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Are COVID fatalities in the US higher than in the EU, and if so, why?

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Abstract
The COVID crisis has severely hit both the United States and Europe. We construct comparable measures of the death toll of the COVID crisis suffered by US states and 35 European countries: cumulative fatalities attributed to COVID at 100 days since the pandemic's onset in a particular nation/state. When taking account of demographic, economic, and political factors (but not health-policy related factors) we find that, controlling for population size, cumulative deaths are between 100 and 130% higher in a US state than in a European country. We no longer find a US/EUROPE gap in fatalities from COVID after taking account of how each nation/state implemented social distance measures. This suggests that various types of social distance measures such as school closings and lockdowns, and how soon they were implemented, help explain the US/EUROPE gap in cumulative deaths measured 100 days after the pandemic's onset in a state or country.

1 Introduction

It is becoming increasingly common to compare Europe and the USA rather than the US and various European countries. For example, according to Richter (2020) "the trend of daily new COVID cases has taken completely different trajectories for the U.S. and the European Union." COVID fatalities are also routinely compared across the two sides of the Atlantic. For example, Drum (2020) charted 7-day averages of daily deaths in the two unions, letting the US lag the EU by 12 days (reproduced in Fig. 1). It shows weekly mortality in the US in June 2020 lying substantially above that of the EU.

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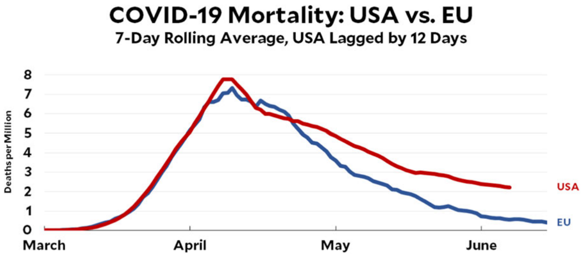

Fig. 1 Reproduced from K. Drum (2020). The graph represents average mortality rates (deaths per million inhabitants) over 7 consecutive days. For comparability, US data is lagged by 12 days

There are at least three problems with such comparisons. First, they ignore the enormous variation in COVID outcomes within Europe and within the US (see Table 1, showing cumulative deaths per million for 35 European countries and all 50 US states). To address this problem we analyze cumulative deaths from COVID in these 85 nations/states. In average population and a number of other characteristics, such as percent of the population aged 65 and older, US States tend to be similar to European countries (see Table 2). Second, a lag of 12 days between the average onset of COVID in the entire EU and its average onset in the entire US masks the great variation in onset dates among the 85 nations/states also reported in Table 1. France was first to experience a death from COVID, on February 15, 2020 (we define time of onset as the day a first death was recorded). Wyoming was the last to experience its first COVID death on April 13, almost two months later. To address this second problem we use statistics on reported COVID deaths 50 or 100 days after the onset of COVID in that nation/state.[1] Looking at means we find a US/EUROPE gap of 207 more COVID-related deaths per million inhabitants 100 days after a nation/state's first death: the mean number of deaths per million is 407 in a US state and 200 in a European country (see Table 2). These averages include New York (the nation/state with most deaths per million inhabitants) and Belgium ranking 7th in the list of all nations/states. A number of other European countries rank among the 20 most affected, but most top 20 nations/states are part of the US.[2] The 5 nations/states with the best 100-days performance are all European countries (Malta, Greece, Latvia and Slovakia) except for Hawaii (see Table 1).

A third problem with many previous comparisons of fatalities in the US and Europe is that they tend to be quick at assigning credit or blame to politicians, while overlooking other factors that may contribute to gaps in COVID deaths. We address this problem by taking account of differences in demographic, political, economic, and health-system characteristics. Demographic characteristics include proportion of the population aged 65 or older and proportion of young adults aged 18 to 34 who live with their parents. We also consider variation in the time that elapsed between onset of pandemic in France and its onset in each of the nations/states. After taking

[1] In Wyoming 100 days from onset occurred on July 23, 2020.

[2] California, Florida, and Arizona reached 100 days from onset respectively on June 12, June 14 and June 28. As of August 13 these states have experienced new increases in COVID infections. Cumulative deaths per capita in those states reached 816, 369 and 535, respectively. This implies that 160 days after its onset, Florida had fewer cumulative deaths from COVID per capita than France after 100 days.

Table 1 Cumulative deaths from Coronavirus per capita 100 days after the onset of the coronavirus outbreak in that nation/state and date when country/state reached 100 days; observed by summer 2020

Rank	Country/state	Deaths pc @100 days	Reached 100 days on
1	New York	2072	22/06/2020
2	New Jersey	1888	18/06/2020
3	Connecticut	1580	26/06/2020
4	Massachusetts	1523	28/06/2020
5	Rhode Island	1181	06/07/2020
6	Louisiana	907	22/06/2020
7	*Belgium*	847	19/06/2020
8	Michigan	806	26/06/2020
9	Illinois	732	25/06/2020
10	Delaware	692	04/07/2020
11	Maryland	688	26/06/2020
12	Pennsylvania	679	26/06/2020
13	*United Kingdom*	627	15/06/2020
14	*Spain*	578	13/06/2020
15	*Italy*	555	02/06/2020
16	Indiana	522	24/06/2020
17	*Sweden*	494	20/06/2020
18	Mississippi	474	27/06/2020
19	*France*	423	25/05/2020
20	Colorado	382	20/06/2020
21	New Hampshire	353	01/07/2020
22	Minnesota	352	29/06/2020
23	*Netherlands*	351	15/06/2020
24	*Ireland*	349	20/06/2020
25	Georgia	335	20/06/2020
26	New Mexico	325	03/07/2020
27	Ohio	319	28/06/2020
28	Iowa	309	02/07/2020
29	Arizona	297	28/06/2020
30	Alabama	273	03/07/2020
31	Virginia	253	22/06/2020
32	Missouri	223	26/06/2020
33	Nevada	214	24/06/2020
34	Washington	204	08/06/2020
35	Nebraska	203	05/07/2020
36	*Switzerland*	196	14/06/2020
37	North Carolina	181	03/07/2020
38	*Luxembourg*	179	23/06/2020
39	Wisconsin	179	27/06/2020

Table 1 continued

Rank	Country/state	Deaths pc @100 days	Reached 100 days on
40	South Carolina	178	24/06/2020
41	Florida	176	14/06/2020
42	Kentucky	168	24/06/2020
43	California	167	12/06/2020
44	North Dakota	159	05/07/2020
45	*Portugal*	151	26/06/2020
46	*North Macedonia*	145	01/07/2020
47	Oklahoma	133	27/06/2020
48	Arkansas	125	02/07/2020
49	South Dakota	123	18/06/2020
50	Kansas	121	20/06/2020
51	Vermont	115	27/06/2020
52	Tennessee	115	29/06/2020
53	Texas	111	24/06/2020
54	*Germany*	107	18/06/2020
55	*Denmark*	104	24/06/2020
56	Maine	103	05/07/2020
57	*Romania*	85	01/07/2020
58	Utah	79	30/06/2020
59	*Austria*	78	21/06/2020
60	Idaho	73	04/07/2020
61	West Virginia	68	07/07/2020
62	*Turkey*	62	27/06/2020
63	*Finland*	59	30/06/2020
64	Oregon	59	22/06/2020
65	*Hungary*	59	24/06/2020
66	Wyoming	58	22/07/2020
67	*Slovenia*	53	26/06/2020
68	*Estonia*	52	04/07/2020
69	*Norway*	46	21/06/2020
70	*Serbia*	39	29/06/2020
71	*Poland*	35	21/06/2020
72	*Czechia*	33	01/07/2020
73	Montana	29	05/07/2020
74	*Iceland*	28	28/06/2020
75	*Lithuania*	28	29/06/2020
76	*Bulgaria*	28	20/06/2020
77	*Croatia*	27	03/07/2020
78	Alaska	27	05/07/2020
79	*Montenegro*	23	05/07/2020

Table 1 continued

Rank	Country/state	Deaths pc @100 days	Reached 100 days on
80	*Cyprus*	22	03/07/2020
81	*Malta*	18	18/07/2020
82	Hawaii	18	09/07/2020
83	*Greece*	18	20/06/2020
84	*Latvia*	16	13/07/2020
85	*Slovakia*	5	16/07/2020

European countries in italics

account of such factors, we find that US/Europe differences in cumulative deaths from COVID are considerably smaller than the gap in mean deaths per population shown in Table 2 and that the US/Europe gap is not related to whether a nation/state's government is affiliated with the left or the right.

Our main finding is that the large US/Europe gap in cumulative deaths becomes statistically insignificant in our models including various social distance measures and the timing of their implementation. Relative to US states, European countries were more likely to implement them and did so at a faster pace, and this appears to have saved lives.

2 Methods

We first estimate log-linear regressions of the log of cumulative number of deaths using a sample of 85 nations/states: 35 European countries and 50 US states. Logarithms allow us to interpret coefficients in percentage terms, which facilitates comparability across highly heterogeneous nations/states.[3] For example, we estimate Model 1 defined as:

$$y_r = \beta_0 + \beta_U U_r + \beta_P POP_r + \varepsilon_r, \tag{1}$$

where y is the log of cumulative COVID-caused deaths 100 days after the first death in nation/state r, U is a dummy for whether the nation/state is in the USA, *POP* stands for size of the population, and r indexes state or country. Epsilon is the error term.[4]

[3] https://stats.stackexchange.com/questions/298/in-linear-regression-when-is-it-appropriate-to-use-the-log-of-an-independent-va.

[4] We provide robust standard errors. We acknowledge that residuals may be correlated across European countries and across states in the United States. However, having only two continents prevents us from applying clustering techniques, including those suggested by Cameron and Miller (2015) for too few clusters. In particular, the bias-corrected cluster-robust variance matrix provides identical standard errors to the uncorrected one when the number of clusters equals two. Bootstrap of clusters is not feasible either as we would select the same two clusters in all draws. Finally, using stricter critical values for our tests would only reinforce our conclusion that estimates become insignificant when we include Covid-related variables as controls.

Table 2 Means and standard deviations for 50 US states and 35 European countries

Variables	US		Europe		Definition
	Mean	S.D.	Mean	S.D.	
Deaths at 50 days	1402	3623	3050	6279	Deaths from covid 50 days after onset in country/state
Deaths at 50 days per million	225.07	319.99	112.97	153.13	Deaths from covid 50 days after onset per million inhabitants
Deaths at 100 days	2413	4833	5079	10545	Deaths from covid 100 days after onset in country/state
Deaths at 100 days per million	406.99	479.54	169.10	216.75	Deaths from covid 100 days after onset per million inhabitants
Population (in millions)	4.91	5.54	17.70	24.65	Population expressed in million inhabitants
Co-residence	31.22	6.19	49.13	15.62	Percent of adults aged 18–34 living with parents;
Missing co-residence	0	0	0.09	0.28	Missing values in co-residence variable
Population over 65 (%)	0.17	0.02	0.19	0.02	Population older than 65 over total population in %
Missing Pop over 65	0	0	0.06	0.24	Missing values in population over 65 variable
Urban (%)	73.59	14.57	72.51	12.37	Population living in urban areas over total population
Missing urban	0	0	0.09	0.28	Missing values in variable urban
GDP per capita	58722	11068	36542	26347	Gross domestic product or gross state product
Rental prices	1642	577	1350	645	Rental prices in the capital of the country/state in dollars
Missing rental prices	0	0	0.11	0.32	Missing values in rental prices variable
Days since onset in France	33.48	7.52	30.69	10.81	Number of days from February 15 to onset
Lockdown measures					
Days to no social events	−3.32	16.82	17.54	32.60	Number of days from onset to social events ban
Days to no schools	24.89	35.57	12.14	29.69	Number of days from onset to schools closure
Days to no shops	3.08	13.65	10.09	23.01	Number of days from onset to shops closure
Days to partial lockdown	3.80	14.12	5.17	17.84	Number of days from onset to partial lockdow
Days to full lockdown	7.68	8.48	3.54	7.15	Number of days from onset to full lockdown

Table 2 continued

Variables	US Mean	US S.D.	Europe Mean	Europe S.D.	Definition
No social events at 100 days	1.00	0.00	1.00	0.00	Social events ban in place 100 days after onset
No schools at 100 days	0.98	0.14	0.43	0.50	Schools closure in place 100 days after onset
No shops at 100 days	0.06	0.24	0.14	0.36	Shops closure in place 100 days after onset
Partial lockdown at 100 days	0.00	0.00	0.09	0.28	Partial lockdown in place 100 days after onset
Full lockdown at 100 days	0.00	0.00	0.09	0.28	Full lockdown in lace 100 days after onset
Tests pc at 86 days	0.09	0.04	0.06	0.05	Number of tests are measured per one million inhabitants
Missing test pc at 86 days	0.00	0.00	0.09	0.28	Missing values in Tests pc at 86 days
Hospital beds pc	2.63	0.72	4.68	1.67	Hospital beds per one thousand inhabitants.
Left-leaning government	0.48	0.50	0.29	0.46	Goverment is left-leaning

Next, we add X_{1r} to this equation: it is a vector of demographic and economic characteristics including the following explanatory variables: intergenerational co-residence (measured as proportion of those aged 18 to 34 who live with their parents), percent of the population over 65, and percent urban, as well as economic variables (Gross Domestic or State Product per capita and rental prices).[5] This gives Eq. 2

$$y_r = \beta_0 + \beta_U U_r + \beta_P POP_r + \beta_1 X_{1r} + \varepsilon_r. \tag{2}$$

Model 3 adds to model 2 by also including X_{2r}, a vector containing the following variables: number of days since first death in France, the square value of this number,[6] and whether a government is left-leaning or not. In the case of EU countries we defined 'left' as having a government that belongs to the Greens-European Free Alliance, European United Left-Nordic Green Left, or Progressive Alliance of Socialists and Democrats groups in the European parliament; in the case of US states 'left' is defined as presence of a governor belonging to the democratic party.

$$y_r = \beta_0 + \beta_U U_r + \beta_P POP_r + \beta_1 X_{1r} + \beta_2 X_{2r} + \varepsilon_r. \tag{3}$$

Regression Eq. 4 is similar to Eq. 4, except for the fact that it also includes X_{3r}, a vector of social distance measures specifying whether a state or country instituted a full or partial lockdown and number of days it took to implement the measure after the onset of the pandemic in each nation/state. The measures we consider are: full lockdown (all-day but could allow citizens to buy essential items), night curfew or other partial lockdown (could apply only to part of the population), closed schools, closed shops and closed social events.[7]

$$y_r = \beta_0 + \beta_U U_r + \beta_P POP_r + \beta_1 X_{1r} + \beta_2 X_{2r} + \beta_3 X_{3r} + \varepsilon_r. \tag{4}$$

We also estimate a model that is similar to Eq. 4, but in addition includes number of hospital beds per capita and number of per capita tests 14 days prior to the day cumulative deaths were measured.[8] All variables are defined in Table 2. Sources are specified in Table 6 of the Appendix.

Parameter β_U in all equations above estimates the difference in the conditional mean between US states and European countries. The predicted mean difference between the US (U) and European (E) death rates can then be written as

$$\left(\bar{\hat{y}}_U - \bar{\hat{y}}_E\right) = \widehat{\beta}_u + \widehat{\beta}_1\left(\overline{X}_{1U} - \overline{X}_{1E}\right) + \widehat{\beta}_2\left(\overline{X}_{2U} - \overline{X}_{2E}\right), \tag{5}$$

where hats indicate predicted values and bars indicate means. This equation could be expanded if there are more than two vectors of explanatory variables. The question of

5 Rental prices may be a proxy for residential patterns and affect real income.

6 France recorded its first death on February 15, and this is the first death recorded in our sample. Time since onset in the West is specified in quadratic terms as we allowed for the possibility of a non-linear relationship with fatalities from COVID.

7 See https://github.com/OlivierLej/Coronavirus_CounterMeasures.

8 Based on data from Los Angeles and New Jersey, Harris (2020a) estimates that, on average, it took 16 days from a test-based COVID diagnosis to death. He presumes that during the worst phase of the epidemic in Italy the time from diagnosis to death was shorter (Harris, personal communication). We measure tests 14 days prior to the time we measure deaths, which is reasonable if many of those tested already have severe symptoms. However, if tests are widely available and many of those tested are asymptomatic it may take more than 16 days from test time to death.

interest to us is: what happens to $\widehat{\beta}_u$ as more variables are included in the model? To the extent that these variables help explain the difference between European countries and US states the estimated value of β_u is expected to decrease. Furthermore, the direction of the change is determined by the last terms in Eq. 5. If the mean value of a variable is *greater* (lower) in the US than in Europe, and it contributes to reducing $\widehat{\beta}_u$, the estimate of $\widehat{\beta}_i$ is expected to be *positive* (*negative*). That is, some of the positive difference in the left-hand side that was captured by$\widehat{\beta}_u$ is now redistributed to the last two terms. For example, to the extent that nations/states with higher income have more deaths, by including GDP per capita in the equation we expect that the coefficient of the US dummy will go down as some of the differential mortality is captured by differences in state/country income.

3 Findings

Regression results based on Eqs. 1–4 are reported in Table 3 (columns 1 to 4), where cumulative deaths are measured 100 days after onset in each country or state. The five regressions in Table 3 each include a dummy for US and population size, a central determinant of cumulative deaths. When these are the only variables taken into consideration (Model 1 in column 1) we find that the logarithm of cumulative deaths 100 days after onset is 1.3 higher in a US state than in a European country. This implies that cumulative deaths are 130% higher in a US state. On average, according to Table 2 cumulative deaths per capita were 169 in a European country. Multiplying this number by 1.3 gives 220 more cumulative deaths per capita for a US state according to model 1, which implies a total of 389 deaths per capita in a US state.

Model 2 presented in Column 2 adds the following demographic and economic variables to the regression in Column 1 that was based on Eq. 1: share of young adults living with their parents, the proportion of the population aged 65 or older, percent urban, GDP or State Product per capita, rental price and dummies indicating that some of these variables have missing values (see Table 7 of Appendix for details about missing values). By adding these variables we see that the US/EUROPE differential in cumulative deaths shrinks to being 100% higher in a US state, which translates into a doubling in the number of deaths, on average from 169 for a European country to 338 for a US state.

Model 3 reported in Column 3 includes three additional variables: date of onset of the pandemic in a particular country, the square value of days since onset, and whether the government of a nation/state is left-leaning. Adding these variables is associated with a slight increase in the intercontinental differential: the coefficient of US in the regression rises, implying that the US/Europe differential increases to 110%.

The model shown in Col. 4 adds various types of social distance measures to Model 3. It corresponds to Eq. 4 above. By adding these measures the US/Europe differential in cumulative deaths shrinks considerably: from 110% based on column 3 to a value that is statistically insignificant and thus not different from zero.

Finally, the model in column 5 indicates that by adding information on tests and beds to the model in column 4 the US/Europe differential continues to be statistically insignificant. Here we also add dummies when variables are missing for particular countries.

The differences in the coefficient of US state across the 5 models in Table 3 can be explained with the help of Eq. 5, interpreting X_1 and X_2 as different (vectors of)

Table 3 The US-Europe differential in regressions of log of cumulative covid-19 deaths measured 100 days after onset

Variables	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5
US	1.302*** (0.374)	0.995** (0.497)	1.111*** (0.419)	0.404 (0.535)	0.234 (0.636)
Population size	0.0810*** (0.0130)	0.0660*** (0.0112)	0.0549*** (0.0129)	0.0575*** (0.0142)	0.0628*** (0.0165)
Co-residence		0.0314** (0.0152)	0.0263** (0.0129)	0.0172 (0.0139)	0.0181 (0.0149)
Missing co-residence		−1.176 (1.170)	−1.575** (0.747)	−1.395 (0.919)	−1.345 (0.999)
% over 65		0.787 (10.28)	0.843 (8.164)	4.802 (8.246)	6.770 (8.929)
Missing % over 65		3.264*** (1.149)	2.759*** (0.715)	2.559*** (0.767)	4.422*** (1.435)
% urban		0.0386*** (0.0137)	0.0268** (0.0122)	0.0265* (0.0138)	0.0240 (0.0159)
Missing % urban		−2.527*** (0.501)	−2.059*** (0.368)	−1.366* (0.716)	−3.865** (1.753)
GDP pc		3.91e-06 (1.33e-05)	−4.27e-06 (1.21e-05)	2.67e-06 (1.26e-05)	6.87e-06 (1.47e-05)
Rental prices		0.000533* (0.000308)	0.000546** (0.000258)	0.000471* (0.000266)	0.000336 (0.000323)
Missing rental prices		−2.455* (1.298)	−1.359* (0.724)	−1.726* (0.940)	−2.845** (1.275)
Days since onset in France			0.0794 (0.0513)	0.120 (0.0882)	0.124 (0.0889)
Days since onset in Fr., squared			−0.00255*** (0.000794)	−0.00278** (0.00120)	−0.00271** (0.00123)
Days until no social events				0.00428 (0.00675)	0.00752 (0.00733)
Days until no schools				0.00432 (0.00476)	0.00512 (0.00510)
Days until no shops				−0.0143 (0.0129)	−0.0127 (0.0137)
Day until partial lockdown				−0.00136 (0.00989)	−0.00519 (0.0106)
Days until full lockdown				0.0189 (0.0255)	0.0256 (0.0279)
No Schools at 100 days				0.584 (0.436)	0.463 (0.479)
No Shops at 100 days				0.912 (0.592)	0.825 (0.693)
Lockdown at 100 days				−0.927 (0.802)	−0.858 (1.022)
Tests pc at 86 days					7.627 (12.48)

Table 3 continued

Variables	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5
Missing tests pc					2.103* (1.232)
Hospital beds per 1000					−0.0128 (0.201)
Missing beds					0.0224 (1.192)
Beds x test pc					−1.451 (2.695)
Leftist government			0.169 (0.293)	0.191 (0.307)	0.0892 (0.351)
Constant	4.857*** (0.340)	0.180 (2.792)	1.853 (2.642)	0.0287 (2.879)	−0.454 (3.554)
Observations	85	85	85	85	85
R-squared	0.415	0.621	0.744	0.768	0.776

For variable definitions see Table 2 and Appendix Table. Robust standard errors in parentheses

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

explanatory variables added to the model. When comparing models 1 and 2 we see that the US/Europe differential in cumulative mortality shrinks, reflecting the addition of the following variables that favor the spread of the virus and that have a higher mean value in the US than in Europe: rental prices and percent urban. On average US states are slightly more urban and more urban states/countries have had more fatalities. In contrast, the US coefficient is expected to be larger in Model 2 that also includes share of multi-generational coresidence: the US has lower coresidence rates, and coresidence is associated with higher mortality. However, relative to European countries, the US suffers more mortality where intergenerational cohabitation is higher (as shown in Aparicio and Grossbard, 2020a).[9]

From model 3 it can be seen that the later the pandemic started in a particular area the lower the number of cumulative deaths, as apparent from the coefficient of the squared value of 'Days since onset in France'.[10] As we add that variable to the model we see that the US/Europe differential rises slightly, given that, on average, COVID epidemics started later in US states than in European countries (the mean time that elapsed between first onset in the West and onset for a US state is 33.5 days; it is 30.7 for a European country). This suggests that the US was favored by the delay in experiencing the first Covid cases. It can be noticed that whether a government is left-leaning or not is not associated with differences in cumulative deaths once all the other variables are included in the regression models. This continues to be the case in the models reported in columns 4 and 5.

What could account for the substantial reduction in the coefficient of US state in column 4, after the addition of social distance measures? First, European countries took less time to close schools (on average, 12.1 days after onset, versus 24.9 days in the US) and to impose full lockdowns in case of full lockdown (on average 3.5 days from onset versus 7.7 days in the US). Second, 100 days after onset in 14 percent of European countries shops were closed (versus in 6 percent of US states) and in 9 percent of European countries there was a partial lockdown (versus zero percent in US states). Even though the results in Col. 4 do not indicate that any of these measures had statistically significant effects on cumulative death rates the presence of the extra vector of variables related to social distance measures does matter and other studies have shown that how quickly lockdowns were imposed was associated with fewer cases or fewer deaths (e.g. Pei et al 2020). We don't expect the reduced coefficient of US state to be explained by the fact that on average US states closed shops faster (3 days after onset, versus 10 days after onset in European countries) and were faster at imposing a partial lockdown if it was imposed (3.8 days after onset, versus 5.2 days in Europe).

The results in column 5 suggest that little explanatory power is added by including information on hospital beds per capita and COVID tests performed 86 days after onset. Our results don't support or deny the possibility that lives were saved thanks to additional hospital beds. European countries had extra hospital beds (an average of

[9] For more on why intergenerational co-residence can contribute to the spreading of COVID among more vulnerable older adults, see Harris (2020b). Note that, on average, a lower proportion of the US population living in multi-generational households: (49% versus 31%, as reported in Table 2).

[10] This negative coefficient could be explained by medical advances that are the result of the experience of nations/states that were hit by COVID earlier and that benefit nations/states facing COVID emergencies at a later stage (see Landoni et al 2020; Aparicio and Grossbard, 2020b).

4.7 versus an average of 2.6 in US states). On average, more tests were given in US states than in European countries, however these tests differences do not seem to be at the origin of the extra deaths in the US.

We include dummies for missing values and it appears that the coefficients of these dummies are often statistically significant. Given that we only have a total of 85 countries or states and some data are missing for 6 European countries (no data are missing for US states) these dummies capture peculiarities unique to the countries missing that information. For instance, we miss information on proportion urban in Cyprus, Macedonia and Turkey. These three countries have fewer cumulative deaths for reasons we can't identify.

Table 4 suggests that the US/Europe differential has grown over time. We reestimated the regressions presented in Table 3, where cumulative deaths are measured 100 days past onset, and instead measured deaths at 50 days past onset. It can be seen that after 50 days the rough differential reported in Column 1 was smaller than after 100 days: cumulative deaths are 90 percent higher in the US, not 130 percent higher, when we only control for population size. Comparing the coefficient of US in Column 1 of Tables 3 and 4 suggests that the US/Europe gap in cumulative deaths has grown over time, as countries and states remain exposed to COVID for a longer time. Furthermore, at 50 days past onset, as soon as we add demographic and economic control variables the US/Europe differential becomes statistically insignificant (Column 2). The differential continues not to be significantly different from zero in the models presented in columns 3 to 5.

To test for the robustness of our results we also estimated regressions using deaths per million inhabitants as an alternative dependent variable (available upon request). Results support our findings that measures such as school closings and lockdowns, and how soon they were implemented, help explain the US/EUROPE gap in Covid deaths.

We also estimated regressions of the mortality rate, measured as number of deaths per COVID case. The same 5 models specified in Section 2 were estimated, but now with a different dependent variable. Results are reported in Table 5. It can be seen that the coefficient of the US dummy is negative in all regressions and it grows in absolute value as we add an increasingly large number of explanatory variables. The negative coefficient indicates that given the number of cases identified 100 days after onset of COVID in a particular country or state fewer people died per case in a US state than in a European country. To explain the contrast with the US dummy coefficient in Table 3, which was positive, we note that per capita there were, on average, more tests in US states than in European countries (Table 2). Consequently, more cases were identified and the numerator is larger, on average, in a US state than in a European country. It is also possible that COVID has been less likely to lead to deaths in the US, conditional on number of cases.

Comparing model 3 in col. 3 (without controls for social distance measures) with the model in col. 4 (including social distance measures) we see that the US dummy rises in absolute value, from −45 to −65. This increase in coefficient is not statistically significant. In both columns 4 and 5 the coefficient of the US dummy is only significant at the 10% level; it was so at the 5% level in cols. 1 to 3. From Table 5 we can't derive the conclusion that US/Europe differentials in the use of social distance measures account for higher mortality in the US. Few variables have a statistically significant coefficient in Table 5, an exception being a positive coefficient of GDP per capita, especially in col. 5 where we also control for hospital beds: richer countries and

Table 4 The US-Europe differential in regressions of log of cumulative covid-19 deaths measured 50 days after onset

	(1)	(2)	(3)	(4)	(5)
Variables	Model 1	Model 2	Model 3	Model 4	Model 5
US	0.921** (0.371)	0.652 (0.485)	0.690 (0.426)	0.135 (0.579)	−0.0239 (0.633)
Population size	0.0763*** (0.0120)	0.0604*** (0.0108)	0.0552*** (0.0134)	0.0536*** (0.0139)	0.0566*** (0.0150)
Co-residence		0.0356** (0.0149)	0.0307** (0.0130)	0.0213 (0.0156)	0.0249 (0.0159)
Missing co-residence		−0.517 (1.037)	−1.096 (0.728)	0.0375 (1.009)	0.712 (1.996)
% over 65		4.424 (9.727)	3.685 (8.180)	2.533 (8.673)	4.957 (9.093)
Missing propor65over		2.795*** (1.019)	2.276*** (0.722)	2.484*** (0.884)	
% urban		0.0375*** (0.0132)	0.0259** (0.0123)	0.0217 (0.0148)	0.0201 (0.0164)
Missing % urban		−2.271*** (0.477)	−1.871*** (0.381)	−1.808*** (0.676)	
GDPpc		1.09e-05 (1.34e-05)	3.71e-06 (1.27e-05)	5.31e-06 (1.51e-05)	1.64e-05 (1.61e-05)
Rental prices		0.000444 (0.000314)	0.000462* (0.000275)	0.000427 (0.000300)	0.000270 (0.000358)
Missing rental prices		−2.760** (1.118)	−1.745** (0.721)	−2.167** (0.953)	−2.930 (2.355)
Days since onset in France			0.107** (0.0519)	0.134 (0.101)	0.156 (0.0971)
Days since onset in Fr., squared			−0.00271*** (0.000776)	−0.00271** (0.00133)	−0.00278** (0.00129)
Days until No social events				0.00104 (0.00743)	0.00358 (0.00804)
Days until No schools				0.00622 (0.00529)	0.00750 (0.00535)
Days until No shops				−0.00750 (0.0130)	−0.00525 (0.0137)
Days until partial lockdown				0.00855 (0.0121)	0.00832 (0.0142)
Days until full lockdown				0.0188 (0.0269)	0.0205 (0.0281)
No Schools at 50 days				0.899* (0.517)	0.933* (0.517)
No Shops at 50 days				0.0751 (0.526)	0.000877 (0.530)
Partial lockdown @50 days				−0.960 (0.768)	−1.262 (0.925)
Full lockdown @50 days				1.172 (0.767)	1.377 (0.911)

Table 4 continued

Variables	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5
Harsh lockdown @50 days				0.182 (0.646)	0.434 (0.636)
Tests pc at 36 days					8.620 (22.04)
Hospital beds per 1000					0.0246 (0.177)
Beds x tests					−5.583 (6.256)
Left			0.293 (0.298)	0.305 (0.343)	0.306 (0.351)
Constant	4.569*** (0.331)	−1.061 (2.679)	−0.0939 (2.698)	−0.974 (3.280)	−2.173 (3.532)
Observations	85	85	85	85	81
R-squared	0.388	0.611	0.717	0.749	0.723

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 5 Regressions of mortality rate per COVID case (deaths per case measured 100 days after onset)

	(1)	(2)	(3)	(4)	(5)
Variables	Model 1	Model 2	Model 3	Model 4	Model 5
US	−30.44** (11.96)	−49.34** (21.07)	−45.12** (19.94)	−64.55* (33.47)	−69.61* (36.08)
Population size	−0.0207 (0.222)	0.00497 (0.234)	−0.159 (0.266)	−0.102 (0.257)	0.0779 (0.303)
Co-residence		0.645 (0.471)	0.657 (0.466)	0.200 (0.347)	0.312 (0.390)
Missing co-residence		4.854 (12.34)	14.30 (15.43)	19.39 (25.78)	−0.412 (26.86)
% over 65		−296.3 (323.3)	−227.6 (314.4)	−47.83 (144.6)	−40.96 (159.1)
Missing % over 65		28.79 (22.08)	21.61 (19.48)	45.80* (25.91)	30.95 (20.38)
% urban		−0.408 (0.604)	−0.396 (0.639)	−0.531 (0.584)	−0.573 (0.681)
Missing % urban		−35.84* (18.85)	−32.40* (17.42)	−22.36 (20.92)	−24.69 (26.88)
GDPpc		0.000835* (0.000490)	0.000846* (0.000474)	0.00106* (0.000550)	0.00113** (0.000554)
Rental prices		0.00563 (0.00641)	0.00542 (0.00642)	0.00532 (0.00573)	0.00173 (0.00614)
Missing rental prices		−22.84 (18.09)	−11.51 (14.31)	−34.69 (26.30)	
Days since onset in France			−0.154 (1.384)	1.341 (2.839)	1.836 (2.808)
Days since onset in Fr., squared			−0.00827 (0.0196)	−0.0132 (0.0344)	−0.0158 (0.0338)
Days until No social events				0.402 (0.274)	0.455 (0.327)
Days until No schools				−0.0388 (0.0846)	−0.0428 (0.0915)
Days until No shops				−0.471 (0.375)	−0.436 (0.350)
Days until partial lockdown				−0.0133 (0.390)	−0.0623 (0.378)
Days until full lockdown				1.305 (0.972)	1.133 (0.878)
No Schools at 100 days				14.02 (18.80)	15.21 (19.84)
No Shops at 100 days				36.71 (43.76)	41.12 (43.14)
Partial lockdown at 100 days				−44.97 (51.38)	−57.87 (51.53)
Tests pc at 86 days					−188.3 (244.8)

Table 5 continued

Variables	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5
Missing tests pc					36.98 (42.20)
Hospital beds per 1000					−7.098 (6.127)
Missing beds					−47.12 (48.35)
Beds x test pc					29.99 (59.32)
Left			−8.290 (8.219)	−8.274 (8.253)	−11.22 (7.770)
Constant	30.65** (12.83)	49.96 (71.69)	52.44 (80.59)	−12.67 (62.58)	9.029 (78.79)
Observations	84	84	84	84	84
R-squared	0.146	0.359	0.382	0.493	0.518

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

states may offer better medical care. We prefer our main results reported in Table 3 where the log of cumulative deaths is the dependent variable to the results in Table 5 which depend on both cumulative deaths and number of measured cases, in view of possible measurement errors in both cases and deaths, and the difficulty of establishing whether a variable affects number of cases, number of deaths per case, or both.

4 Conclusions

Using a sample of 50 US states and 35 European countries we find that 100 days after onset of the COVID pandemic in a particular state or country the US/Europe gap in cumulative deaths stands at 130% when we only control for population size. Given that on average a European country had 169 deaths this implies that on average a US state had 350 cumulative deaths. When we control for other demographic factors and some economic factors, the gap shrinks to 100%. Once we also control for national or state differences in social distancing measures related to COVID the US-Europe gap shrinks considerably and becomes statistically insignificant. This suggests that various types of social distance measures such as school closings and lockdowns, and how soon they were implemented, help explain the gap in cumulative deaths. Relative to US states, European countries were more likely to implement them and did so at a faster pace.

There is much left for further research to establish. We hope that our estimations will be computed with better statistics on deaths from COVID (such as comparisons of number of deaths before and after COVID), better health policy data, and based on a larger sample of countries. It would also be useful to further explore our findings at a more detailed level, such as the US counties, European provinces, or other sub-national levels. There have been studies estimating determinants of fatalities using data for small geographic units in the US (e.g. Ahammer et al. 2020) or Europe (e.g. Arpino et al. 2020, Belloc et al. 2020, Laliotis and Minos 2020). Insights could also be gained from combining such sub-national data from the US and Europe, but pooling large sets of data for small geographic units in the USA and Europe is a complex task that has not been undertaken yet. We also hope that further research will keep track of further changes in lockdown policy, beyond the measures taken in the first 100 days of the pandemic and covered in this study.

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Compliance with ethical standards

Conflict of interest The authors declares that they have no conflict of interest.

5 Appendix

Table 6 Data sources

Variable	EU countries	US states	Year Measured	Downloaded on
Covid deaths	https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases	https://github.com/nytimes/covid-19-data/blob/master/us-states.csv	2020	August 3, 2020
Demographics				
Total population, and % over 65	https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do	https://data.census.gov/cedsci/table?q=S0102&tid=ACSST1Y2018.S0102	2018	May 11, 2020
% Urban population	https://population.un.org/wup/DataQuery/	https://www.icip.iastate.edu/tables/population/urban-pct-states	2010	May 16, 2020
Intergenerational co-residence (% aged 18–34 living w their parents)	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_lvps08&	https://data.census.gov/cedsci/table?q=Young%20Adults,%2018-34%20Years%20Old,%20Living%20At%20Home%20by%20state&g=0100000US.04000.001&hidePreview=true&tid=ACSDT1Y2018.B09021&vintage=2018&layer=VT_2018_040_00_PY_D1&cid=B09021_008E	2018	April 23, 2020
Economic variables				
Rental Prices	https://www.ubs.com/microsites/prices-earnings/en/	https://www.zillow.com/research/data/	2020	May 8, 2020
Gross Domestic or State Product in dollars (per capita)	https://data.worldbank.org/indicator/NY.GDP.PCAP.CD	https://www.bea.gov/ https://www2.census.gov/programs-surveys/popest/tables/2010-2016/state/totals/nst-est2016-01.xlsx	2018	April 29, 2020
Health-related variables				
Number of tests[a]	https://ourworldindata.org/grapher/full-list-total-tests-for-covid-19	https://covidtracking.com/api	2020	August 3, 2020
Days from 1st death to lockdown[b]	https://github.com/OlivierLej/Coronavirus_CounterMeasures	https://github.com/OlivierLej/Coronavirus_CounterMeasures	2020	April 25, 2020
Hospital beds (per 1000 inhabitants)[c]	https://www.oecd-ilibrary.org/social-issues-migration-health/health-at-a-glance-2019_4dd50c09-en	http://ghdx.healthdata.org/record/united-states-hospital-beds-1000-population-state	2017	June 25, 2020

[a]The number of tests was measured 14 days prior to the number of fatalities

[b]Number of days from February 15, when the first Covid death in our sample was reported in France, to the first death in a particular country

[c]Data for Bulgaria, Croatia, Romania and Serbia is from https://ourworldindata.org/

Table 7 Missing values among European countries, by country

Missing information on						
Country	Co-residence	% Urban	Proportion 65+	Rental Prices	Tests pc @86	Beds
Cyprus	0	1	0	0	1	1
Iceland	1	0	0	1	0	0
Malta	0	0	0	1	0	1
Montenegro	1	0	0	1	1	1
North Macedonia	0	1	1	1	1	1
Turkey	1	1	1	0	0	0

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