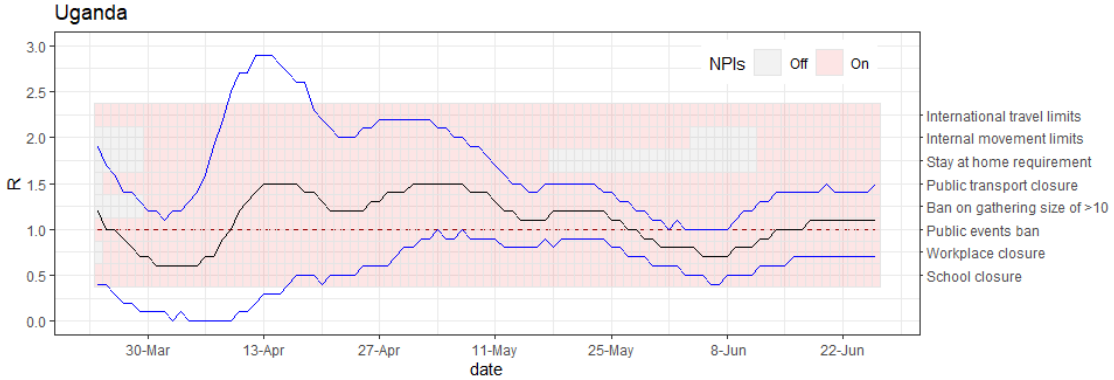

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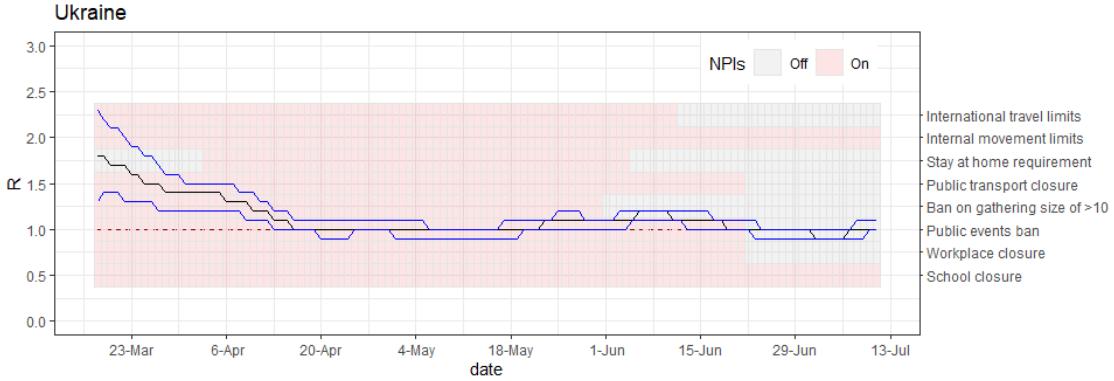

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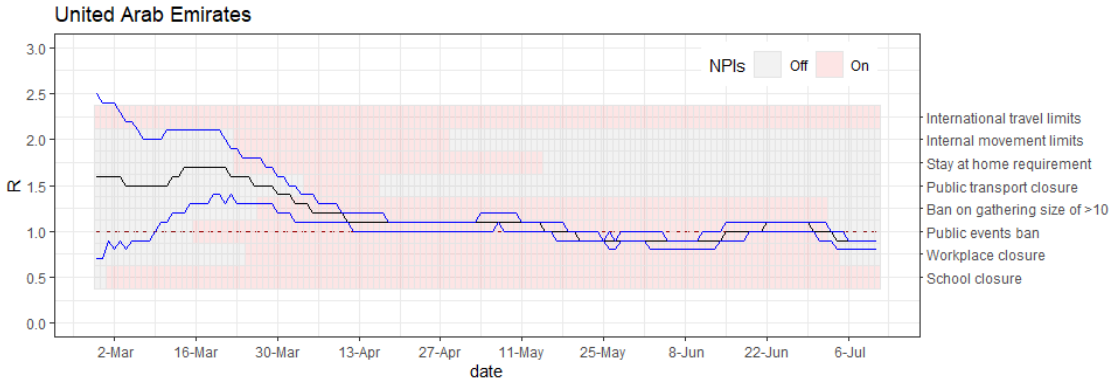

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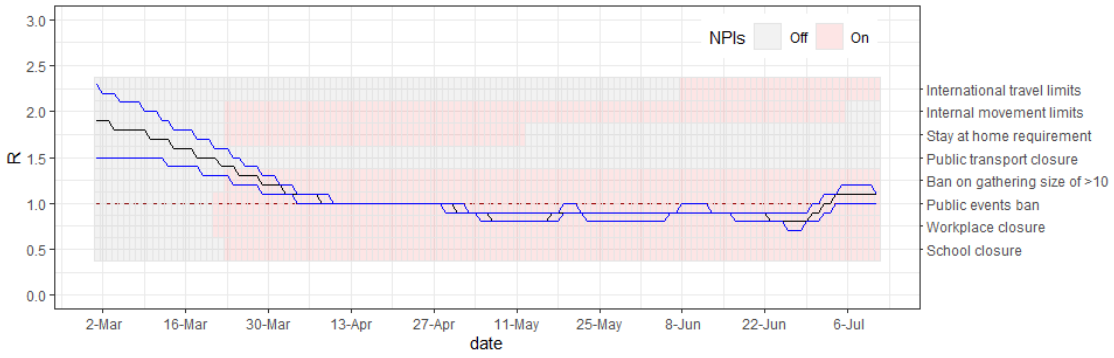

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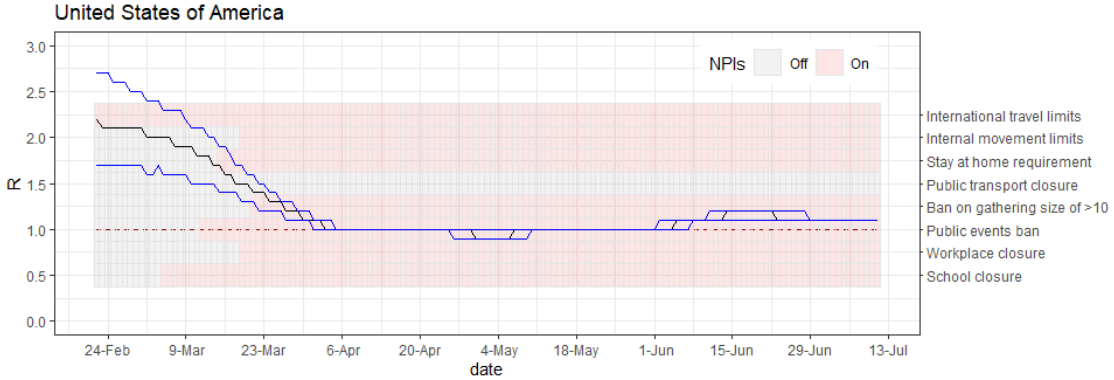

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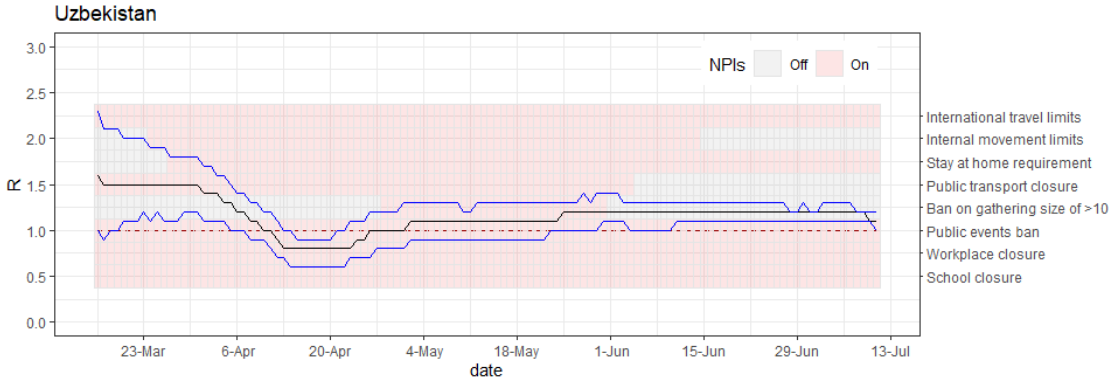
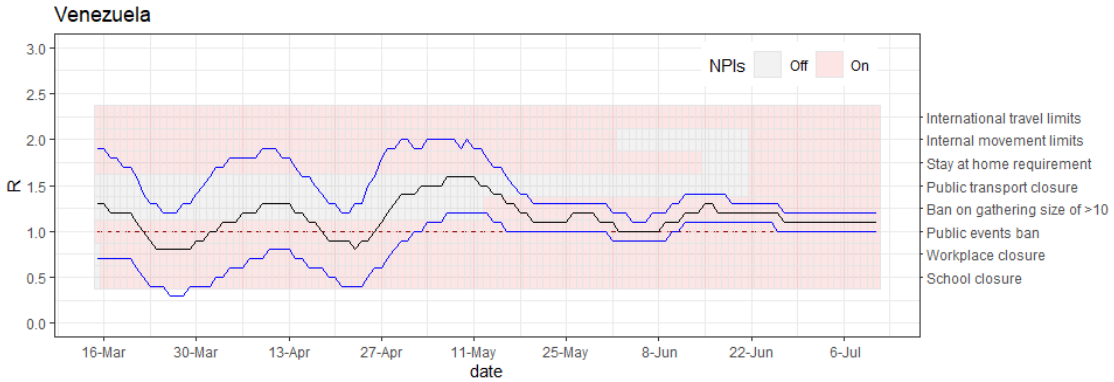
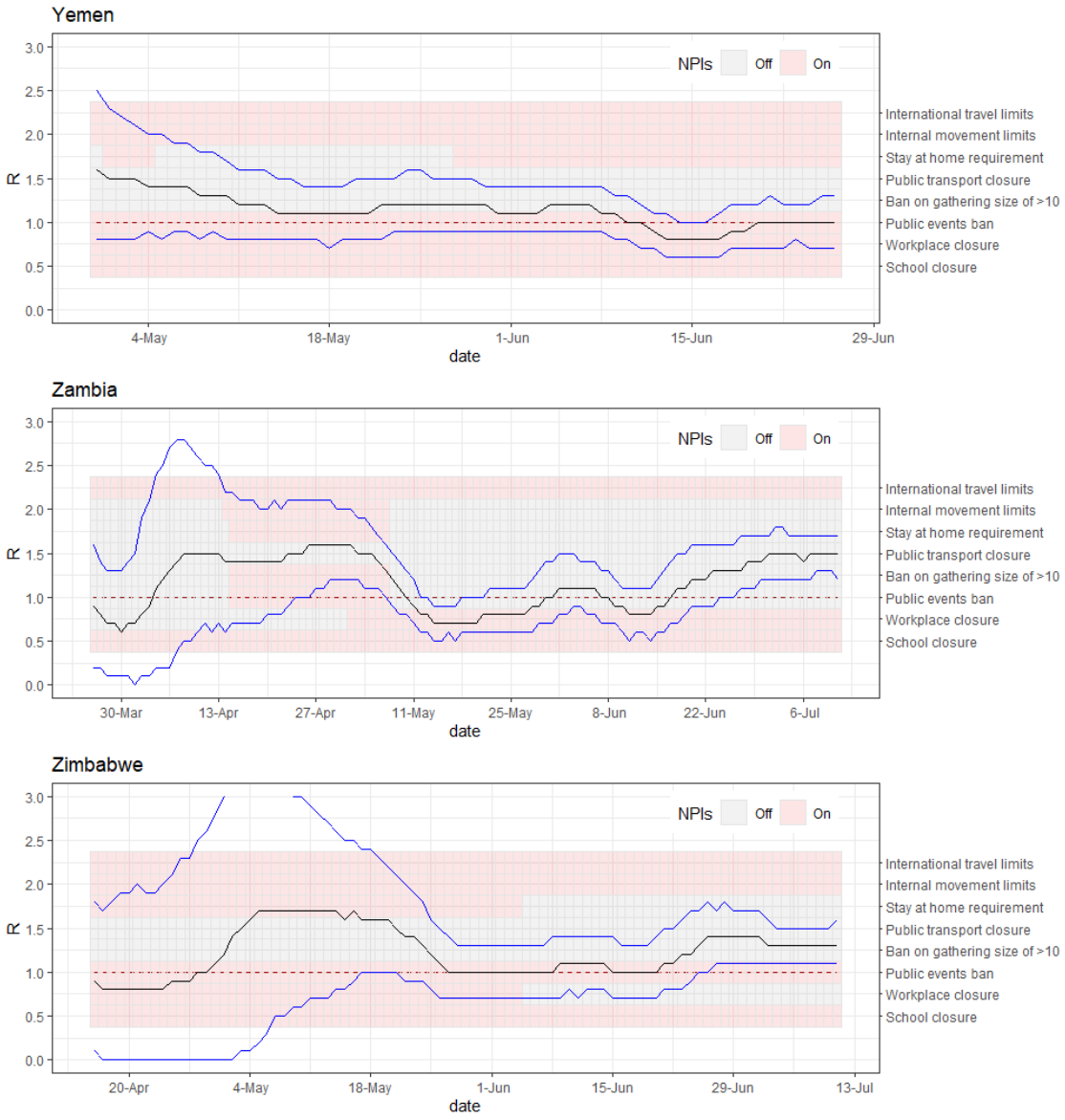


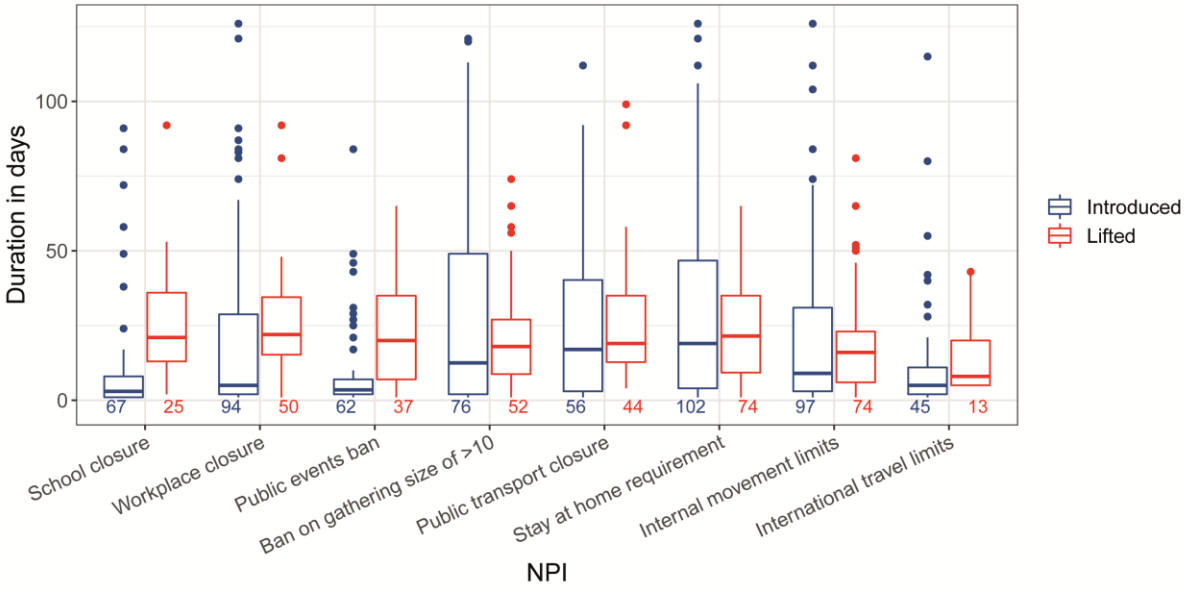
Venezuela





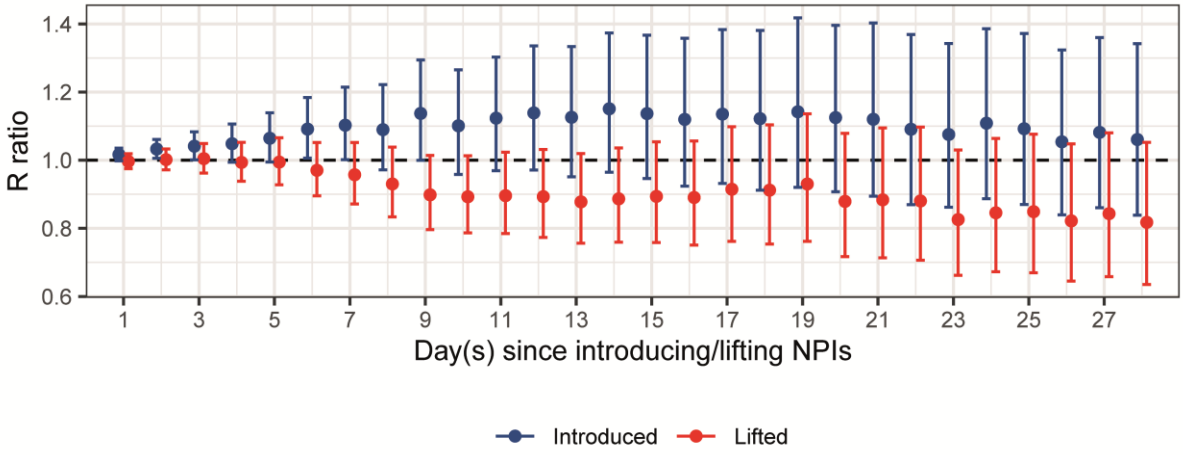
Black line and blue lines denote the point estimate and the 90% confidence intervals of the R estimates. Shaded areas denote the status of the eight NPIs. R = time-varying reproduction number; NPI = non-pharmaceutical intervention.

Figure S2. Duration of included phases by the change in NPI



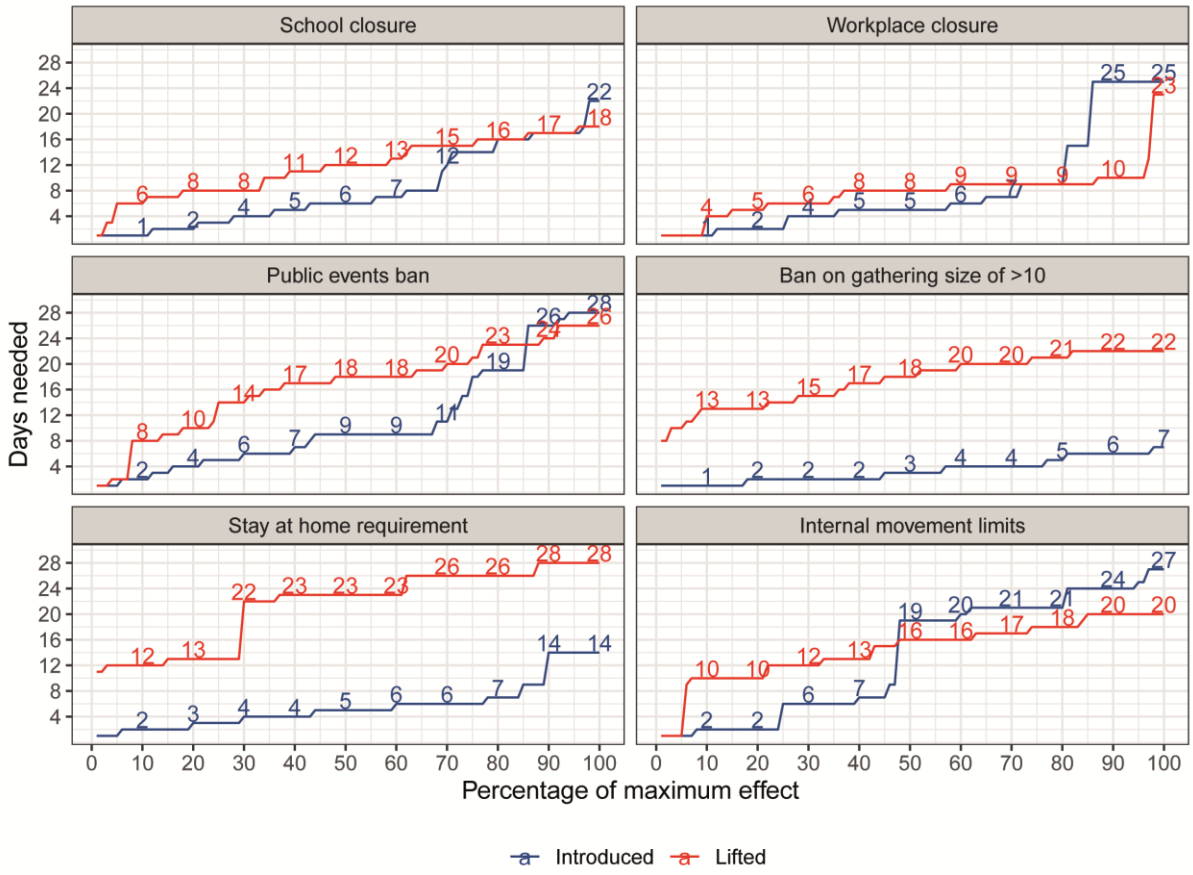
Each individual data point denotes a phase. Number of included data points is indicated below the boxplot for each NPI. NPI = non-pharmaceutical intervention.

Figure S3. Interaction effects of multiple NPIs introduced/lifted simultaneously, from the main model



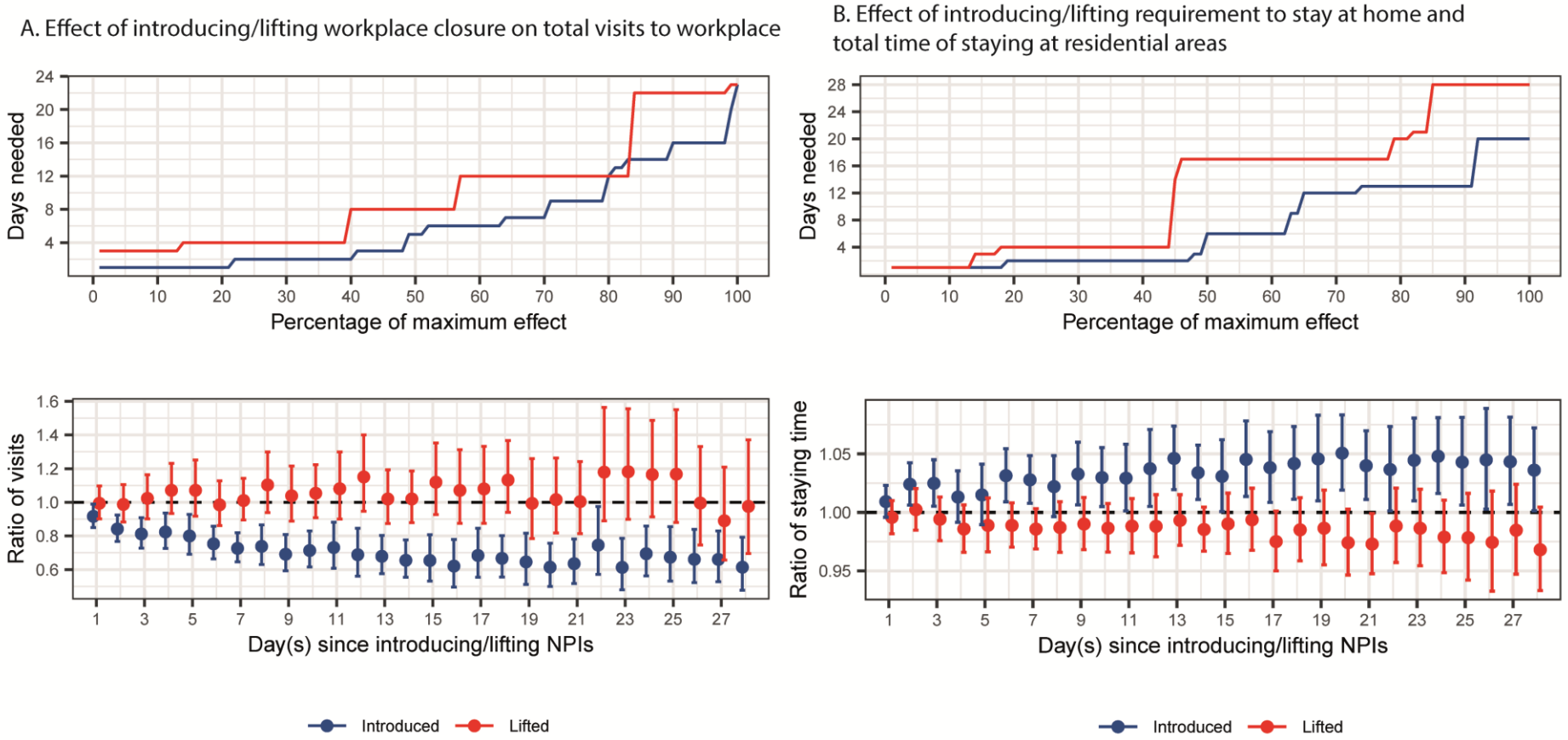
Only the additional effect (i.e. interaction effect) by multiple NPIs was presented. R ratio >1 indicates increased transmission and R ratio <1 indicates decreased transmission. NPI = non-pharmaceutical intervention.

Figure S4. Time length in days required to reach different levels of effect by introducing/lifting NPIs



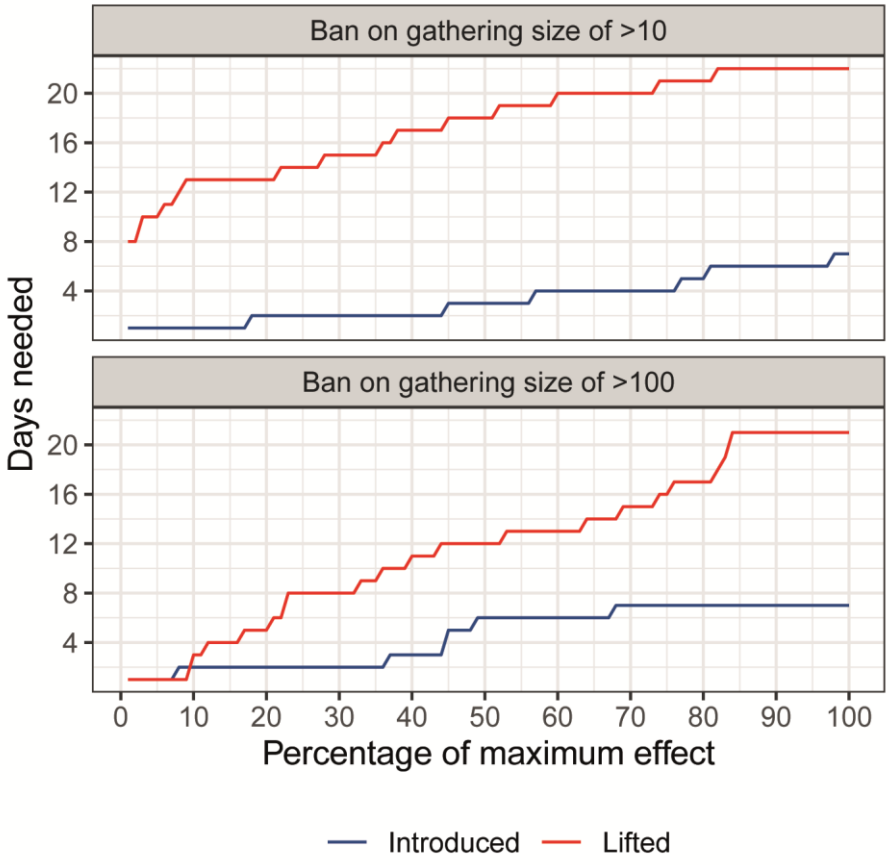
The lines show the length in days required to reach different percentage of the maximum effect of each NPI in the first 28 days following its introduction/relaxation. For the same percentage (x axis), a line on the top indicates a delay in the effect of an NPI. NPI = non-pharmaceutical intervention.

Figure S5. Effect of introducing/lifting workplace closure and requirement to stay at home on the total visits to workplace and the total time of staying at residential areas, respectively



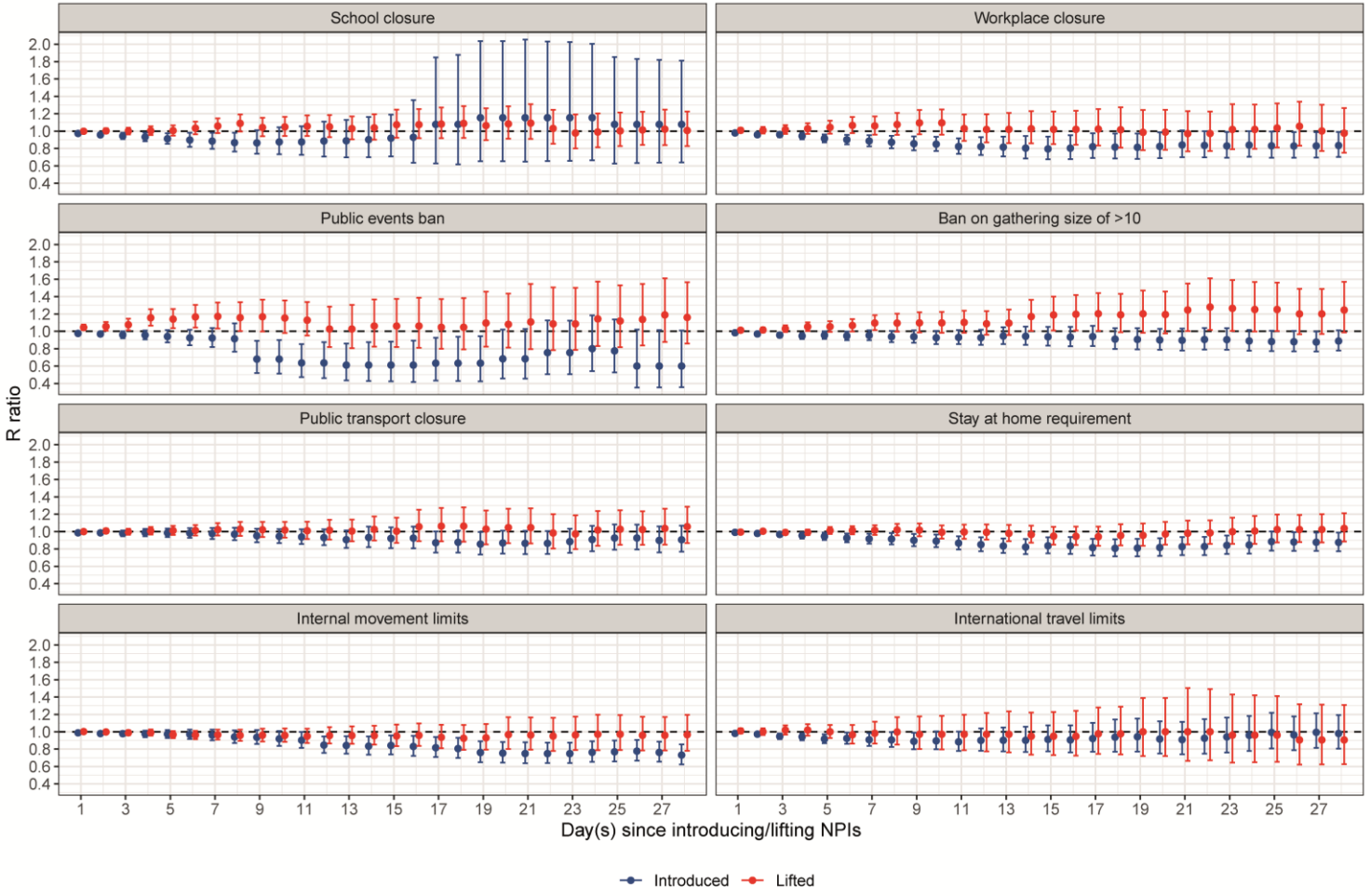
Upper figures show the time length in days required to reach different levels of effect; the lines show the length in days required to reach different percentage of the maximum effect of each NPI in the first 28 days following its introduction/relaxation. Lower figures show the change in the total visits/time measured as ratio (compared with Day 0) following the introduction and relaxation. NPI = non-pharmaceutical intervention.

Figure S6. Time length in days required to reach different levels of effect by introducing/lifting ban on gathering size of >10 persons vs >100 persons



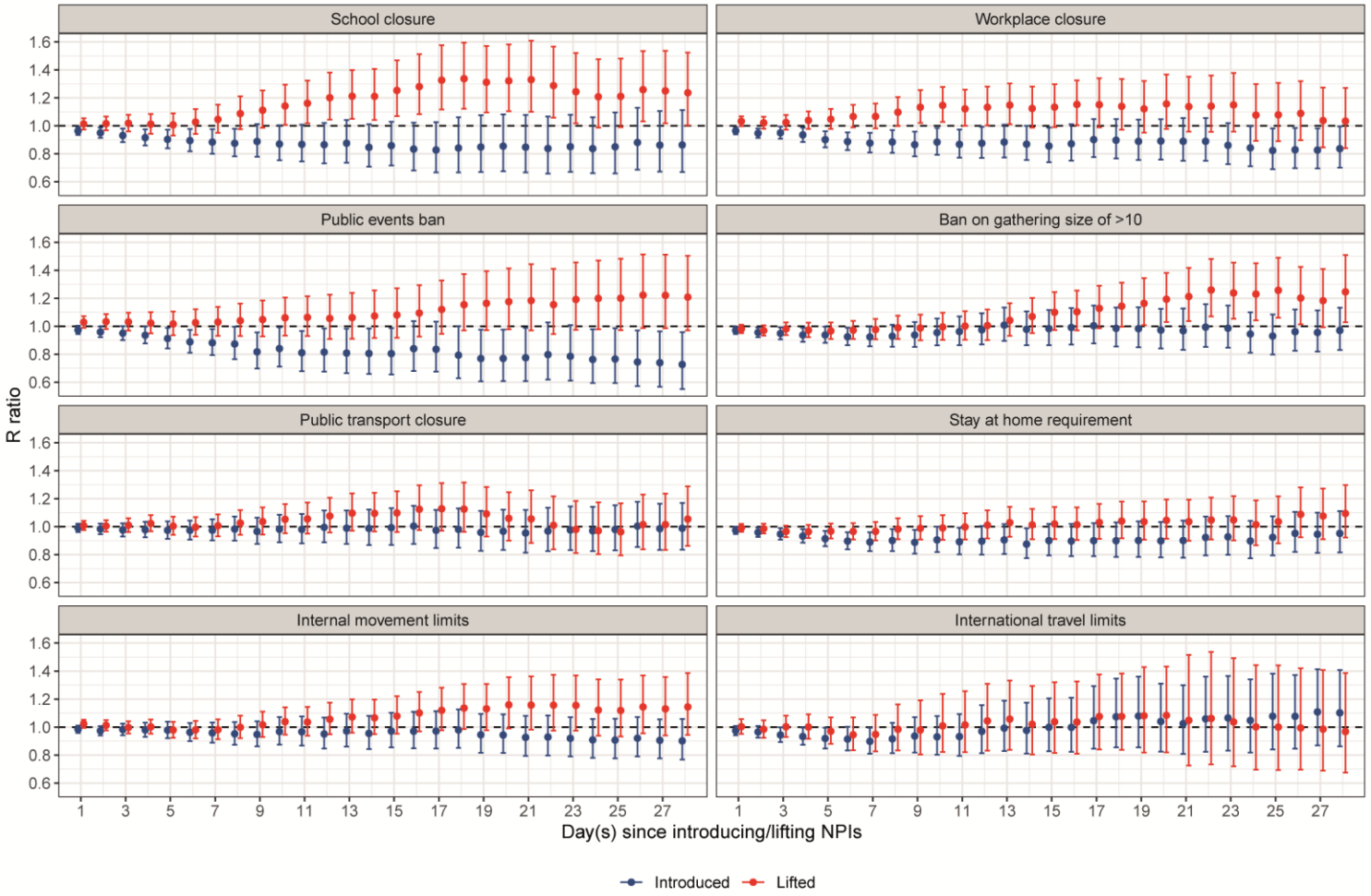
The lines show the length in days required to reach different percentage of the maximum effect of each NPI in the first 28 days following its introduction/relaxation. For the same percentage (x axis), a line on the top indicates a delay in the effect of an NPI. NPI = non-pharmaceutical intervention.

Figure S7. Results from the sensitivity analysis that only included phases during which only one NPI was changed



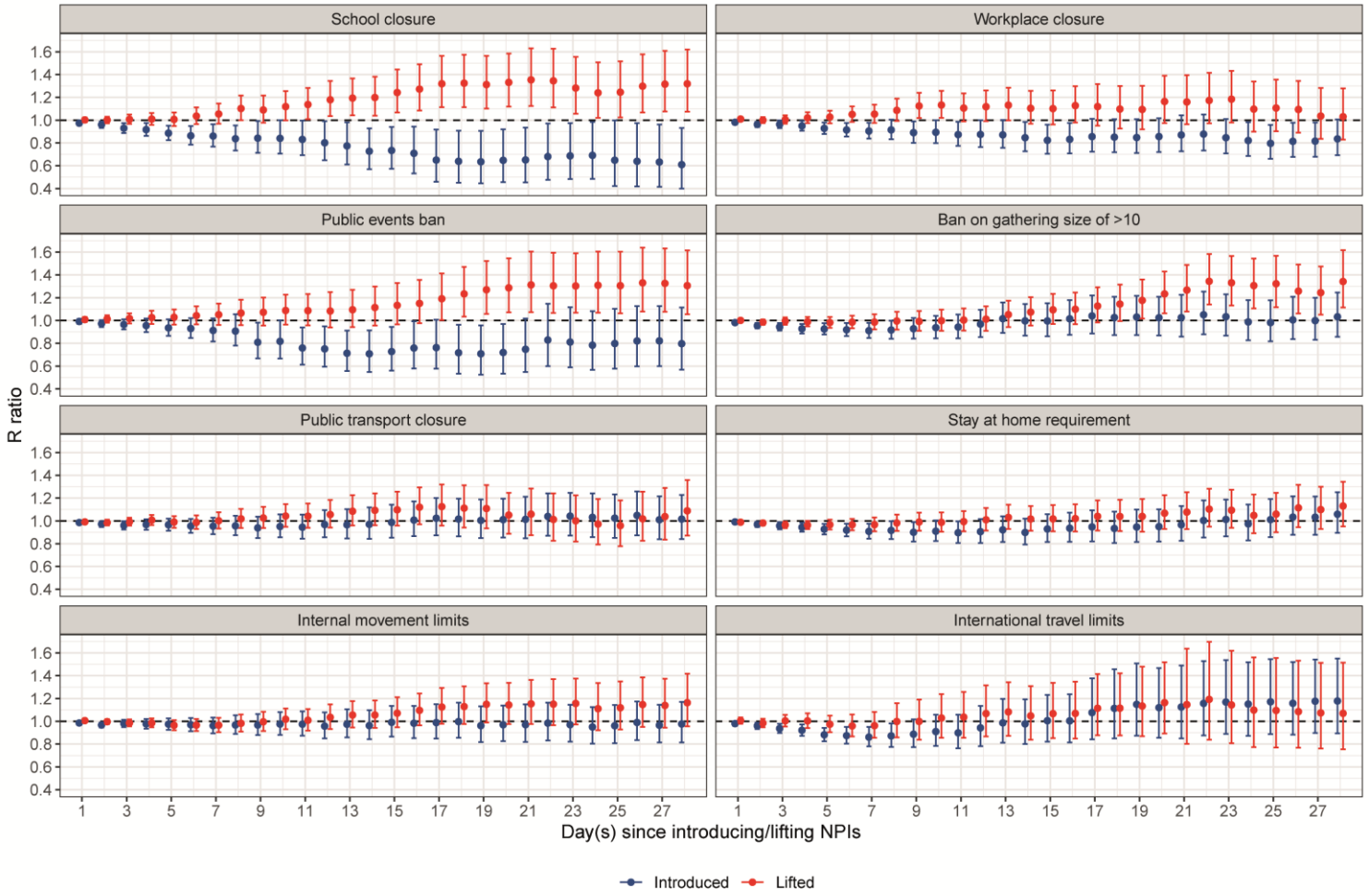
R ratio >1 indicates increased transmission and R ratio <1 indicates decreased transmission. NPI = non-pharmaceutical intervention.

Figure S8. Results from the sensitivity analysis that used the average R in the last 7 days of the previous phase for calculating R ratio



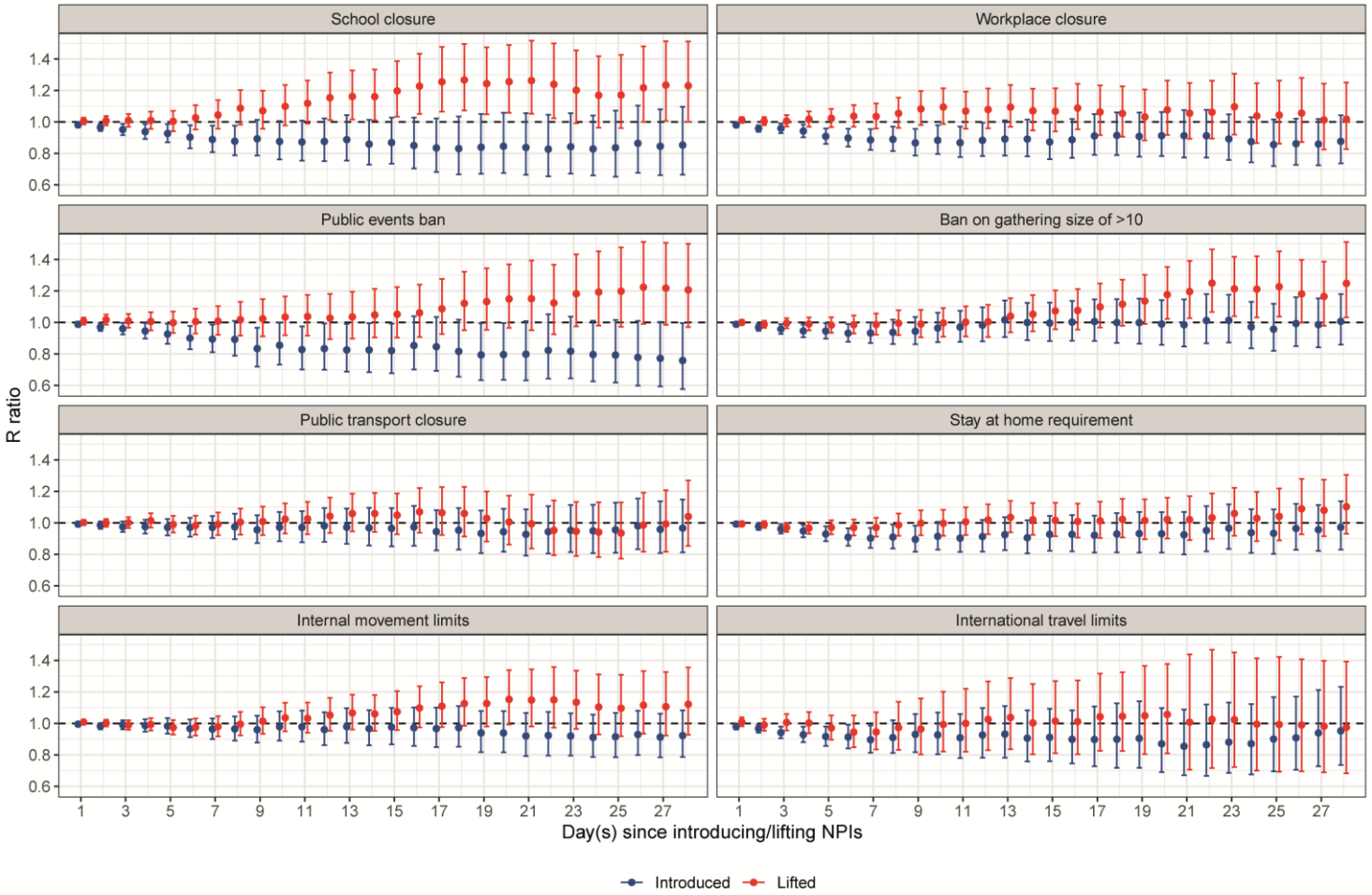
R ratio >1 indicates increased transmission and R ratio <1 indicates decreased transmission. NPI = non-pharmaceutical intervention.

Figure S9. Results from the sensitivity analysis that excluded early phases in which country's first NPI was introduced



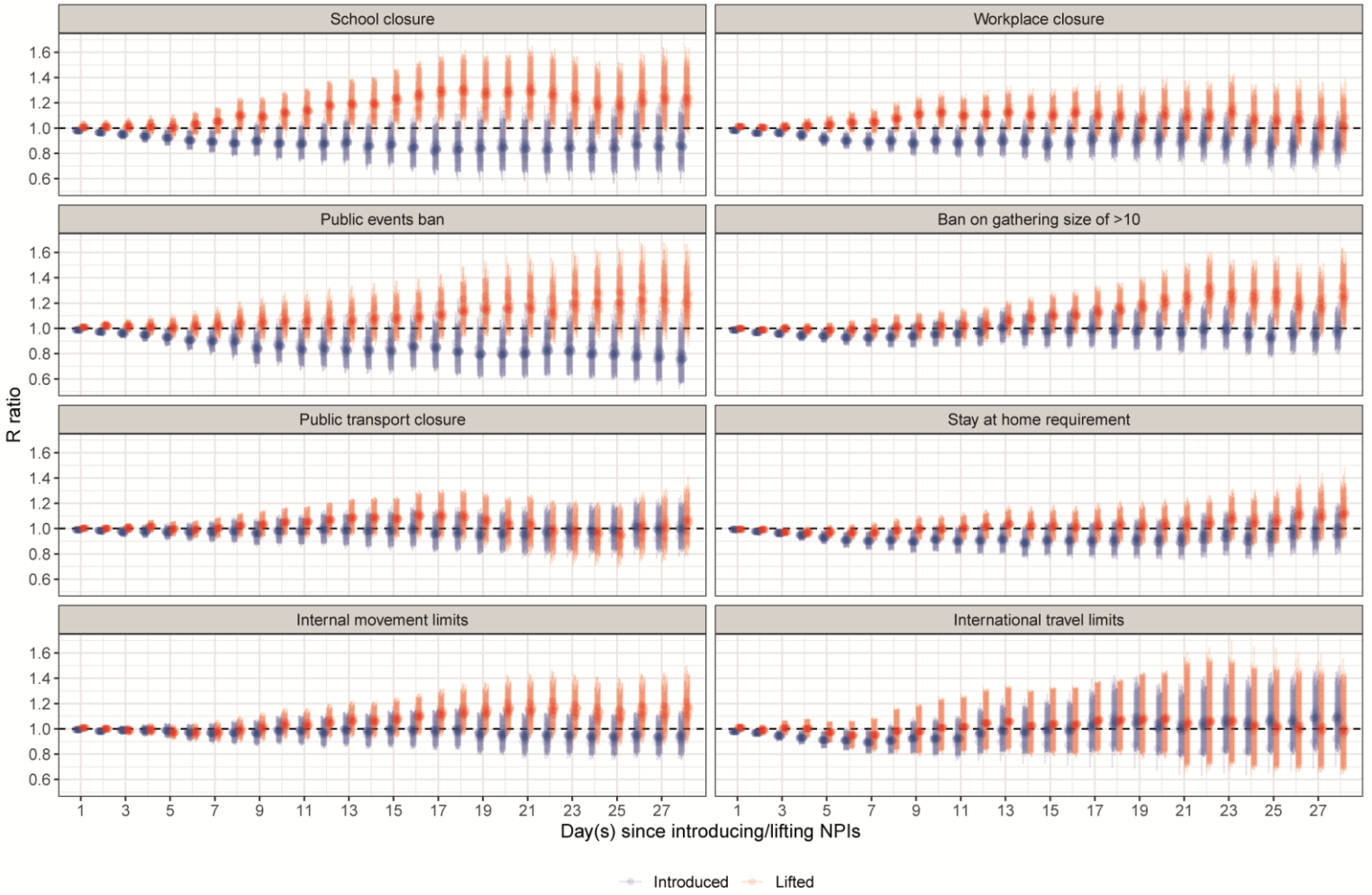
R ratio >1 indicates increased transmission and R ratio <1 indicates decreased transmission. NPI = non-pharmaceutical intervention.

Figure S10. Results from the sensitivity analysis that excluded countries that could have greater variability in NPI policies



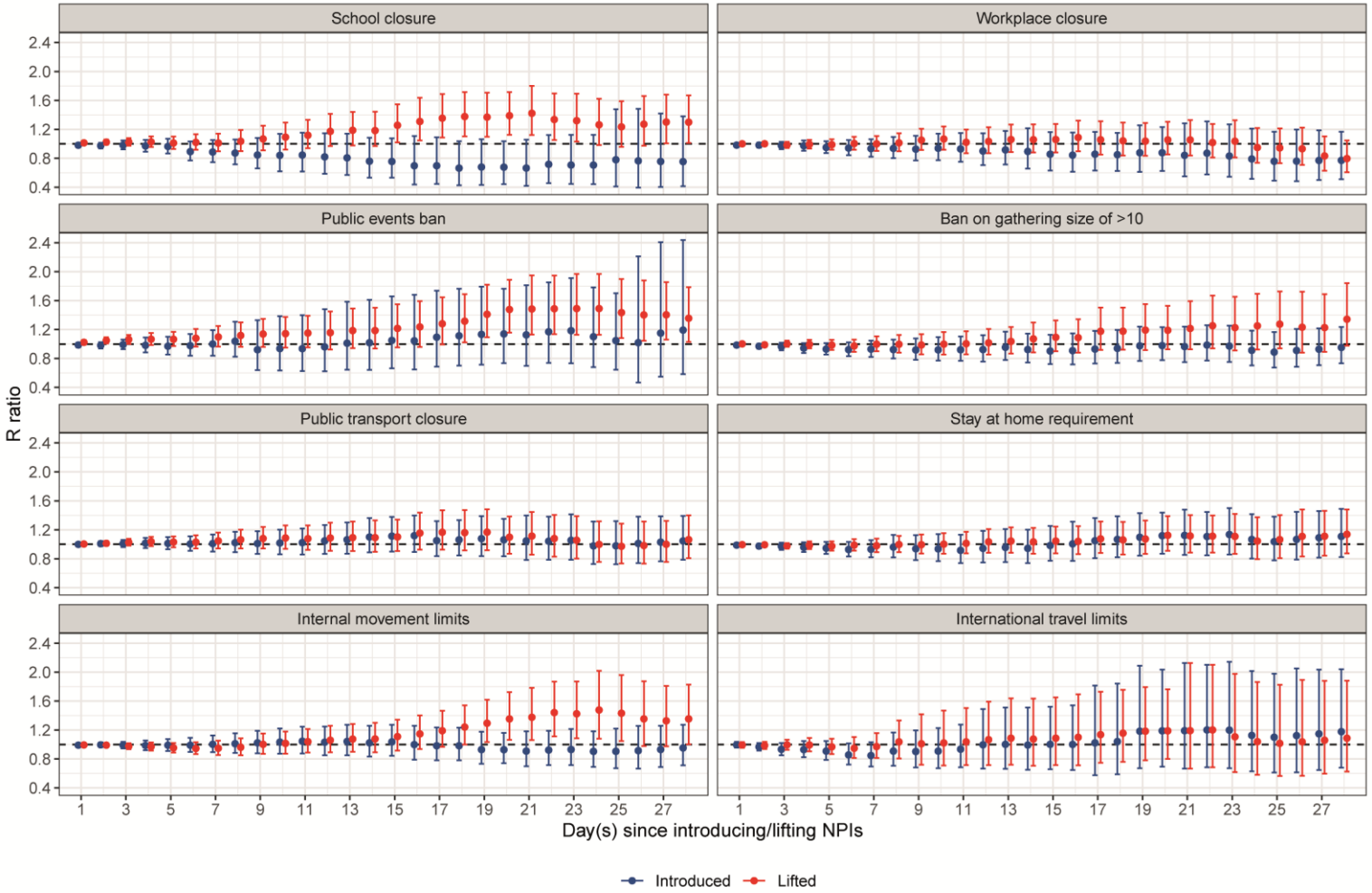
The following countries were excluded from the analysis: Brasil, Canada, China, India, Russia and United States. R ratio >1 indicates increased transmission and R ratio <1 indicates decreased transmission. NPI = non-pharmaceutical intervention.

Figure S11. Results from the sensitivity analysis that excluded 10 countries randomly each time for 20 times



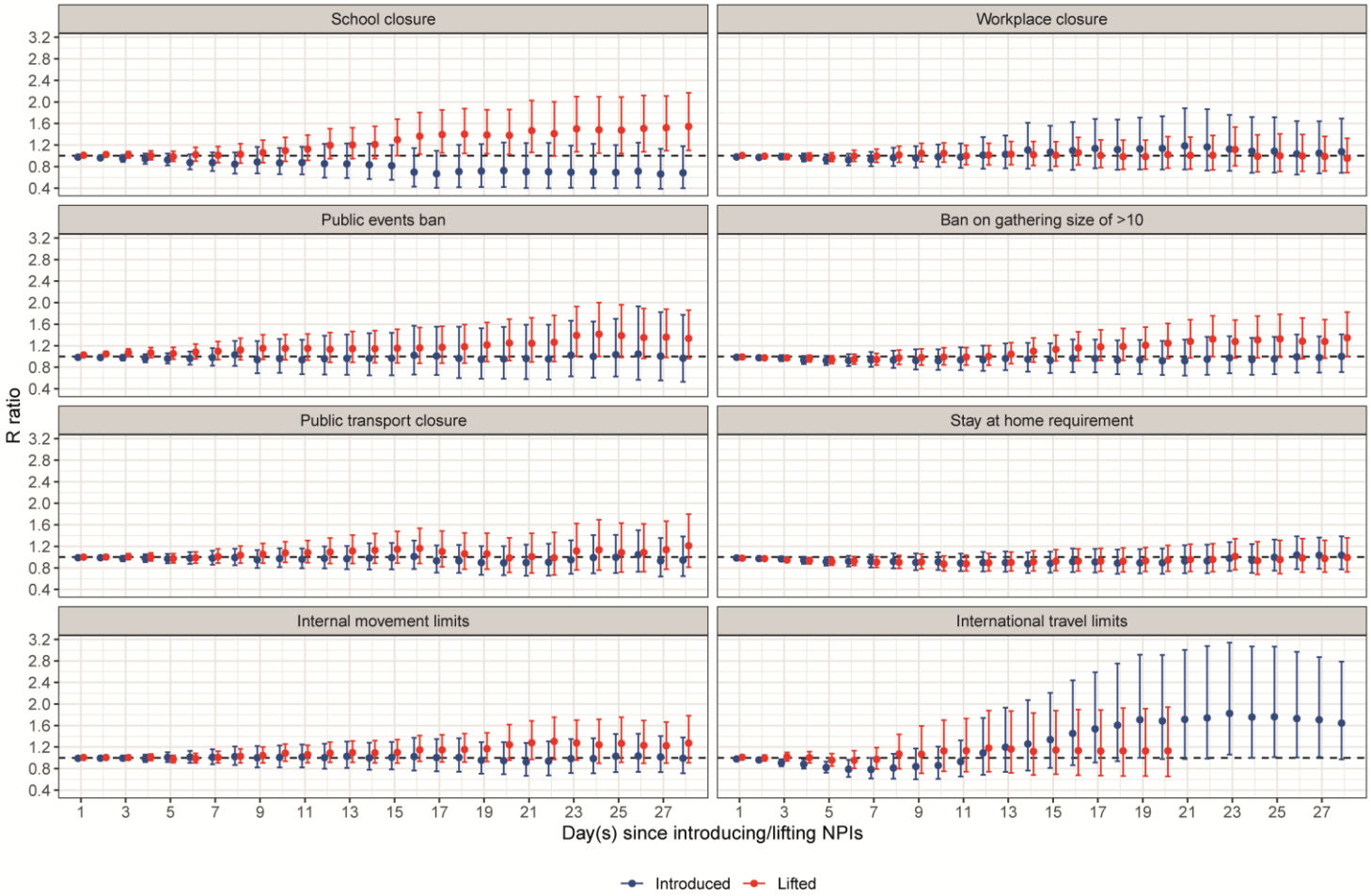
The figure represents the results from all 20 separate analyses, each of which excluded a random list of 10 countries (random seed set as 12346). The results are presented with colours of 10% transparency. For each NPI, the reference period is the day before introduction/relaxation of that NPI. R ratio >1 indicates increased transmission and R ratio <1 indicates decreased transmission. NPI = non-pharmaceutical intervention.

Figure S12. Results from the sensitivity analysis that included only phases with comprehensive testing



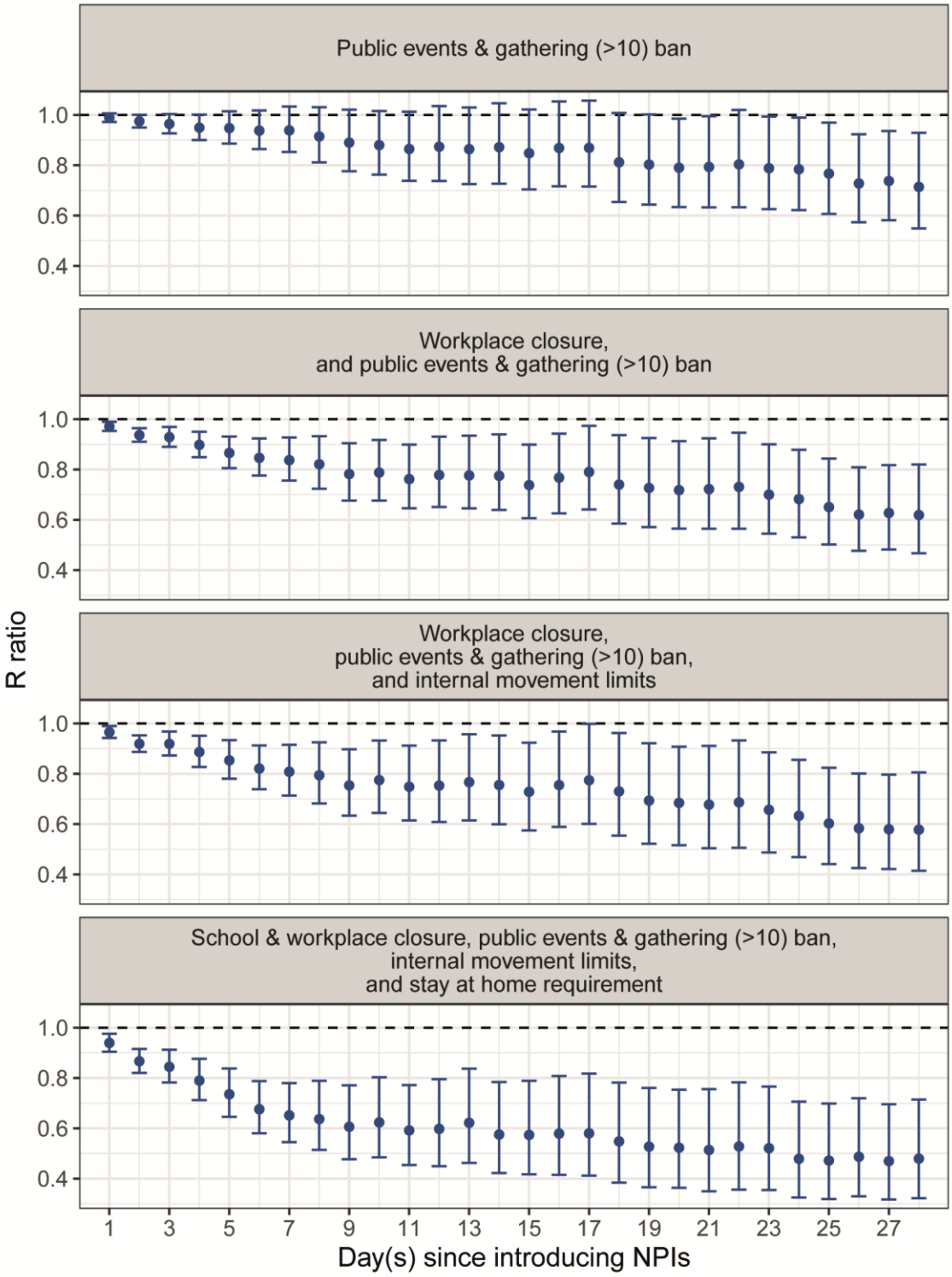
Comprehensive testing is defined by testing all patients with COVID-19 symptoms. For each NPI, the reference period is the day before introduction/relaxation of that NPI. R ratio >1 indicates increased transmission and R ratio <1 indicates decreased transmission. NPI = non-pharmaceutical intervention.

Figure S13. Results from the sensitivity analysis that included only phases with comprehensive contact tracing



Comprehensive contact tracing is defined by conducting contact tracing for all COVID-19 cases. For each NPI, the reference period is the day before introduction/relaxation of that NPI. R ratio >1 indicates increased transmission and R ratio <1 indicates decreased transmission. NPI = non-pharmaceutical intervention.

Figure S14. Modelled change in the R ratio over time in the first 28 days since the introduction of different composites of NPIs



The reference period is the day before introduction of NPIs. R ratio >1 indicates increased transmission and R ratio <1 indicates decreased transmission. NPI = non-pharmaceutical intervention.