THE LANCET
Public Health

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: Mills MC, Rüttenauer T. The effect of mandatory COVID-19 certificates on vaccine uptake: synthetic-control modelling of six countries. *Lancet Public Health* 2021; published online Dec 13. https://doi.org/10.1016/S2468-2667(21)00273-5.

Supplementary Materials

The impact of mandatory COVID-19 certificates on vaccine uptake: Synthetic Control Modelling of Six Countries

Melinda C. Mills, PhD* (ORCID: 0000-0003-1704-0001) and Tobias Rüttenauer, PhD (ORCID: 0000-0001-5747-9735) *corresponding author: melinda.mills@nuffield.ox.ac.uk

Leverhulme Centre for Demographic Science, Nuffield College and Pandemic Sciences Centre, 1 New Road, Oxford, OX1 1NF, University of Oxford, UK

Contents

1. Summary of COVID-19 certification regulations, selected countries

Table A1 provides a summary of COVID-19 certification announcements and regulations for the six selected countries in this study. The following countries that did not introduce certification in this period are included in the pool of control countries: Austria, Belgium, Canada, Croatia, Czech Republic, Finland, Great Britain, Ireland, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Turkey, and the United States. Based on additional sensitivity checks, we excluded Norway from the control pool (see Supplement 5).

The current study only considered countries that made explicit announcements about the imminent introduction of certificates from April to 23 September 2021. Given the fast moving nature of in this policy realm, some countries in our control group were considering or imminently introducing certification on or around the end of our analysis period. We use Great Britain (England, Scotland and Wales) as a control group, since in England, for instance, there was only repeated speculation and as of mid-November 2021, it had not been introduced. Certificates were only later introduced gradually in October and November in Scotland and Wales. Some provinces in Canada (Quebec, Manitoba, BC, Ontario) also gradually introduced certification schemes in late September or October. Austria introduced COVID certification in hospitality and events with more than 25 guests in early November, with plans to move to vaccine only certification in December 2021. The Netherlands initially introduced a ‘coronapas’ at the end of June 2021 aimed mostly at nightclubs, which was halted almost immediately (largely related to forgery) and reintroduced for a second time on 25 September 2021. Various sensitivity analyses are described later in this supplementary material. However, including countries that may have introduced lighter versions of certification rules in the control pool is likely to bias our results downwards if those lighter versions are also linked to an increase uptake in vaccination. We would thus err on the conservative side in our main analysis.

Table A1 Summary of COVID-19 certification announcements and regulations, selected countries (as of 23 Sept 2021)

Country	Announced	Introduced	Setting requirements	Exemptions, additional rules	Antigen testing	Selected sources
Denmark	4 February 2021	6 April - 1 September 2021 (until 10 September for night clubs, large events)	6 April: for access to hairdressers, beauty salons and driving schools, 21 April: outdoor hospitality, 6 May: indoor hospitality, cultural events, 21 May: all other venues		Free of charge	End of covid pass: https://www.euronews.com/2021/09/01/denmark-s-high-vaccination-rate-sees-covid-pass-ended-for-restaurants Introduction of covid pass: https://www.euronews.com/2021/04/06/covid-19-denmark-launches-coronapas-certificate-to-reopen-economy Plans announced: https://www.euronews.com/2021/02/04/covid-in-europe-denmark-announces-plans-for-a-corona-pass
France	23 July 2021	09 August (or 29 July guidelines) depending on specific rules	Visiting hospitals, care homes, hospitality venues, events (>50 people), long-distance travel by plane, train or coach, campsites/hotels, malls, Mandatory for workers who have contact with customers (since 30 August 2021), mandatory for workers in healthcare, fire service and police (since 15 September)	Local authorities able to put in place further restrictions on events	Free of charge for those covered by French social security	https://www.gouvernement.fr/en/coronavirus-covid-19 announcement: https://www.lemonde.fr/politique/article/2021/07/23/passe-sanitaire-les-deputes-votent-la-mesure-controversee-nuit-d-apres-debats-a-l-assemblee_6089243_823448.html mandatory for certain workers: https://www.connexionfrance.com/French-news/French-health-pass-pass-sanitaire-to-become-obligatory-for-public-facing-employees-of-public-venues-from-August-30 August 09 reference: https://uk.ambafrance.org/Health-pass-and-vaccination-in-the-UK

						29 July reference to other guidelines: https://www.gouvernement.fr/en/coronavirus-covid-19
Germany	3 August 2021	23 August 2021	Visiting hospitals, care homes, hospitality venues, events, indoor parties and sports, for the use of body-related services (e.g., hairdresser, massages, etc.) Vaccinated individuals do not need to self-isolate when entering Germany (even from high risk areas)	counties below a specific incidence rate exempted depending on federal state rules (7 day rate < 35 new infections per 100,000)	Free of charge until 11 October	https://www.bundesregierung.de/breg-de/aktuelles/bund-laender-beratung-corona-1949606 Speculation about prices of tests after 11 October: https://www.merkur.de/leben/gesundheit/corona-tests-kosten-ab-oktober-selbst-zahlen-pcr-antigentest-90978260.html Announcement: https://www.tagesschau.de/inland/gesundheitsministerium-schutz-corona-101.html
Israel	'old' green pass used previously reintroduced 29 July 2021 22 July 2021 (for reintroduction of 'old' green pass) 29 August 2021 (for introduction of 'new' green pass)	19 February - 1 June 2021 initial 'old' green pass required 29 July 2021: Re-introduction of 'old' green pass 3 October 2021: 'new' green pass (valid for 6 months after vaccination or infection)	Cultural, sporting events, gyms, hospitality venues, conferences, tourist attractions, places of worship, events, higher education establishments		Free of charge	https://www.bbc.co.uk/news/world-europe-56522408 https://lexatlas-c19.org/israel-is-the-green-pass-an-example-to-follow/ (initial green pass) https://www.gov.il/en/departments/news/29072021-02 https://www.gov.il/en/departments/news/spoke_greenbadge220721 (announcement re-introduction) New green pass (Ministry of health) https://corona.health.gov.il/en/directives/green-pass-info/ Announcement: https://www.gov.il/en/departments/news/29082021-01
Italy	22 July 2021	6 August 2021	Train stations, culture/leisure venues,		Free of charge	https://www.bbc.co.uk/news/world-europe-58590187

			indoor sport, private parties, fairs, hospitality venues Additionally: Mandatory for all workers (from 15 October, announced 16 September)			https://www.schengenvisainfo.com/news/italy-makes-covid-health-pass-mandatory-for-unvaccinated-people-including-foreign-tourists/ https://www.bbc.co.uk/news/world-europe-58590187 Testing: https://www.thelocal.it/20210504/how-you-can-get-a-free-coronavirus-test-in-11-italian-cities/
Switzerland	19 May 2021 08 September 2021	7 July 2021 13 September 2021	Obligatory: Events > 1000 people, indoor events (e.g. clubs, discos, nightclubs) Obligatory: Events > 30 people indoor hospitality, culture/leisure venues (e.g., museums, swimming pools), private events in public venues (e.g., weddings)	Covid-certificate (valid for 1 year after vaccination/ 6 months after infection)	Free of charge until 10 October	https://www.newsd.admin.ch/newsd/message/attachments/68144.pdf Announcement: https://www.srf.ch/news/schweiz/leben-mit-dem-coronavirus-so-soll-das-covid-zertifikat-genutzt-werden https://www.admin.ch/gov/de/start/dokumentation/medienmitteilungen.msg-id-85035.html Testing: https://www.bag.admin.ch/bag/de/home/krankheiten/ausbrueche-epidemien-pandemien/aktuelle-ausbrueche-epidemien/novel-cov/testen.html#-634686877

2. Vaccine eligibility for children aged 12 and older by selected countries, 2021

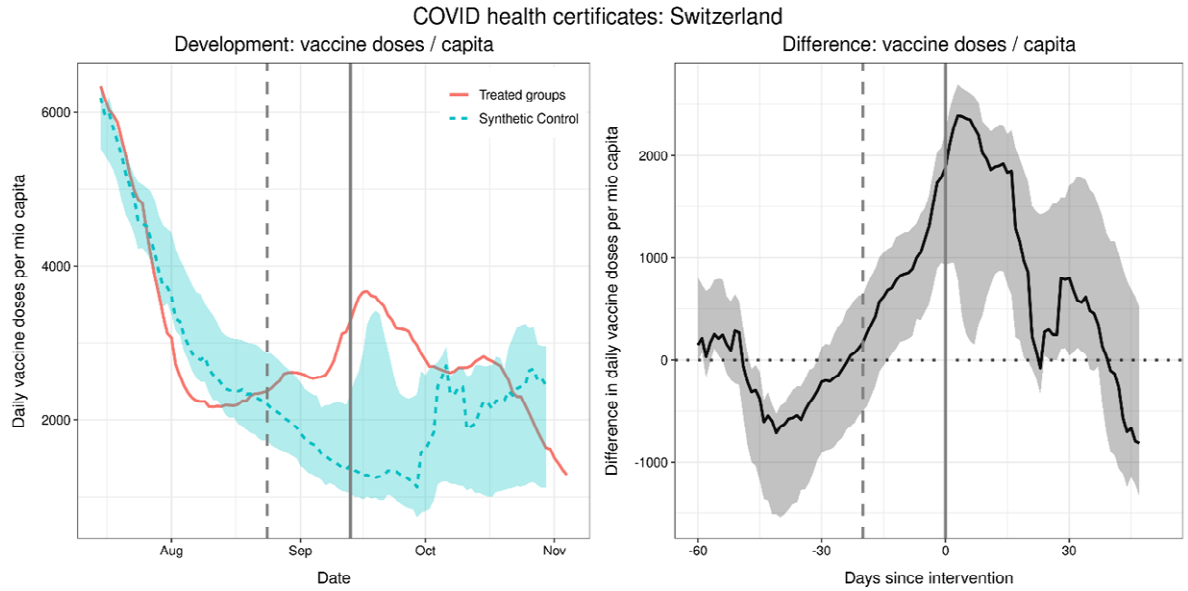
Table A2 Vaccine eligibility for children aged 12 and older by selected countries, 2021

Country	Timing of age-related eligibility	Age related eligibility for younger groups	Exemptions, additional rules	Source
Denmark	mid July 2021	12-15 years	Earlier 16-17 year olds	https://www.euronews.com/next/2021/09/14/covid-vaccine-for-children-who-in-europe-is-leading-the-race https://www.sst.dk/en/English/Corona-eng/Vaccination-against-COVID-19/Who-should-be-vaccinated/12-15-year-olds https://www.thelocal.dk/20210715/children-aged-12-15-in-denmark-begin-covid-19-vaccination/ https://www.sst.dk/en/English/Corona-eng/Vaccination%20against%20COVID-19/Who%20should%20be%20vaccinated/16-18%20years
France	15 June 2021	12 years and older		https://www.euronews.com/2021/06/02/france-extends-covid-19-vaccination-to-12-18-year-olds https://www.euronews.com/next/2021/09/14/covid-vaccine-for-children-who-in-europe-is-leading-the-race
Germany	07 June 2021	12 and older	Pfizer recommended only for children with certain chronic illnesses	https://www.reuters.com/world/europe/german-panel-gives-limited-approval-covid-19-shot-adolescents-2021-06-10/ https://www.reuters.com/business/healthcare-pharmaceuticals/eu-regulator-endorses-pfizer-biontech-covid-19-vaccine-adolescents-2021-05-28/
	16 August 2021	12 and older	No health restrictions	https://www.euronews.com/2021/08/02/germany-to-offer-covid-19-shots-for-all-kids-over-12
Israel	06 June 2021	12-15 year olds eligible		https://www.jpost.com/israel-news/covid-did-israel-screw-up-not-vaccinating-children-ages-12-15-right-away-672203
	23 June 2021		After slow uptake Israeli PM urges citizens to vaccinate children, warning that allotted doses would expire on July 09	https://www.reuters.com/world/middle-east/school-covid-19-cases-spur-israeli-parents-vaccinate-kids-2021-06-22/
	27 July 2021	Vulnerable 5-11 year olds eligible	Vulnerable children only	https://www.timesofisrael.com/israel-to-start-vaccinating-kids-aged-5-11-who-have-severe-background-illnesses/
	End August 2021	plan to roll-out vaccines in schools		https://www.thetimes.co.uk/article/children-in-israel-to-have-covid-vaccines-at-school-f565t8mjj https://www.reuters.com/world/middle-east/school-covid-19-cases-spur-israeli-parents-vaccinate-kids-2021-06-22/

Italy	03 June 2021	12 years and older	Start of offering appointments to 12+ in some regions	https://www.thelocal.it/20210603/which-italian-regions-are-offering-covid-vaccine-appointments-to-all-from-thursday/ https://www.thelocal.it/20210811/covid-19-italy-to-vaccinate-12-18-year-olds-without-appointments/
	Beginning July 2021 (Pfizer authorised late May 2021)	12 years and older	Pfizer vaccines (authorised late May 12-15) began across most regions; Moderna (12-17) approved end July)	https://www.euronews.com/next/2021/09/14/covid-vaccine-for-children-who-in-europe-is-leading-the-race https://www.thelocal.it/20210603/which-italian-regions-are-offering-covid-vaccine-appointments-to-all-from-thursday/
	16 August 2021	12 years and older	Can get vaccine without an appointment	https://www.thelocal.it/20210811/covid-19-italy-to-vaccinate-12-18-year-olds-without-appointments/
Switzerland	04 June 2021	Approved for 12-15 year olds		https://www.bag.admin.ch/bag/de/home/krankheiten/ausbrueche-epidemien-pandemien/aktue[…]-cov/information-fuer-die-aerzteschaft/covid-19-impfung.html, https://www.swissmedic.ch/swissmedic/de/home/news/coronavirus-covid-19/covid-19-impfstoff-pfizer-biontech-fuer-jugendliche.html
	Late June, early July 2020	12 and older	Some areas started to offer to 12-15 such as canton of Zurich 25 June or Luzern end July	Zurich: https://www.zh.ch/de/gesundheit/coronavirus/coronavirus-impfung/impfgruppen.html#-1702582428 Luzern: https://gesundheit.lu.ch/themen/Humanmedizin/Infektionskrankenheiten/Informationen_Coronavisu/Covid_Impfung
	26 August 2021	12 and older	Recommended without restrictions	https://www.kinderaerzteschweiz.ch/Fuer-Mitglieder/Coronavirus---COVID-19

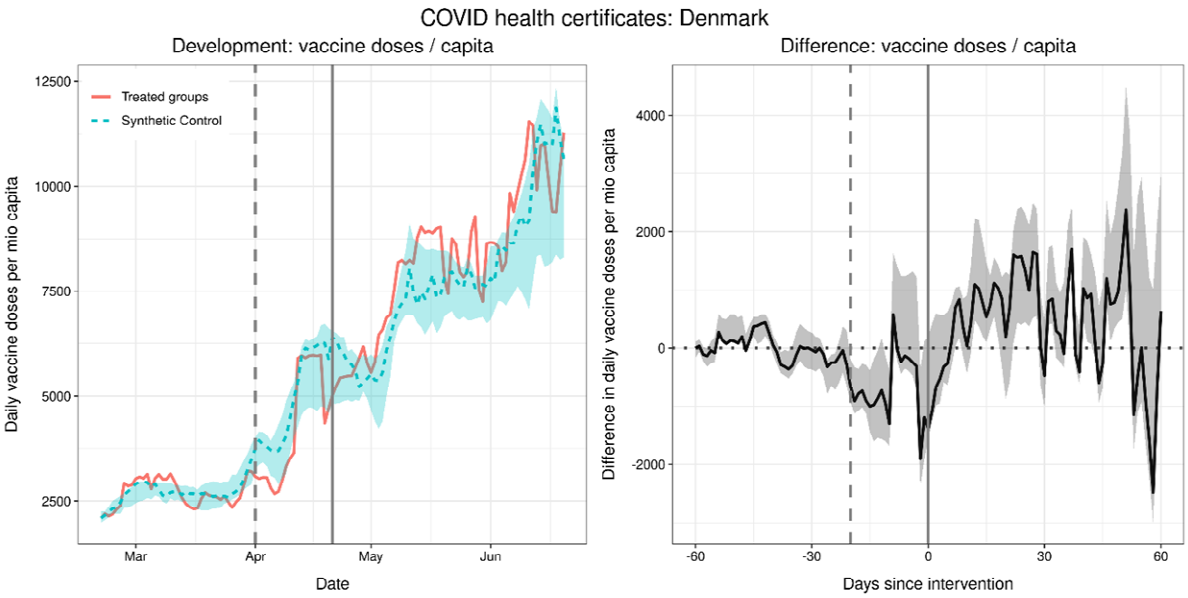
3. Switzerland, Denmark and Germany

Figure A1.1. Daily new vaccinations in Switzerland around the introduction of a mandatory COVID certificate for several venues as compared to a reweighted Synthetic Control group.



Data sources: Our World in Data,(28) OxCGRT.(29) Control pool: see methods. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs).

Figure A1.2. Daily new vaccinations in Denmark around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



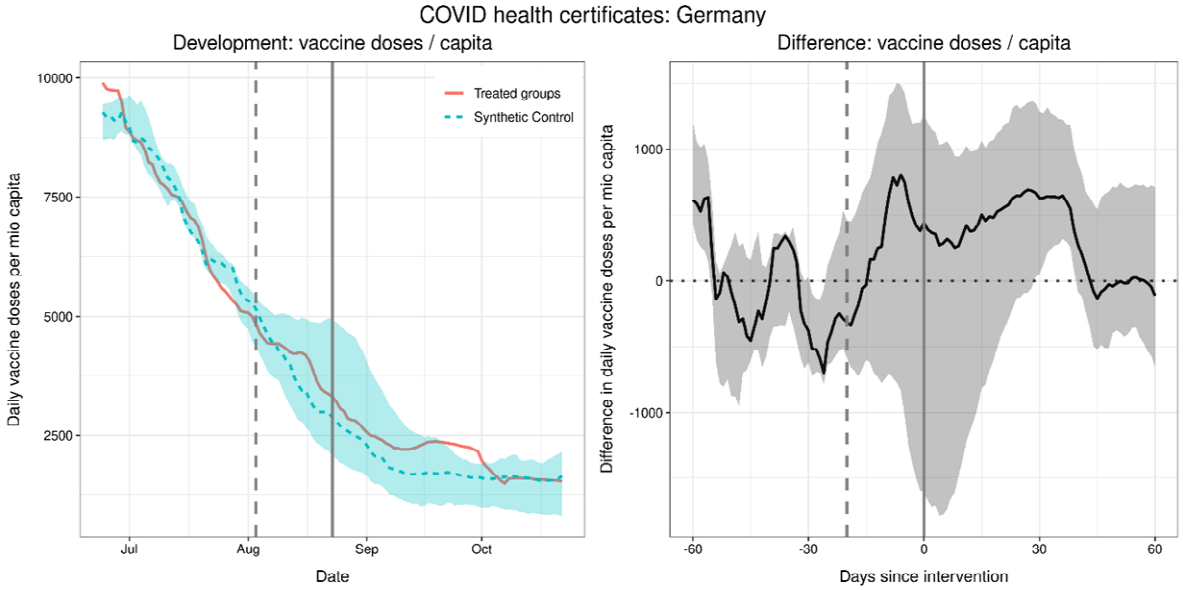
Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs).

The results of the analyses for France, Israel, Italy and Switzerland were discussed in the main body of the text. In Denmark, we observe a brief spike in vaccinations before the certificates were introduced. After introduction, daily vaccination rates were higher than among comparable countries. However, the daily variation is very high, which indicates that this effect might be driven by Denmark

providing higher supplies than other countries since they are one of the earliest to implement vaccine passports.

Germany provides an interesting exception for the patterns of daily vaccination doses before and after introducing mandatory health certificates. First, Germany did not introduce the certificates while following a below-average vaccination rate in comparison to other countries (note the small y range as compared to other figures/countries). Second, we see some slight spikes in vaccine uptake before introducing mandatory COVID certificates. Third, in contrast to remaining cases, daily vaccinations after the implementation fell below the rate observed in reweighted control countries. However, around 21 days after introduction, the vaccination uptake reaches above average levels (as the decline is smaller than the synthetic control unit. However, the difference is far from significant. It is important to keep the local context in mind. First, Germany had different local measures in place already before the introduction of certificates. Second, federal states can exempt counties with an incidence rate below 35 from the restrictions related to the certificates. Third, the implementation was not linked to a lower-than-average vaccination rate prior to the intervention.

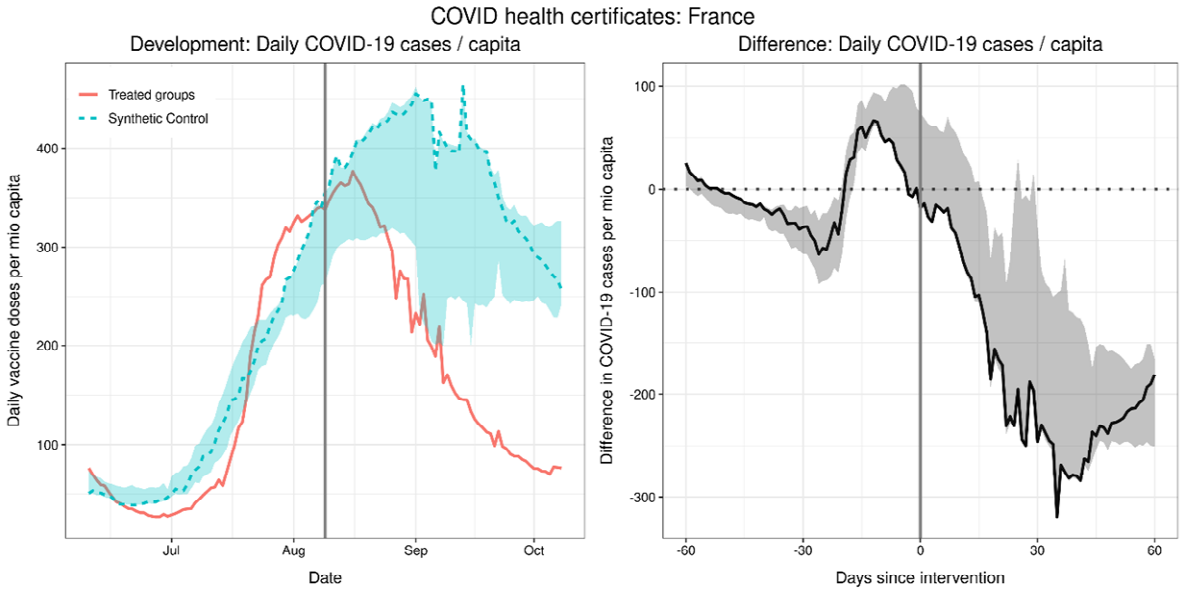
Figure A1.3. Daily new vaccinations in Germany around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs).

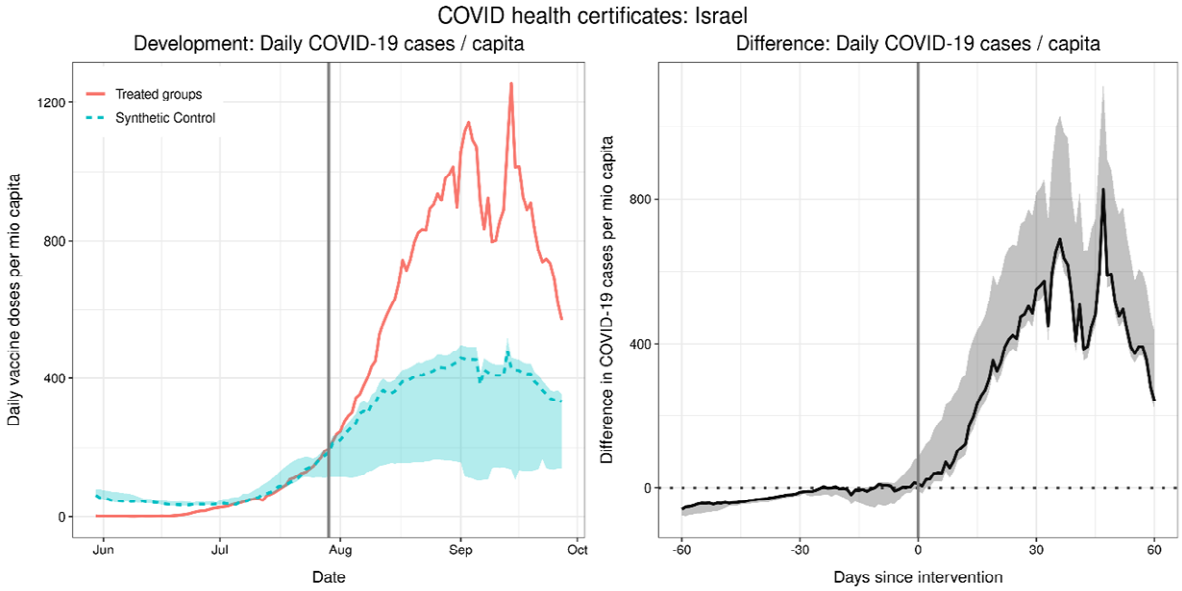
4. Effect on COVID-19 cases

Figure A2.1. Daily COVID-19 cases in France around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



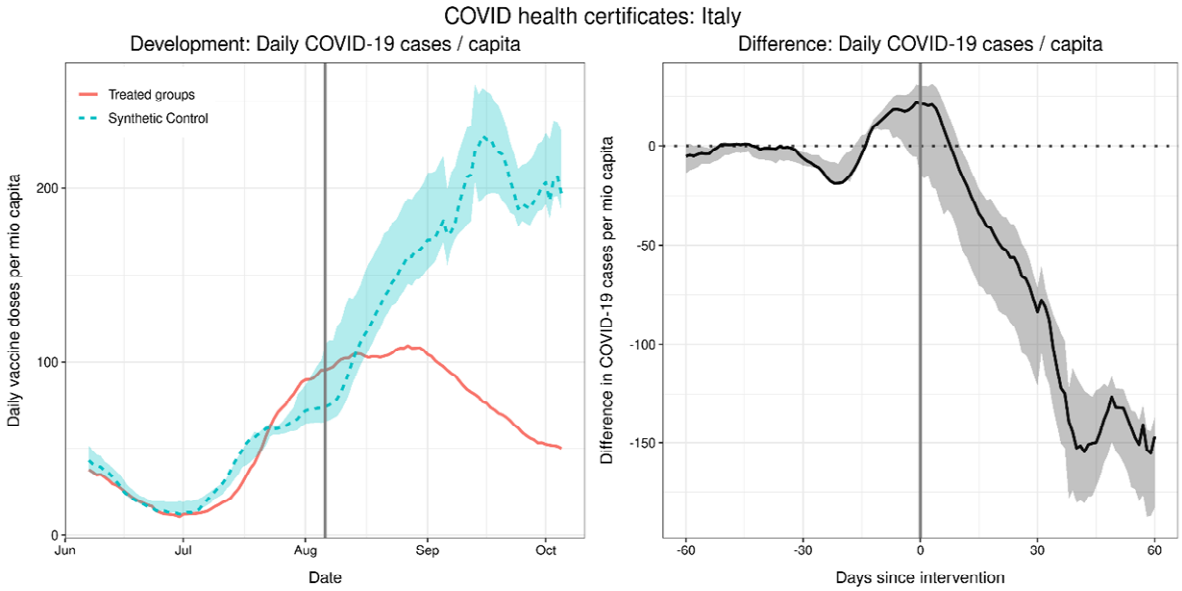
Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs).

Figure A2.2. Daily COVID-19 cases in Israel around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



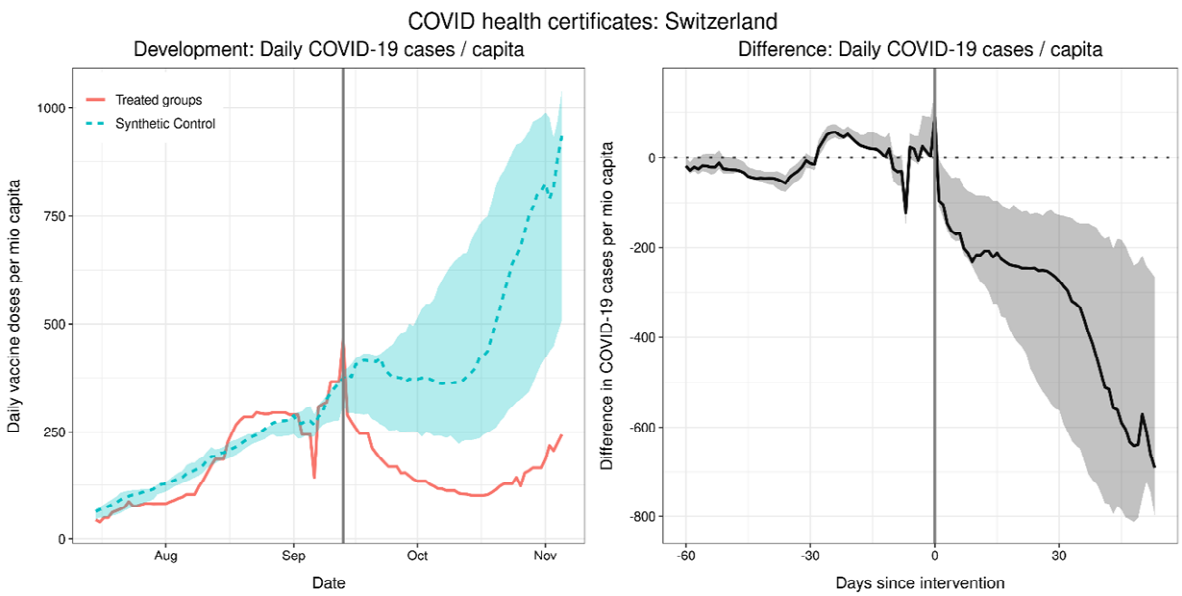
Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs).

Figure A2.3. Daily COVID-19 cases in Italy around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



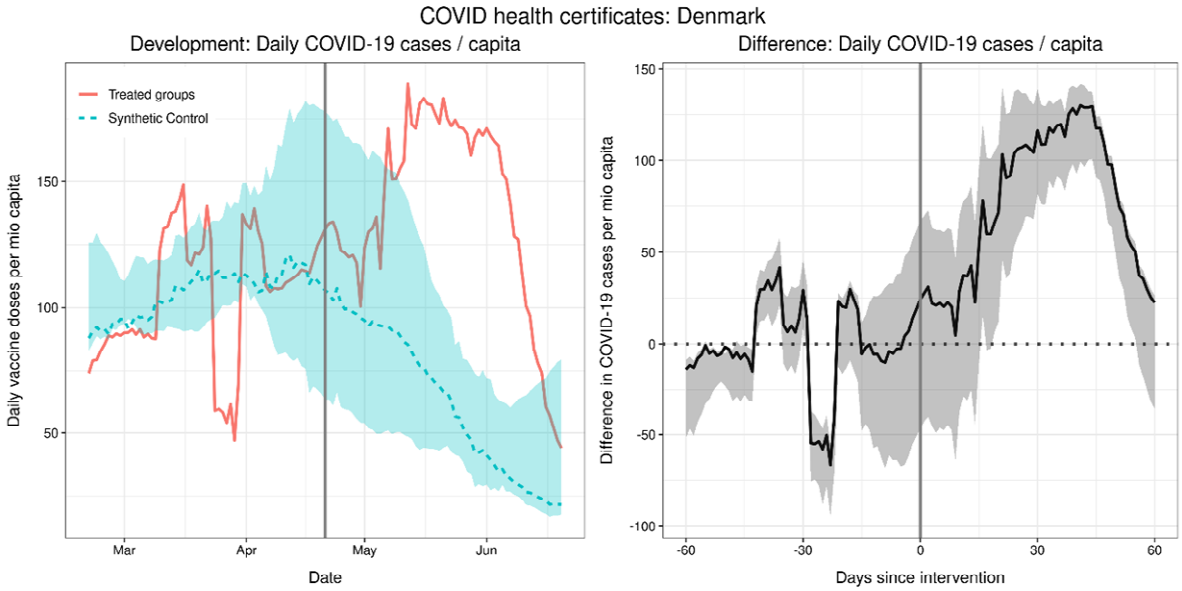
Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs).

Figure A2.4. Daily COVID-19 cases in Switzerland around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



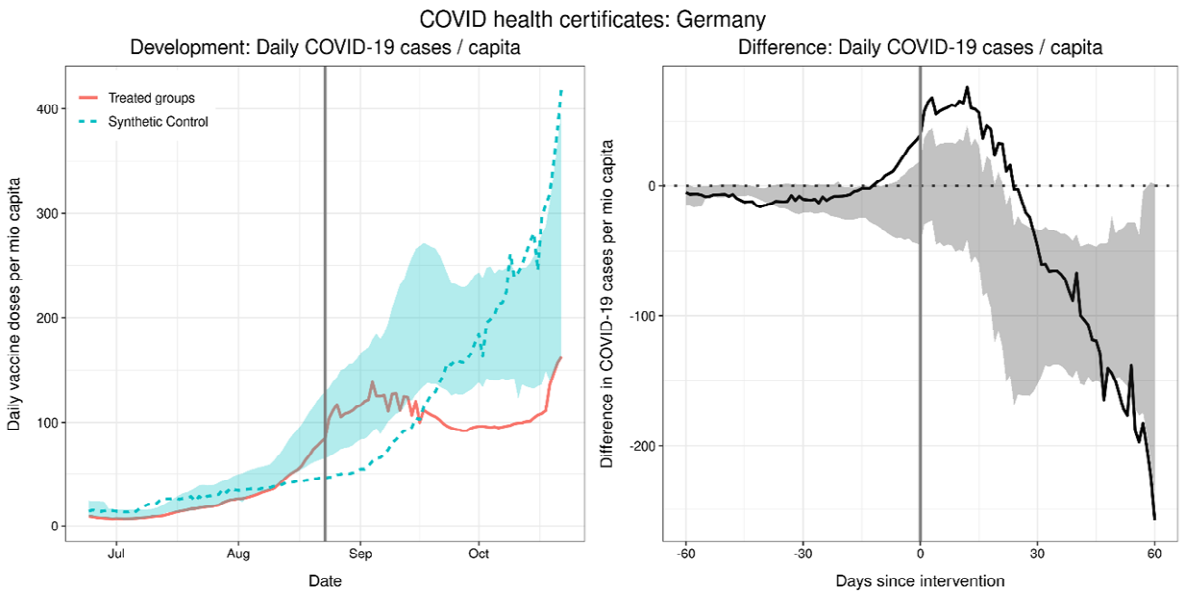
Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs).

Figure A2.5. Daily COVID-19 cases in Denmark around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs).

Figure A2.6. Daily COVID-19 cases in Germany around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs).

5. Confidence intervals for Synthetic control

Calculating uncertainty estimates for Synthetic Control methods is an ongoing methodological challenge. Recent work, for instance, suggest to quantify uncertainty based on permutation inference procedures (Chernozhukov et al. 2021) or on conditional prediction intervals (Cattaneo et al. 2021). However, the common software packages of these interventions does not allow the models to account for additional covariate adjustment. As the covariate adjustment plays an important role in our study (e.g., by controlling for the percentage of fully vaccinated before the intervention or the presence of non-pharmaceutical interventions), we unfortunately could not use these inference methods.

The uncertainty estimate in this study is therefore based on non-parametric bootstrap methods. More specifically, we set up a simulation design, where control countries are randomly selected with replacement in each simulation run. Subsequently, the Synthetic Control model is estimated based on the treated country and the re-sampled control pool. As we first calculate the importance of all covariates for the prediction of the outcome, and subsequently construct the country weights based on the weighted importance of these covariates, we receive a distribution of different weights for each control-pool country. We then construct the counterfactual outcome of each combination of weights, thereby receiving a distribution of R different counterfactual outcome trajectories, where R is the number of bootstrap runs. In this study, we performed R=1,000 bootstrap runs. The 95% confidence intervals were then calculated based on the $\alpha/2$ (0.025) and 1- $\alpha/2$ (=0.975) percentiles of the distribution. This approach takes the uncertainty in the construction of weights into account.

We originally included 20 countries in our initial analyses. However, when undertaking additional sensitivity analyses with data updated to November 08, 2021, we discovered that Norway had a highly usual pattern compared to other control countries. This was attributed to a change in vaccine eligibility to cover 16 and 17 year olds at the end of August, which was also around the treatment timing of other countries.[1] For this reason, we removed Norway from the control countries and use 19 countries, which leads to more precision in our estimates.

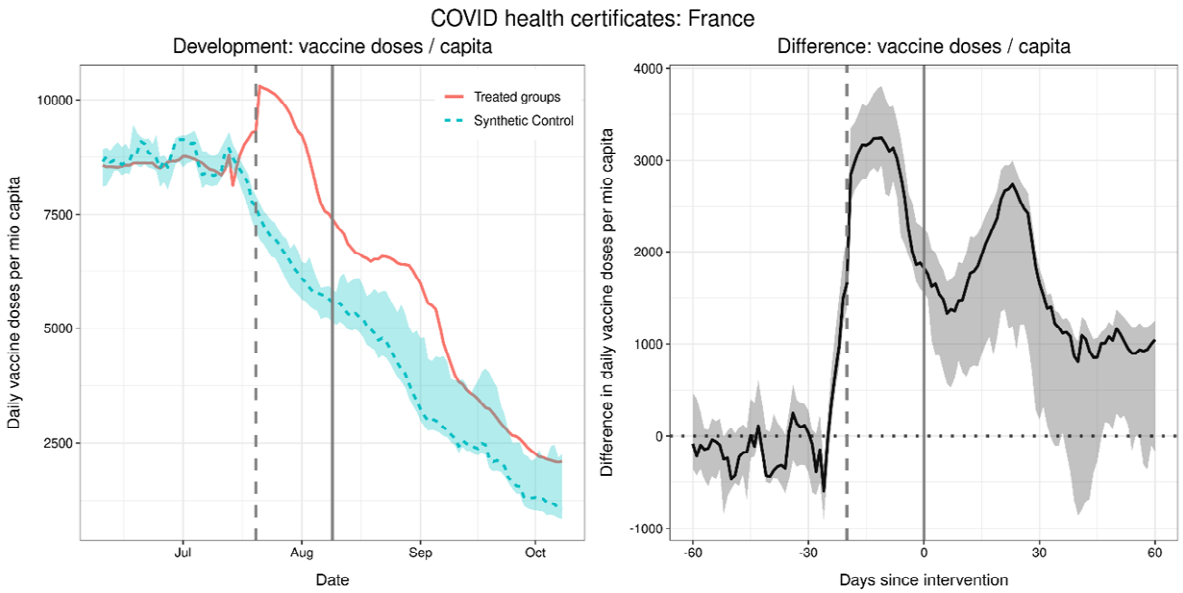
Note, however, that the main results are unchanged when we include Norway in the control pool (see Figure A6.3). The only difference is that the results for France (where the implementation of certification coincides with eligibility changes in Norway) show a higher amount of uncertainty as indicated by larger confidence intervals. The increase is still statistically significant at the 5% level.

[1] See: https://www.reuters.com/world/europe/norway-offer-16-17-year-olds-covid-19-vaccine-government-says-2021-08-18/

6. Resampling of variables

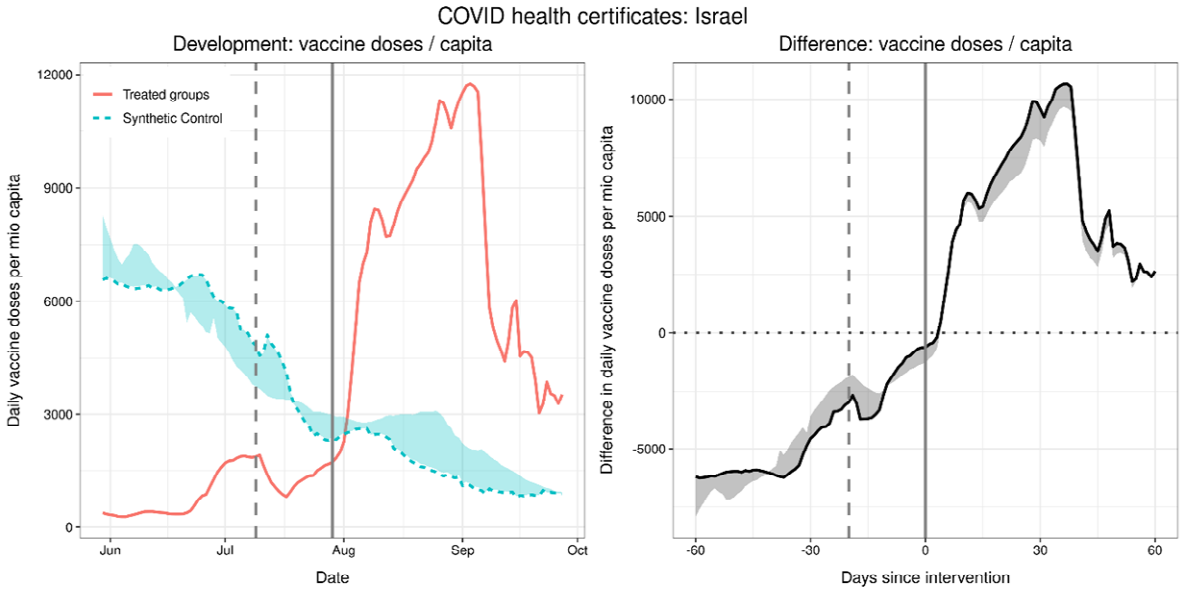
As an additional sensitivity analysis, we predicted 95% confidence intervals by resampling the covariates included in the matching and re-weighting process of the synthetic control group. More specifically, we conduct 1,000 bootstrap runs, in which 50% of the original covariates (see Methods) are randomly selected and then included in the matching / re-weighting process of the respective bootstrap run. We report the 95% percentile confidence intervals. This strategy tests whether our analyses are sensitive to the selection of covariates. Moreover, given that our main covariates are included at various distances to the treatment, this also ensures that our analysis is not sensitive to the time window included for construction of the weights.

Figure A3.1. Daily new vaccinations in France around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



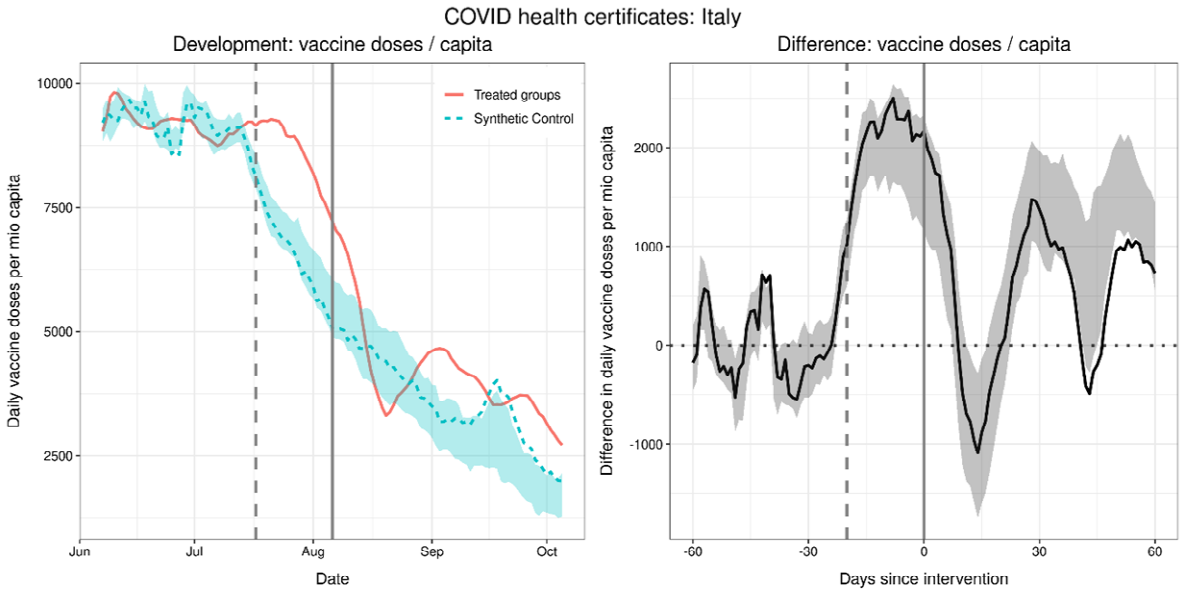
Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs).

Figure A3.2. Daily new vaccinations in Israel around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



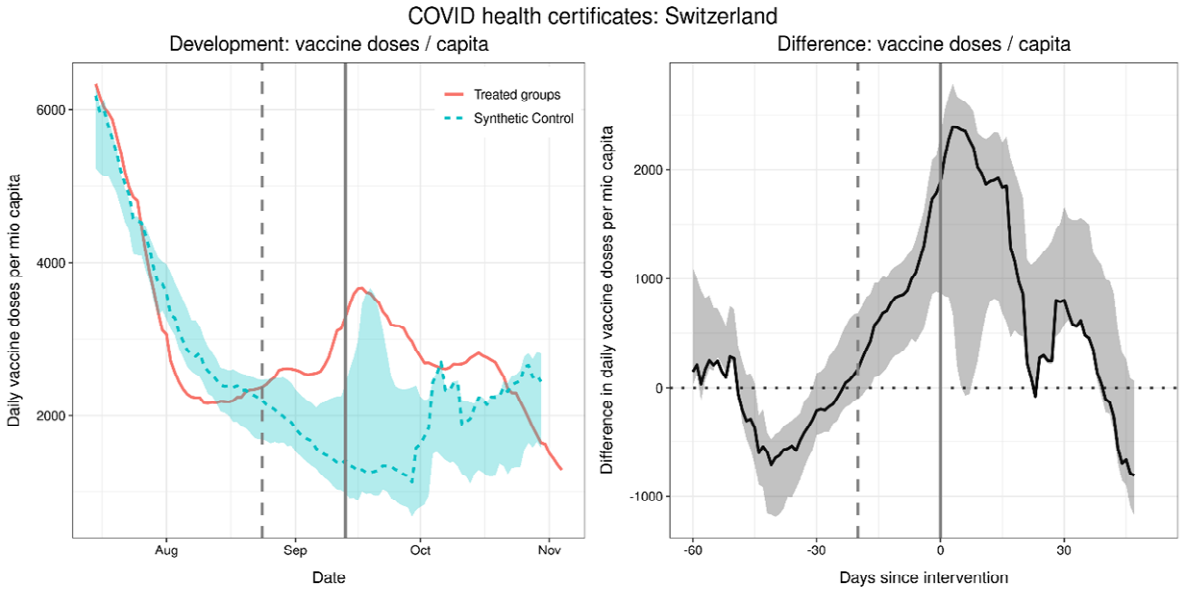
Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs). Not that we had to omit the USA for this robustness check. Thus, the results slightly differ from those reported in the main text of the paper.

Figure A3.3. Daily new vaccinations in Italy around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



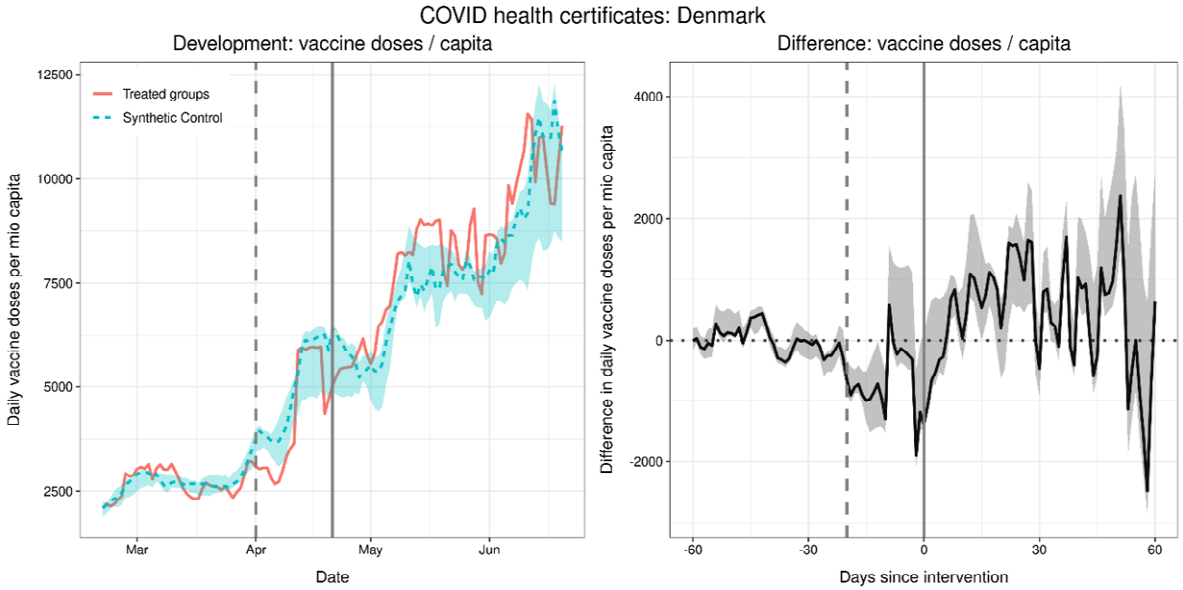
Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs).

Figure A3.4. Daily new vaccinations in Switzerland around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



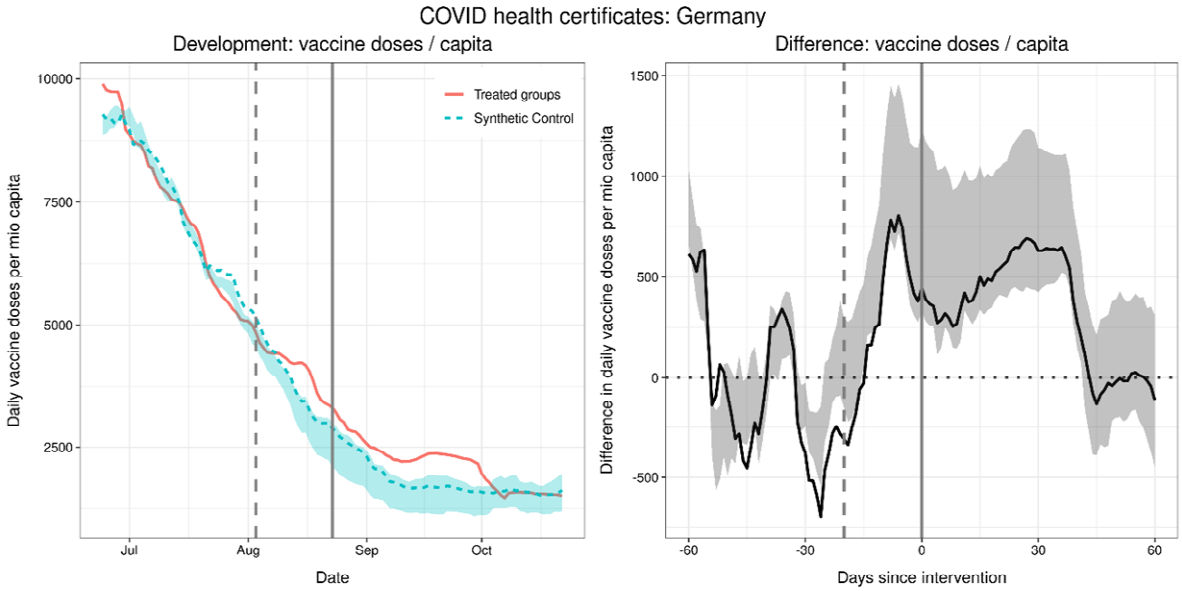
Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs).

Figure A3.5. Daily new vaccinations in Denmark around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs).

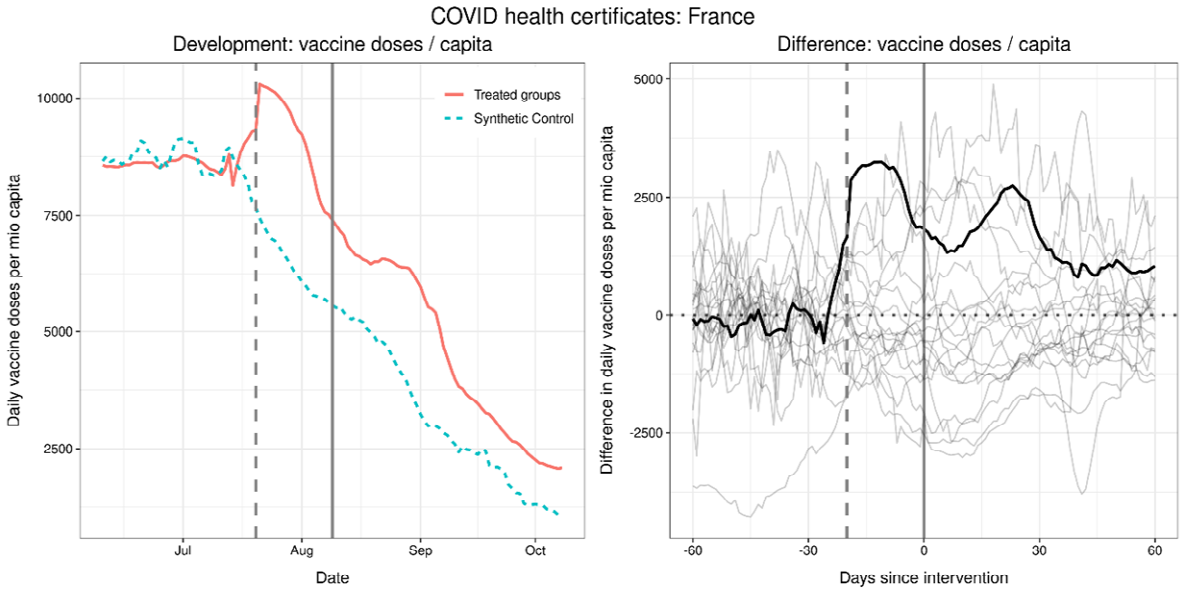
Figure A3.6. Daily new vaccinations in Germany around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs).

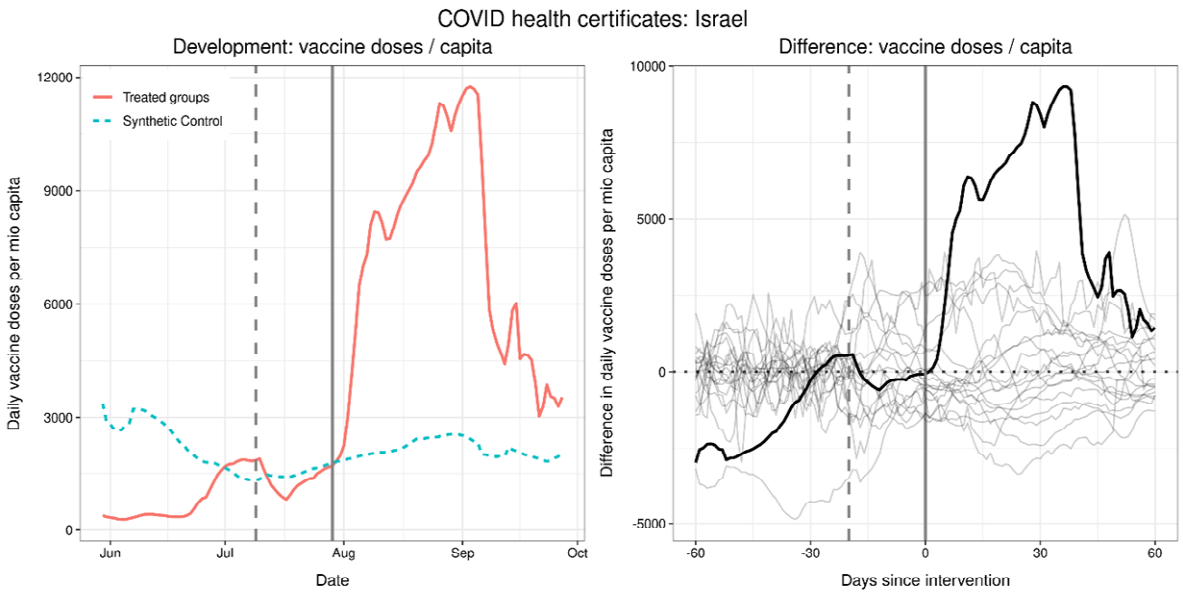
7. Placebo analysis

Figure A4.1. Daily new vaccinations in France around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



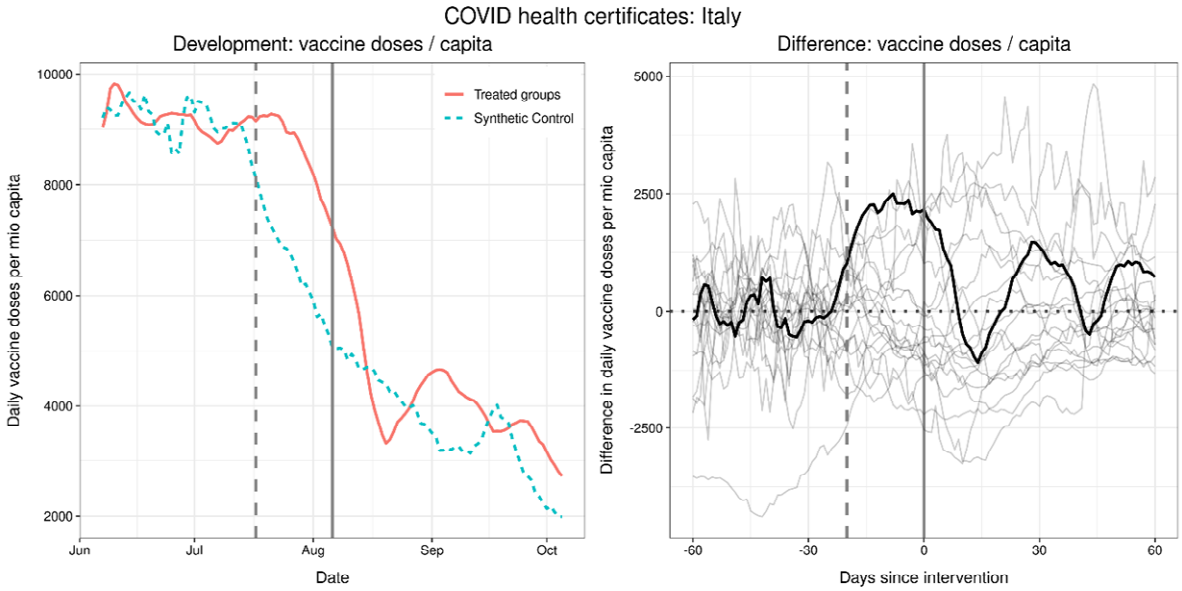
Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA.

Figure A4.2. Daily new vaccinations in Israel around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



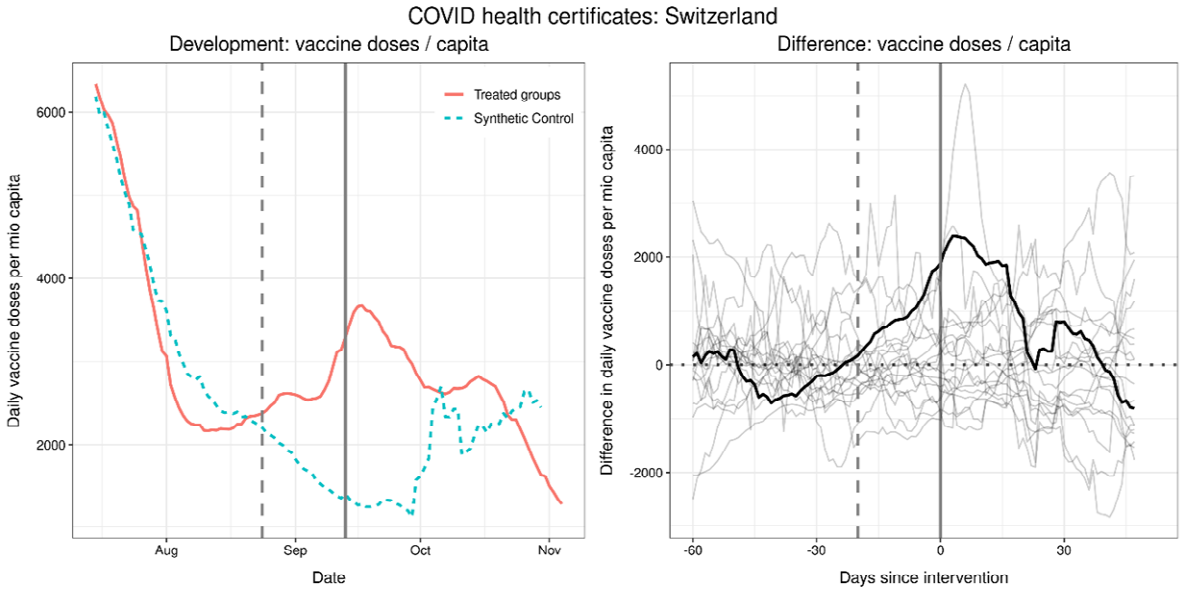
Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA.

Figure A4.3. Daily new vaccinations in Italy around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



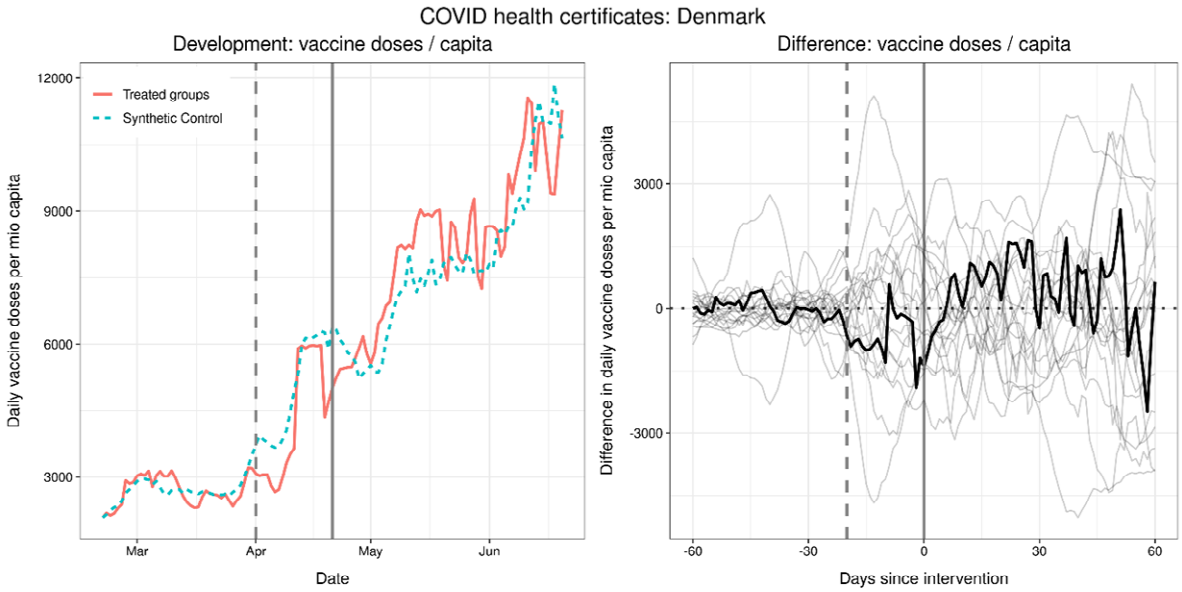
Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA.

Figure A4.4. Daily new vaccinations in Switzerland around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



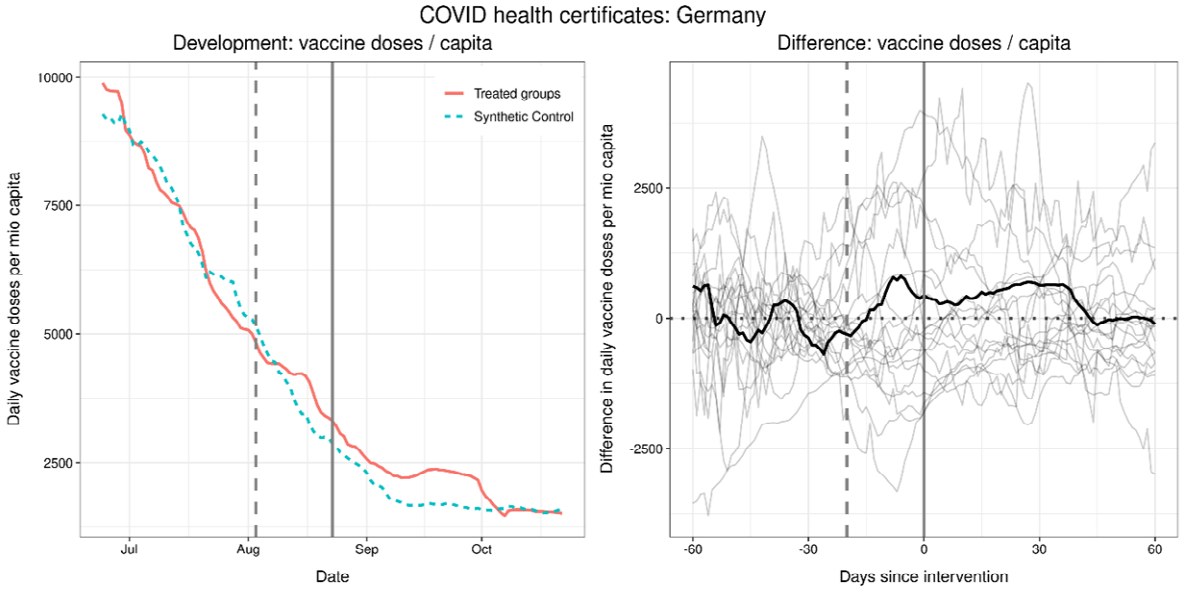
Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA.

Figure A4.5. Daily new vaccinations in Denmark around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA.

Figure A4.6. Daily new vaccinations in Germany around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group.



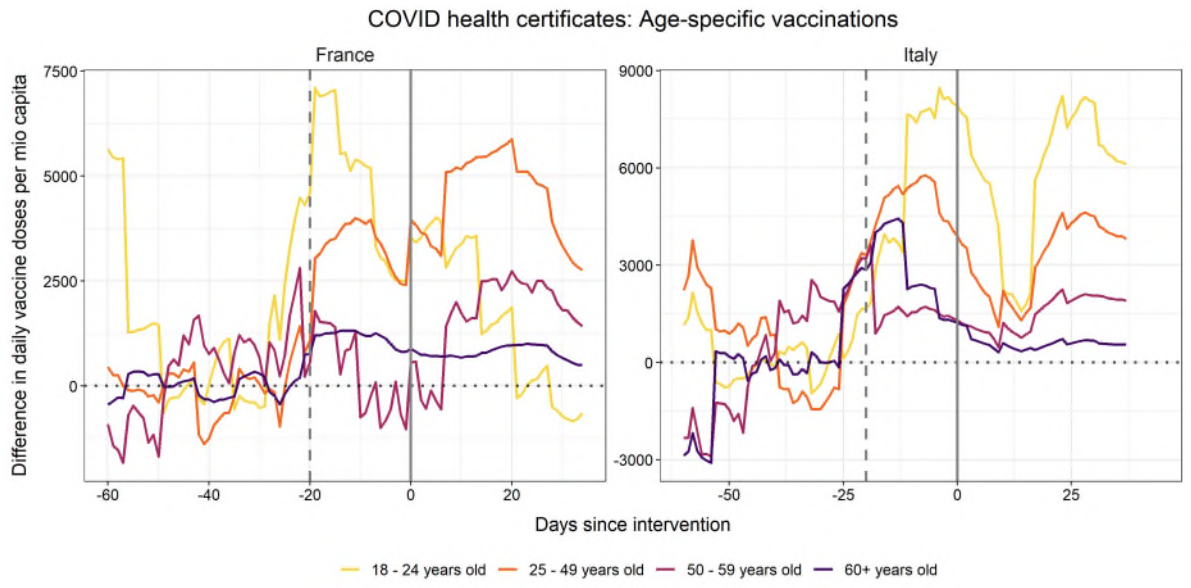
Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Control pool: AUT, BEL, CAN, CZE, ESP, FIN, GBR, GRC, HRV, IRL, LTU, LUX, NLD, POL, PRT, SVK, SVN, SWE, USA.

8. Descriptive development of age-specific vaccinations

For age-specific vaccination doses, we allocated the age-specific weekly doses (by ECDC) to each day of the week proportionate to each day's share of total doses administered in the respective week (by Our World in Data). For instance, if there were 1,000 doses amongst the age group 18-24 in week 30 (ECDC), and 25% of all vaccine doses in this week were given on a Wednesday (Our World in Data), we allocated 250 doses for the age group 18-24 to Wednesday, and so forth. Harmonized age-specific vaccination rates from the ECDC were only available for France, Italy, and Denmark among the treated countries.

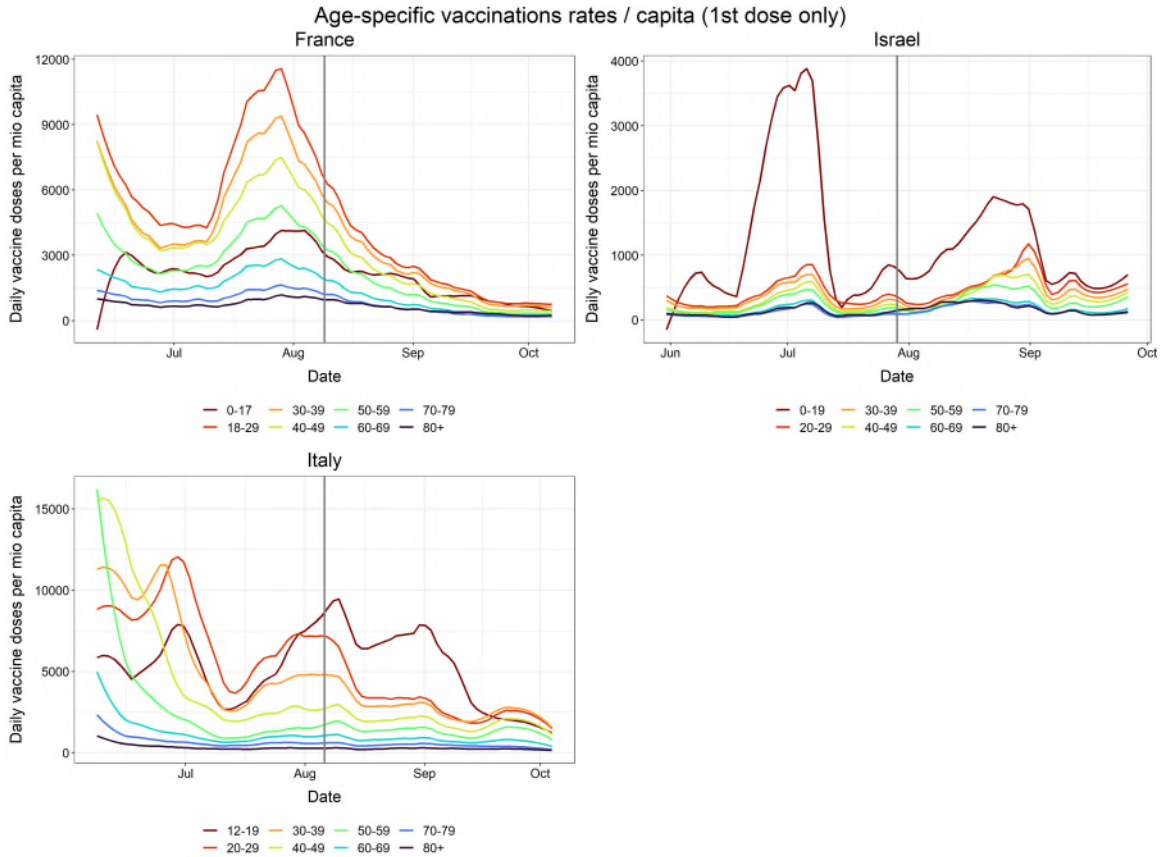
Due to data availability in some control countries, the following countries were included as control units for the age-specific analyses: Austria, Belgium, Cyprus, Czech Republic, Estonia, Finland, Turkey, Croatia, Ireland, Iceland, Lithuania, Luxembourg, Latvia, Malta, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden. We note that the results look similar for these two sets of control units.

Figure 5.1. Daily new vaccinations by age group in France and Italy around the introduction of a mandatory COVID health certificate for several venues as compared to a reweighted Synthetic Control group



Data sources: Our World in Data,(28) OxCGRT,(29) European Centre for Disease Prevention and Control.(15) Control pool: see methods.

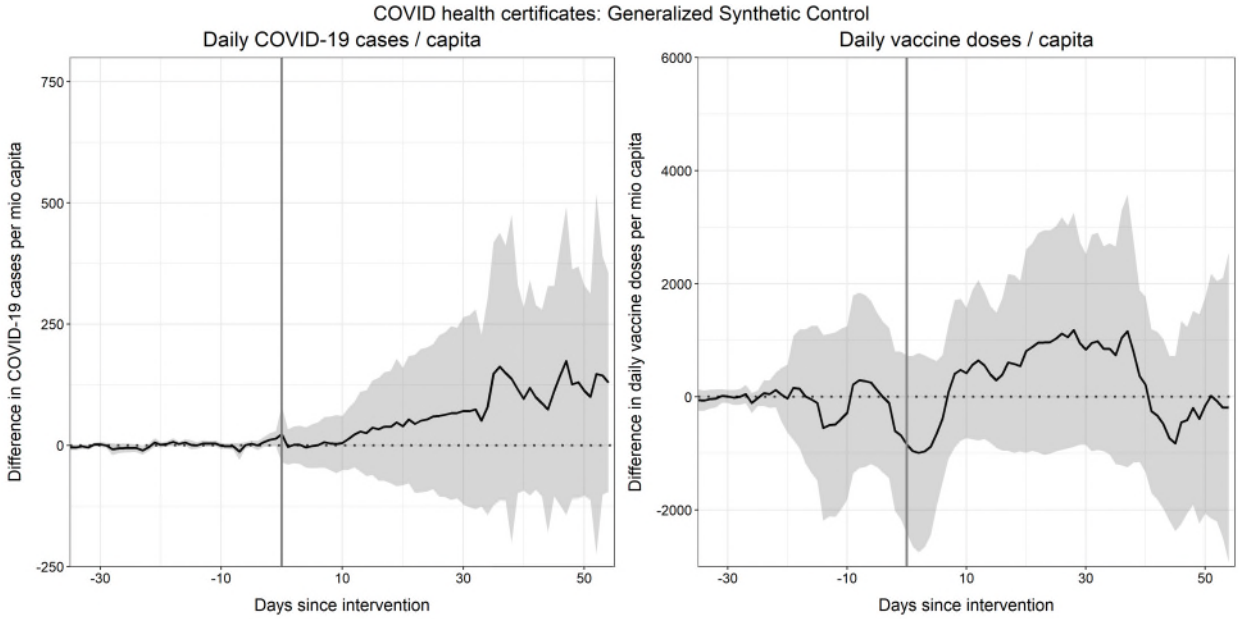
Figure A5.2. Descriptive development of daily new vaccinations by age group in France, Israel, Italy, and Switzerland for the first dose only around the introduction of a mandatory COVID health certificate.



Data sources: Government Database Israel (https://data.gov.il/dataset/covid-19/resource/57410611-936c-49a6-ac3c-838171055b1f), Open platform for French public data (https://www.data.gouv.fr/en/datasets/donnees-relatives-aux-personnes-vaccinees-contre-la-covid-19-1/), Extraordinary Commissioner for the Covid-19 emergency Italy (https://github.com/italia/covid19-opendata-vaccini), Federal Office of Public Health Switzerland (https://www.covid19.admin.ch/en/vaccination/persons).
Note: the vertical lines represent the date of implementing mandatory COVID health certificates.

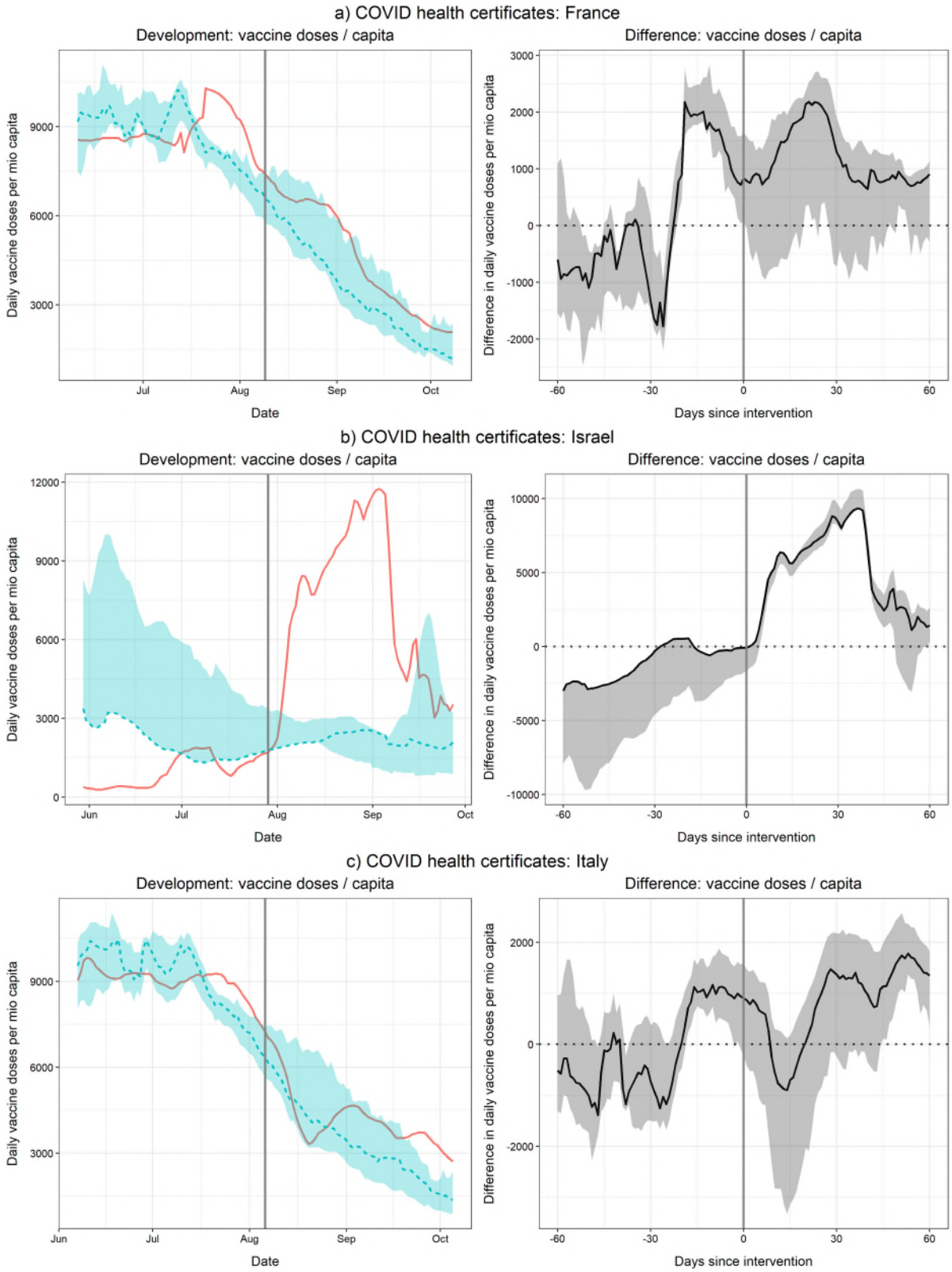
9. Additional robustness checks

Figure A6.1. Generalized Synthetic Control method, comparing the case rates and vaccination rates in Germany, Denmark, France, and Israel to a counterfactual trajectory estimated based on all remaining countries.



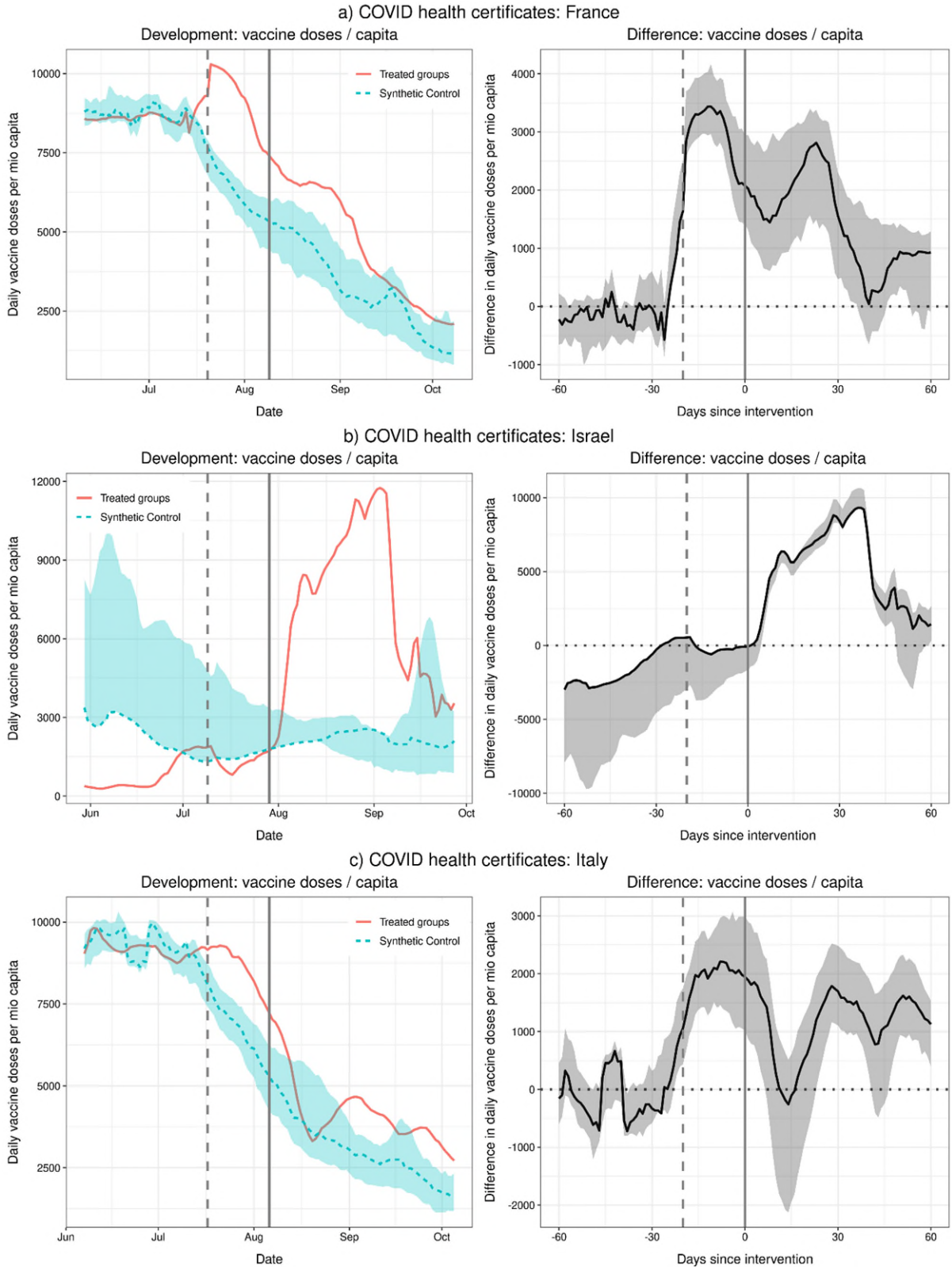
Data sources: Our World in Data (https://github.com/owid/covid-19-data), Oxford COVID-19 Government Response Tracker (https://github.com/OxCGRT/covid-policy-tracker). Treated: CHE, DEU, DNK, FRA, ITA, and ISR. Control: 163 remaining countries.
Note: Analysis of vaccinations controls for the 3-weeks lagged percentage of fully vaccinated. The treatment timing was preponed by three weeks to allow for potential anticipation effects. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs).

Figure A6.2. Daily new vaccinations in a) France, b) Israel, and c) Italy around the introduction of a mandatory COVID certificate for several venues as compared to a reweighted Synthetic Control group without back-dating the treatment.



Source: Our World in Data,(28) OxCGRT.(29) Notes: Control pool: see methods. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs). The solid vertical line marks the intervention and dashed vertical line marks the 20 days backwards dated intervention.

Figure A6.3. Daily new vaccinations in a) France, b) Israel, and c) Italy around the introduction of a mandatory COVID certificate for several venues as compared to a reweighted Synthetic Control group including Norway in the control pool.



Source: Our World in Data,(28) OxCGRT.(29) Notes: Control pool: see methods. Shaded areas represent 95% confidence intervals based on a non-parametric bootstrap procedure (1,000 runs). The solid vertical line marks the intervention and dashed vertical line marks the 20 days backwards dated intervention.

10. Summary measure of vaccine uptake

Table A5.1. Summary measure of the total difference in vaccinations between the synthetic control group and the treated country for an anticipation period and after the certificates were introduced. 95% confidence intervals are shown in brackets.

	Anticipation (sum over 20 days before)		Uptake afterwards (sum over 40 days after)	
	Total*	Per mio capita	Total*	Per mio capita
France	3,761,440 [3,355,761 ; 4,979,952]	55,672 [49,668 ; 73,707]	4,874,857 [2,563,396 ; 7,711,769]	72,151 [37,940 ; 114,140]
Italy	2,513,065 [1,505,684 ; 3,207,418]	41,629 [24,942 ; 53,132]	1,494,270 [72,366 ; 4,475,654]	24,753 [1,199 ; 74,140]
Israel	-31,485 [-489,267 ; -31,485]	-3,582 [-55,663 ; -3,582]	2,168,728 [1,925,688 ; 2,364,362]	246,733 [219,083 ; 268,990]
Switzerland	153,152 [31,851 ; 221,482]	17,572 [3,655 ; 25,412]	412,940 [86,021 ; 685,270]	47,380 [9,870 ; 78,627]
Denmark	-78,066 [-124,420 ; 38,816]	-13,429 [-21,403 ; 6,677]	118,567 [-22,314 ; 317,693]	20,396 [-3,839 ; 54,649]
Germany	483,830 [-1,450,116 ; 1,729,508]	5,767 [-17,284 ; 20,614]	1,676,254 [-2,137,802 ; 3,876,700]	19,979 [-25,480 ; 46,206]

Note: The sums show the daily differences between the synthetic control group and the respective treatment country (as shown in the right panels of Figures 2-5 of the main text). Bootstrapped standard errors are possible to compute for synthetic control methods but it is not possible given the low number of treated and control countries.

* Total describes the total number of administered vaccine doses as compared to the synthetic control group within the respective period. This highly depends on the total population, and the numbers are thus not comparable across the countries.

Table A5.2. Summary statistics of mean daily new vaccinations per million capita in treatment and all (unweighted) control countries across various time intervals before and after the intervention. Standard deviations in parentheses.

	40 -21 days before		20 – 1 days before		1 – 20 days after		21 – 40 days after	
	Treat	Control	Treat	Control	Treat	Control	Treat	Control
France	8676 (269)	7725 (3269)	9071 (1061)	5489 (2462)	6634 (263)	4010 (2190)	4570 (1035)	2615 (1591)
Israel	1220 (597)	8395 (2919)	1366 (334)	6679 (3036)	6532 (2499)	4732 (2219)	10559 (1055)	3355 (1990)
Italy	9048 (178)	7960 (3232)	8553 (744)	5797 (2606)	4789 (1351)	4189 (2196)	4319 (263)	2778 (1685)
Switzerland	2255 (80)	4375 (2194)	2706 (292)	2919 (1776)	3249 (329)	2035 (1187)	2652 (133)	1648 (935)
Denmark	2608 (252)	3476 (1662)	4313 (1343)	4986 (1652)	6502 (1154)	6158 (1390)	8397 (608)	7582 (1216)
Germany	6039 (860)	6247 (2808)	4086 (475)	4383 (2204)	2567 (315)	2979 (1799)	2260 (135)	2064 (1213)

References

Cattaneo, Matias D., Yingjie Feng & Rocio Titiunik (2021). Prediction Intervals for Synthetic Control Methods, *Journal of the American Statistical Association*, DOI: 10.1080/01621459.2021.1979561

Chernozhukov, Victor, Kaspar Wüthrich & Yinchu Zhu (2021). An Exact and Robust Conformal Inference Method for Counterfactual and Synthetic Controls, *Journal of the American Statistical Association*, DOI: 10.1080/01621459.2021.1920957