

Online Appendix

Association of vaccine hesitancy and immunization coverage rates in the European Union

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Table A1: Regression results: aggregate vaccine uptake regressed on aggregate vaccine hesitancy, parent sample, data for 2019

	Vaccine Coverage					
	DTP3		MCV1		MCV2	
Multilevel Model						
Vaccine Hesitancy	-1.844	*	-3.136	**	-2.987	*
	(0.916)		(1.196)		(1.378)	
Mandatory Vax	1.531		1.662		3.456	
	(1.289)		(1.653)		(2.232)	
Intercept	95.669	***	95.404	***	93.074	***
	(0.840)		(1.084)		(1.453)	
N	176		177		142	
Countries	20		20		15	
Log-Likelihood	-431.617		-483.347		-400.137	
Weighted Multilevel Model						
Vaccine Hesitancy	-1.619	†	-2.560	*	-3.295	*
	(0.924)		(1.211)		(1.416)	
Mandatory Vax	1.443		1.614		3.348	
	(1.304)		(1.624)		(2.124)	
Intercept	95.580	***	95.087	***	93.271	***
	(0.841)		(1.063)		(1.390)	
N	175		176		141	
Countries	20		20		15	
Log-Likelihood	-428.457		-479.378		-398.063	
MRP						
Vaccine Hesitancy	-3.400	*	-5.349	*	-5.549	*
	(1.681)		(2.118)		(2.659)	
Mandatory Vax	1.769		1.298		3.799	
	(1.328)		(1.457)		(2.273)	
Intercept	96.378	***	97.095	***	94.304	***
	(1.121)		(1.334)		(1.830)	
N	171		172		142	
Countries	19		19		15	
Log-Likelihood	-419.038		-465.142		-400.311	

Notes: ***, **, *, and † denote p less than 0.001, 0.01, 0.05, and 0.1, respectively.

Table A2: Regression results: aggregate vaccine uptake regressed on aggregate vaccine hesitancy, parent sample, data for 2019, models without control variable for mandates

	Vaccine Coverage					
	DTP3		MCV1		MCV2	
Multilevel Model						
Vaccine Hesitancy	-1.729	†	-3.018	*	-2.825	*
	(0.914)		(1.193)		(1.377)	
Intercept	96.076	***	95.844	***	94.140	***
	(0.786)		(1.007)		(1.351)	
N	176		177		142	
Countries	20		20		15	
Log-Likelihood	-432.292		-483.842		-401.263	
Weighted Multilevel Model						
Vaccine Hesitancy	-1.522		-2.444	*	-3.131	*
	(0.922)		(1.208)		(1.416)	
Intercept	95.970	***	95.517	***	94.309	***
	(0.780)		(0.984)		(1.295)	
N	175		176		141	
Countries	20		20		15	
Log-Likelihood	-429.047		-479.861		-399.230	
MRP						
Vaccine Hesitancy	-3.056	†	-5.019	*	-4.989	†
	(1.677)		(2.095)		(2.657)	
Intercept	96.761	***	97.332	***	95.274	***
	(1.110)		(1.320)		(1.824)	
N	171		172		142	
Countries	19		19		15	
Log-Likelihood	-419.877		-465.532		-401.616	

Notes: ***, **, *, and † denote p less than 0.001, 0.01, 0.05, and 0.1, respectively.

Table A3: Regression results: aggregate vaccine uptake regressed on aggregate vaccine hesitancy, parent sample, data for 2019, regional samples with less than 25 observations are excluded, model pools vaccines (DTP3, MCV1, and MCV2)

	Vaccine Coverage	
	Regions with 25+ N '18	Regions with 25+ N '19
Parent Sample Pooled Model		
Vaccine Hesitancy	-3.328 * (1.489)	-3.287 * (1.614)
Mandatory Vax	0.034 (1.368)	2.228 (1.455)
Intercept	94.807 *** (1.637)	94.641 *** (1.408)
N	281	261
Countries	21	20
Log-Likelihood	-787.640	-724.986
Full Sample Pooled Model		
Vaccine Hesitancy	-1.470 (1.056)	-1.790 (1.179)
Mandatory Vax	-0.364 (1.397)	2.218 (1.346)
Intercept	94.281 *** (1.466)	94.230 *** (1.181)
N	495	442
Countries	21	20
Log-Likelihood	-1345.644	-1173.986

Notes: ***, **, *, and † denote p less than 0.001, 0.01, 0.05, and 0.1, respectively.

Table A4: Regression results: aggregate vaccine uptake regressed on aggregate vaccine hesitancy, parent sample, data for 2019, model includes observations at NUTS2 level (lower levels were aggregated up)

	Vaccine Coverage		
	DTP3	MCV1	MCV2
Multilevel Model			
Vaccine Hesitancy	-1.402 (1.087)	-1.676 (1.071)	-1.214 (1.804)
Mandatory Vax	1.707 (1.507)	0.880 (1.529)	1.797 (2.341)
Intercept	95.135 *** (1.087)	95.204 *** (1.100)	93.329 *** (1.741)
N	93	94	70
Countries	14	14	10
Log-Likelihood	-212.513	-216.143	-188.694
Weighted Multilevel Model			
Vaccine Hesitancy	-1.491 (1.055)	-1.818 † (1.058)	-1.944 (1.846)
Mandatory Vax	1.752 (1.442)	1.017 (1.493)	2.021 (2.428)
Intercept	95.197 *** (1.035)	95.298 *** (1.067)	93.603 *** (1.786)
N	92	93	69
Countries	14	14	10
Log-Likelihood	-208.088	-212.069	-187.748
MRP			
Vaccine Hesitancy	-3.387 † (1.871)	-3.636 † (1.899)	-2.350 (3.284)
Mandatory Vax	2.038 (1.422)	1.198 (1.467)	2.069 (2.433)
Intercept	96.043 *** (1.235)	96.107 *** (1.266)	93.763 *** (2.022)
N	93	94	70
Countries	14	14	10
Log-Likelihood	-211.943	-215.692	-188.664

Notes: ***, **, *, and † denote p less than 0.001, 0.01, 0.05, and 0.1, respectively.

Table A5: Regression results: aggregate vaccine uptake regressed on aggregate vaccine hesitancy, full sample (parents and non parents), data for 2019

	Vaccine Coverage		
	DTP3	MCV1	MCV2
Multilevel Model			
Vaccine Hesitancy	-1.041 (0.820)	-2.690 * (1.080)	-2.979 * (1.246)
Mandatory Vax	1.436 (1.304)	1.636 (1.658)	3.432 (2.245)
Intercept	95.308 *** (0.837)	95.270 *** (1.074)	93.166 *** (1.447)
N	178	179	144
Countries	20	20	15
Log-Likelihood	-436.836	-488.136	-407.545
Weighted Multilevel Model			
Vaccine Hesitancy	-1.585 (0.965)	-3.213 * (1.263)	-3.235 * (1.494)
Mandatory Vax	1.424 (1.314)	1.669 (1.639)	3.342 (2.119)
Intercept	95.607 *** (0.878)	95.553 *** (1.112)	93.392 *** (1.436)
N	178	179	144
Countries	20	20	15
Log-Likelihood	-436.867	-487.630	-408.312
MRP			
Vaccine Hesitancy	-2.138 (1.374)	-5.168 ** (1.737)	-5.581 * (2.165)
Mandatory Vax	1.626 (1.338)	1.291 (1.465)	3.794 (2.314)
Intercept	95.807 *** (1.043)	97.144 *** (1.228)	94.449 *** (1.723)
N	173	174	144
Countries	19	19	15
Log-Likelihood	-423.869	-468.391	-407.121

Notes: ***, **, *, and † denote p less than 0.001, 0.01, 0.05, and 0.1, respectively.

Table A6: Regression results: aggregate vaccine uptake regressed on aggregate vaccine hesitancy, parent sample, data for 2018

	Vaccine Coverage		
	DTP3	MCV1	MCV2
Multilevel Model			
Vaccine Hesitancy	-2.030 * (0.880)	-1.213 (0.913)	-2.126 † (1.279)
Mandatory Vax	0.706 (1.215)	-0.090 (1.202)	-0.125 (2.440)
Intercept	95.668 *** (0.871)	95.528 *** (0.820)	92.246 *** (1.744)
N	198	181	178
Countries	21	19	18
Log-Likelihood	-494.825	-454.056	-507.101
Weighted Multilevel Model			
Vaccine Hesitancy	-1.466 † (0.856)	-1.258 (0.997)	-3.198 * (1.362)
Mandatory Vax	0.663 (1.203)	-0.115 (1.198)	-0.134 (2.332)
Intercept	95.330 *** (0.849)	95.487 *** (0.829)	92.756 *** (1.679)
N	197	180	177
Countries	21	19	18
Log-Likelihood	-483.343	-463.745	-510.985
MRP			
Vaccine Hesitancy	-3.657 * (1.630)	-2.604 (1.668)	-4.827 † (2.484)
Mandatory Vax	0.888 (1.206)	0.051 (1.188)	0.232 (2.440)
Intercept	96.478 *** (1.100)	96.219 *** (1.068)	93.554 *** (2.017)
N	198	181	178
Countries	21	19	18
Log-Likelihood	-494.992	-453.745	-506.604

Notes: ***, **, *, and † denote p less than 0.001, 0.01, 0.05, and 0.1, respectively.

Table A7: Regression results: aggregate vaccine uptake regressed on aggregate vaccine hesitancy, full sample, data for 2018

	Vaccine Coverage				
	DTP3		MCV1		MCV2
Multilevel Model					
Vaccine Hesitancy	-1.495	†	-1.442	†	-0.899
	(0.839)		(0.859)		(1.202)
Mandatory Vax	0.621		-0.042		-0.304
	(1.225)		(1.198)		(2.458)
Intercept	95.453	***	95.689	***	91.672
	(0.881)		(0.818)		(1.756)
N	200		183		180
Countries	21		19		18
Log-Likelihood	-500.262		-457.612		-512.814
Weighted Multilevel Model					
Vaccine Hesitancy	-1.931	*	-1.847	†	-2.104
	(0.939)		(1.049)		(1.495)
Mandatory Vax	0.652		-0.015		-0.472
	(1.222)		(1.197)		(2.382)
Intercept	95.631	***	95.854	***	92.357
	(0.901)		(0.871)		(1.761)
N	200		183		180
Countries	21		19		18
Log-Likelihood	-493.243		-467.638		-522.043
MRP					
Vaccine Hesitancy	-3.028	*	-2.698	†	-3.329
	(1.377)		(1.399)		(2.048)
Mandatory Vax	0.784		0.083		0.030
	(1.210)		(1.193)		(2.471)
Intercept	96.249	***	96.341	***	92.901
	(1.041)		(0.997)		(1.947)
N	200		183		180
Countries	21		19		18
Log-Likelihood	-499.465		-457.177		-511.783

Notes: ***, **, *, and † denote p less than 0.001, 0.01, 0.05, and 0.1, respectively.

Table A8: Regression results: aggregate vaccine uptake regressed on aggregate vaccine hesitancy, parent sample, data for 2019, sample includes only countries with no immunisation mandate

	Vaccine Coverage			
	DTP3	MCV1	MCV2	
Multilevel Model				
Vaccine Hesitancy	-2.502 (1.311)	†	-3.200 * (1.604)	-2.832 (2.252)
Intercept	96.016 (1.007)	***	95.428 *** (1.297)	93.010 *** (1.690)
N	116		117	90
Countries	14		14	10
Log-Likelihood	-280.353		-310.175	-257.860
Weighted Multilevel Model				
Vaccine Hesitancy	-2.856 (1.323)	*	-3.889 * (1.694)	-3.297 (2.329)
Intercept	96.191 (1.006)	***	95.717 *** (1.284)	93.288 *** (1.589)
N	115		116	89
Countries	14		14	10
Log-Likelihood	-278.149		-310.791	-256.058
MRP				
Vaccine Hesitancy	-5.484 (2.378)	*	-6.987 * (2.798)	-5.128 (4.361)
Intercept	97.451 (1.450)	***	97.923 *** (1.670)	94.107 *** (2.492)
N	111		112	90
Countries	13		13	10
Log-Likelihood	-266.848		-290.418	-257.980

Notes: ***, **, *, and † denote p less than 0.001, 0.01, 0.05, and 0.1, respectively.

Table A9: Respondents per region, based on Eurobarometer survey data

Index	Region Code	Full Sample N	Parent N	Full Sample VH	Parent VH
1	BE1	125	47	0.572	0.481
2	BE2	539	184	0.638	0.636
3	BE3	307	115	0.817	0.799
4	BG31	70	31	0.574	0.619
5	BG32	68	23	0.756	0.685
6	BG33	114	33	0.696	0.686
7	BG34	111	44	0.782	0.761
8	BG41	190	81	0.454	0.484
9	BG42	122	59	0.620	0.553
10	CY0001	165	69	0.504	0.433
11	CY0002	120	57	0.454	0.445
12	CY0003	79	42	0.453	0.496
13	CY0004	39	20	0.425	0.470
14	CY0005	31	12	0.508	0.398
15	CZ01	136	41	0.481	0.603
16	CZ02	96	38	0.730	0.644
17	CZ03	119	46	0.565	0.621
18	CZ04	124	37	0.562	0.687
19	CZ05	141	67	0.573	0.506
20	CZ06	142	46	0.478	0.473
21	CZ07	106	39	0.698	0.611
22	CZ08	99	34	0.584	0.550
23	DE1	141	63	0.479	0.504
24	DE2	162	52	0.579	0.481
25	DE3	111	39	0.525	0.525
26	DE4	62	20	0.363	0.333
27	DE5	10	5	0.190	0.254
28	DE7	78	14	0.527	0.687
29	DE8	56	9	0.465	0.413
30	DE9	114	35	0.474	0.488

31	DEA	214	71	0.487	0.362
32	DEB	58	16	0.689	0.761
33	DEC	30	4	0.564	0.480
34	DED	144	35	0.262	0.190
35	DEE	66	13	0.369	0.235
36	DEF	46	11	0.574	0.846
37	DEG	37	4	0.523	0.549
38	DK01	252	98	0.138	0.121
39	DK02	182	55	0.158	0.108
40	DK03	196	49	0.161	0.154
41	DK04	193	62	0.498	0.483
42	DK05	117	37	0.288	0.306
43	EE001	254	99	0.511	0.441
44	EE004	105	31	0.581	0.674
45	EE006	97	22	0.546	0.639
46	EE007	103	21	0.650	0.568
47	EE008	264	65	0.498	0.513
48	ES11	34	8	0.301	0.077
49	ES12	39	17	0.326	0.256
50	ES13	13	8	0.715	0.662
51	ES21	48	16	0.563	0.421
52	ES22	8	4	0.579	0.000
53	ES23	7	2	0.587	0.400
54	ES24	23	16	0.166	0.165
55	ES30	131	57	0.530	0.493
56	ES41	45	12	0.331	0.229
57	ES42	37	14	0.347	0.465
58	ES43	22	7	0.146	0.138
59	ES51	170	55	0.558	0.581
60	ES52	104	42	0.619	0.595
61	ES53	14	6	0.462	0.849
62	ES61	174	86	0.329	0.307
63	ES62	37	13	0.586	0.482
64	ES70	29	5	0.698	0.677

65	HR031	67	18	0.648	0.342
66	HR032	13	8	1.136	1.064
67	HR033	14	5	0.863	0.881
68	HR034	33	14	1.019	0.952
69	HR035	99	41	0.709	0.615
70	HR036	40	17	1.187	1.090
71	HR037	22	9	1.263	1.320
72	HR041	190	80	0.611	0.524
73	HR042	27	6	0.437	0.433
74	HR043	16	8	0.352	0.305
75	HR044	59	35	0.982	1.051
76	HR045	29	11	0.294	0.189
77	HR046	31	16	1.357	1.383
78	HR047	42	21	0.494	0.654
79	HR048	19	11	0.556	0.566
80	HR049	14	7	0.930	1.004
81	HR04A	31	15	0.414	0.521
82	HR04B	71	30	0.678	0.570
83	HR04C	25	9	0.801	0.408
84	HR04D	11	7	0.947	0.873
85	HR04E	40	25	0.645	0.619
86	HU10	269	101	0.790	0.783
87	HU21	147	56	0.438	0.401
88	HU22	77	30	0.636	0.661
89	HU23	75	18	0.494	0.341
90	HU31	129	54	0.409	0.320
91	HU32	135	63	0.752	0.709
92	HU33	88	32	0.518	0.406
93	IE011	104	49	0.648	0.533
94	IE012	32	17	0.828	0.490
95	IE013	83	32	0.480	0.572
96	IE021	343	168	0.622	0.589
97	IE022	140	81	0.591	0.551
98	IE023	77	32	0.437	0.250

99	IE024	30	14	0.349	0.352
100	IE025	106	51	0.572	0.474
101	ITC1/ITC2	75	20	0.533	0.547
102	ITC3	9	2	0.395	0.263
103	ITC4	118	52	0.378	0.261
104	ITF1/ITF2	25	17	0.857	0.836
105	ITF3	78	37	1.021	1.019
106	ITF4/ITF5	106	59	0.532	0.506
107	ITF6	2	0	1.600	—
108	ITG1	80	39	0.747	0.846
109	ITH1/ITH2	8	3	0.634	0.532
110	ITH3	51	22	0.756	0.660
111	ITH4	5	0	2.491	—
112	ITH5	103	46	0.929	0.961
113	ITI1	46	20	0.945	0.946
114	ITI2	38	21	1.069	1.138
115	ITI3	22	11	0.603	0.510
116	ITI4	86	27	0.333	0.332
117	LT011	217	79	0.665	0.707
118	LT021	50	7	0.723	0.690
119	LT022	170	41	0.406	0.557
120	LT023	99	24	0.715	0.618
121	LT024	50	14	0.726	0.636
122	LT025	82	30	0.546	0.510
123	LT026	91	22	0.652	0.635
124	LT027	37	8	0.752	0.557
125	LT028	47	6	1.082	0.883
126	LT029	36	10	0.609	0.565
127	LV003	87	28	1.001	0.959
128	LV005	90	27	0.763	0.953
129	LV006	206	73	0.679	0.746
130	LV007	156	66	0.949	0.913
131	LV008	129	50	0.982	1.014
132	LV009	136	57	0.971	0.830

133	NL11	27	6	0.395	0.135
134	NL12	43	13	0.235	0.183
135	NL13	36	7	0.156	0.103
136	NL21	78	40	0.324	0.312
137	NL22	136	45	0.290	0.290
138	NL23	26	3	0.330	0.335
139	NL31	71	22	0.190	0.202
140	NL32	143	39	0.204	0.185
141	NL33	195	54	0.323	0.403
142	NL34	17	10	0.300	0.385
143	NL41	169	54	0.210	0.207
144	NL42	48	16	0.194	0.178
145	PT11	345	142	0.438	0.378
146	PT15	47	11	0.732	0.625
147	PT16	219	94	0.325	0.305
148	PT17	256	87	0.423	0.420
149	PT18	72	14	0.352	0.130
150	RO11	83	36	0.811	0.902
151	RO12	133	50	0.611	0.611
152	RO21	152	54	1.097	1.045
153	RO22	85	35	0.650	0.555
154	RO31	122	49	1.000	0.892
155	RO32	100	44	0.856	0.838
156	RO41	112	54	1.156	1.128
157	RO42	74	24	0.717	0.746
158	SE11	266	63	0.283	0.203
159	SE21	43	12	0.483	0.684
160	SE22	146	34	0.340	0.380
161	SE23	234	49	0.314	0.303
162	SE31	55	14	0.259	0.230
163	SE33	55	11	0.259	0.077
164	SK01	112	25	0.992	1.139
165	SK02	231	85	0.758	0.635
166	SK03	225	78	0.399	0.352

167	SK04	240	99	0.558	0.539
168	UKC	38	5	0.625	0.050
169	UKD	81	21	0.597	0.798
170	UKE	85	30	0.559	0.540
171	UKF	61	23	0.530	0.428
172	UKG	85	34	0.553	0.458
173	UKH	92	34	0.473	0.336
174	UKI	114	53	0.654	0.753
175	UKJ	121	48	0.361	0.343
176	UKK	71	12	0.394	0.304
177	UKL	34	10	0.374	0.288
178	UKM	80	24	0.554	0.696
179	UKN	29	9	0.620	0.481

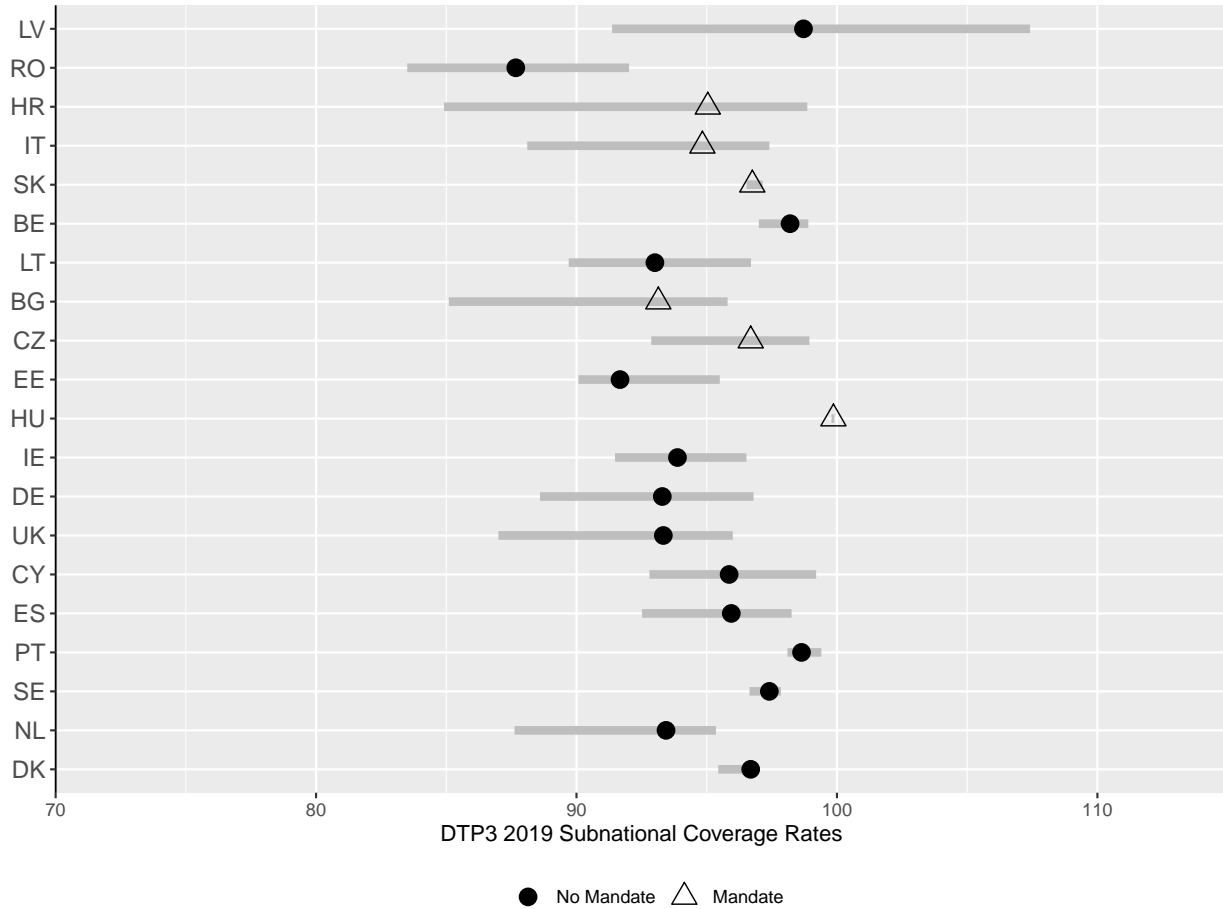


Figure A1: Figure shows the range of subnational vaccine uptake in each country, sorted by vaccine hesitancy. Vaccine hesitancy is high in the countries at the top and low in the countries at the bottom (for values, see Table 2). Lines cover the minimum-maximum range of uptake in the regions of a respective country. Dots and triangles are used to refer to the country mean. Dots are used in countries without mandate and triangles are used in countries with vaccination mandate. Uptake rates are provided by the WHO and would be above 100 percent if more children get vaccinated in a region than are registered there.

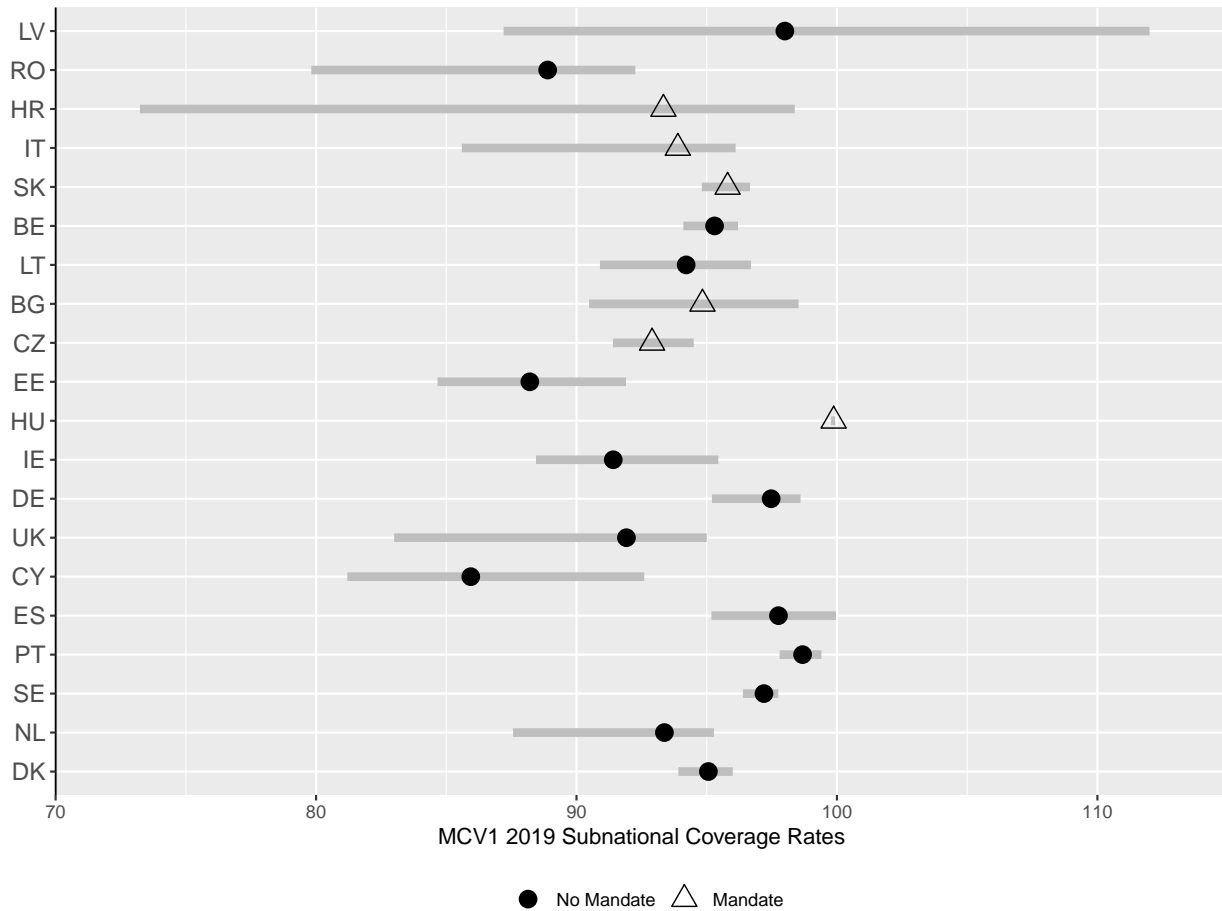


Figure A2: Figure shows the range of subnational vaccine uptake in each country, sorted by vaccine hesitancy. Vaccine hesitancy is high in the countries at the top and low in the countries at the bottom (for values, see Table 2). Lines cover the minimum-maximum range of uptake in the regions of a respective country. Dots and triangles are used to refer to the country mean. Dots are used in countries without mandate and triangles are used in countries with vaccination mandate. Uptake rates are provided by the WHO and would be above 100 percent if more children get vaccinated in a region than are registered there.

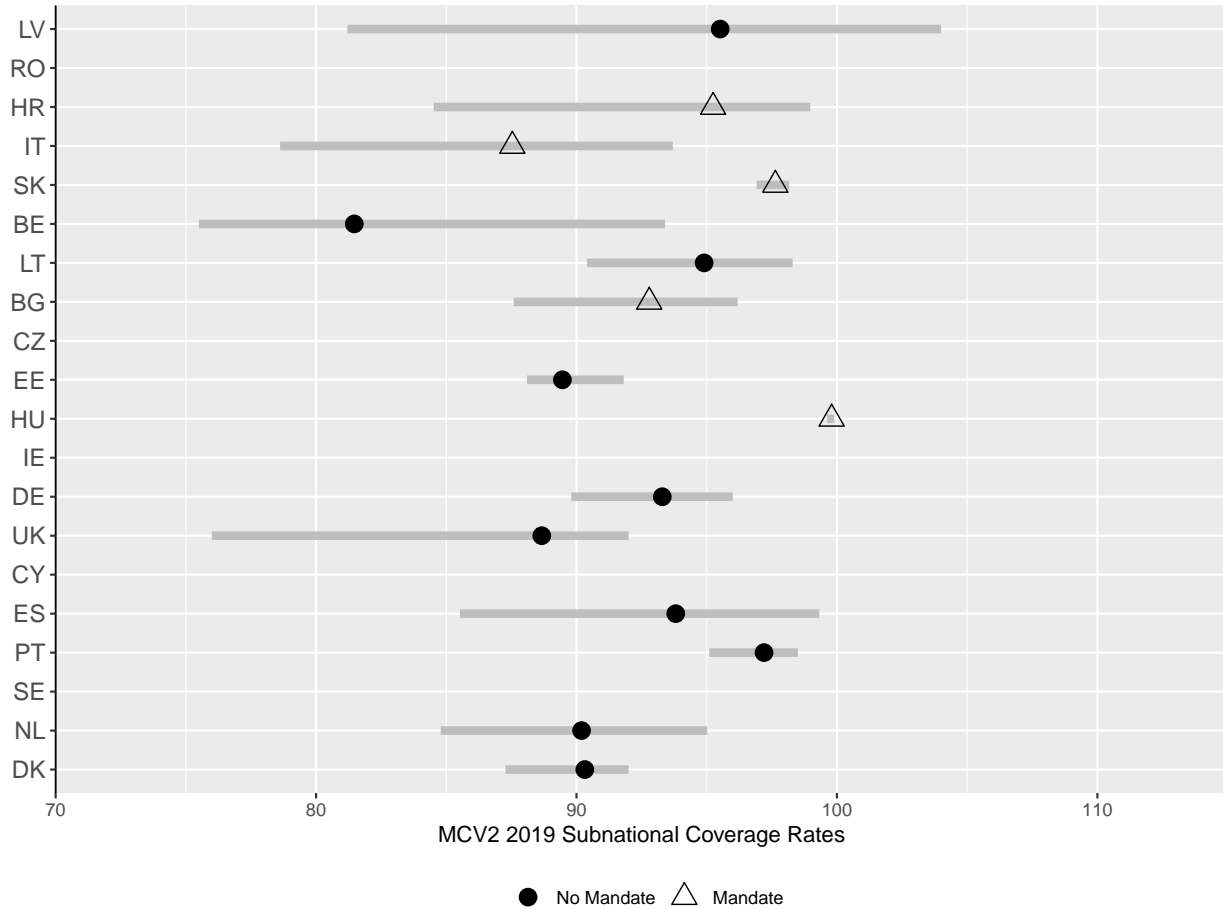


Figure A3: Figure shows the range of subnational vaccine uptake in each country, sorted by vaccine hesitancy. Vaccine hesitancy is high in the countries at the top and low in the countries at the bottom (for values, see Table 2). Lines cover the minimum-maximum range of uptake in the regions of a respective country. Dots and triangles are used to refer to the country mean. Dots are used in countries without mandate and triangles are used in countries with vaccination mandate. Uptake rates are provided by the WHO and would be above 100 percent if more children get vaccinated in a region than are registered there.

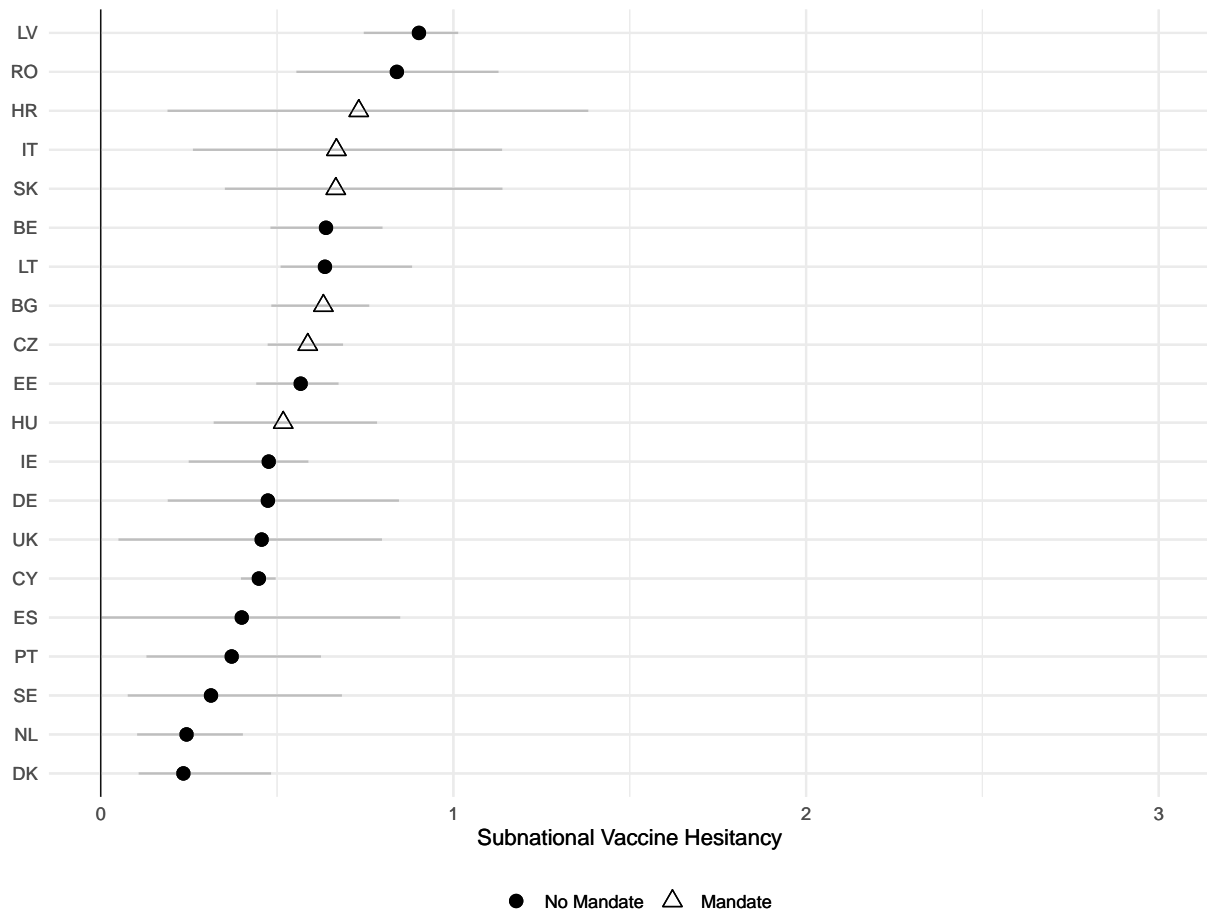


Figure A4: Figure shows the range of subnational vaccine hesitancy in each country. Dots and triangles are used to refer to the country mean. Dots are used in countries without mandate and triangles are used in countries with vaccination mandate. Lines cover the minimum-maximum range of hesitancy in the regions of a respective country.