

Letters

RESEARCH LETTER

COVID-19 and Excess All-Cause Mortality in the US and 18 Comparison Countries

The US has experienced more deaths from coronavirus disease 2019 (COVID-19) than any other country and has one of the highest cumulative per capita death rates.^{1,2} An unanswered question is to what extent high US mortality was driven by the early surge of cases prior to improvements in prevention and patient management vs a poor longer-term response.³ We compared US COVID-19 deaths and excess all-cause mortality in 2020 (vs 2015-2019) to that of 18 countries with diverse COVID-19 responses.

Methods | We compared the US to Organisation for Economic Co-operation and Development countries with populations exceeding 5 million and greater than \$25 000 per capita gross domestic product. For each country, we calculated the COVID-19

per capita mortality rate and grouped countries by mortality: (1) low (COVID-19 deaths, <5/100 000), (2) moderate (5-25/100 000), and (3) high (>25/100 000).¹ We used Poisson regression for comparisons across countries.

We calculated the difference in COVID-19 deaths between each country and the US through September 19, 2020 (week 38) under 3 scenarios: if the US had a comparable per capita COVID-19 mortality rate to each country from the start of the pandemic (February 13) or if the US mortality rate became comparable to other countries beginning May 10 or June 7, to allow lag time for policy interventions.³ (See the Supplement for formulas.)

We also considered all-cause mortality per capita for countries with publicly available data through July 25, 2020 (week 30). This measure is robust to country-level differences in COVID-19 death coding and captures indirect pandemic effects. We estimated excess all-cause mortality (the difference between mean 2020 deaths and deaths in corresponding weeks of 2015-2019) for each country and the US, compared rates across countries using Poisson regression with country and

Table 1. COVID-19 Mortality in the US Compared With That of Other Countries^a

Country	Date COVID-19 cases surpassed 1 per million	COVID-19 deaths per 100 000			Excess US COVID-19 deaths (% of reported deaths)		
		Since the start of the pandemic	Since May 10, 2020	Since June 7, 2020	Since the start of the pandemic	Since May 10, 2020	Since June 7, 2020
Low mortality (COVID-19 deaths, <5/100 000)							
South Korea	2/20/20	0.7	0.2	0.2	196 161 (99)	120 625 (61)	88 771 (45)
Japan	2/23/20	1.2	0.7	0.5	194 711 (98)	119 090 (60)	87 939 (44)
Australia	3/1/20	3.3	2.9	2.9	187 661 (94)	111 747 (56)	79 849 (40)
Moderate mortality (COVID-19 deaths, 5-25/100 000)							
Norway	2/29/20	5.0	1.0	0.5	182 099 (92)	118 074 (59)	87 655 (44)
Finland	3/2/20	6.1	1.4	0.3	178 373 (90)	116 698 (59)	88 432 (45)
Austria	3/1/20	8.6	1.7	1.0	170 247 (86)	115 874 (58)	86 066 (43)
Denmark	3/4/20	10.9	2.1	0.8	162 600 (82)	114 438 (58)	86 669 (44)
Germany	3/1/20	11.3	2.4	0.9	161 393 (81)	113 422 (57)	86 521 (44)
Israel	3/2/20	14.0	11.2	10.6	152 393 (77)	84 676 (43)	54 529 (27)
Switzerland	2/29/20	20.6	2.8	1.2	130 654 (66)	112 205 (57)	85 402 (43)
Canada	3/6/20	24.6	12.4	4.0	117 622 (59)	80 631 (41)	76 235 (38)
High mortality (COVID-19 deaths, >25/100 000)							
The Netherlands	3/3/20	36.2	5.2	1.5	79 318 (40)	104 177 (52)	84 514 (43)
France	3/1/20	46.6	7.5	3.2	45 142 (23)	96 763 (49)	78 947 (40)
Sweden	2/29/20	57.4	23.5	10.3	9581 (5)	44 210 (22)	55 607 (28)
Italy	2/23/20	59.1	9.1	3.1	4136 (2)	91 604 (46)	79 120 (40)
United Kingdom	3/3/20	62.6	16.3	5.0	-7459 (-4)	67 927 (34)	73 103 (37)
Spain	2/29/20	65.0	8.6	4.6	-15 204 (-8)	93 247 (47)	74 163 (37)
Belgium	3/2/20	86.8	12.4	4.2	-87 057 (-44)	80 475 (41)	75 572 (38)
United States	3/7/20	60.3	36.9	27.2			

^a Data on coronavirus disease 2019 (COVID-19) deaths are from February 13, 2020, through September 19, 2020 (n = 198 589 US deaths). In columns 4-6, due to large sample sizes, all mortality rates are statistically significantly different from the corresponding US mortality rates (P < .001). Scenarios in the last 3 columns assume that compared with the country in a given row,

(A) the US had a comparable cumulative mortality rate; (B) the US mortality rate was unchanged until May 10 (n = 77 180 deaths), when it became comparable to the other country's death rate; and (C) the US mortality rate was unchanged until June 7 (n = 109 143 deaths), when it became comparable to the other country's death rate.

Table 2. Excess All-Cause Mortality in the US Compared With That in Other Countries^a

Country	Excess all-cause mortality per 100 000			Excess US deaths from all causes (% of reported deaths)		
	Since the start of the pandemic	Since May 10, 2020	Since June 7, 2020	Since the start of the pandemic	Since May 10, 2020	Since June 7, 2020
Moderate mortality (COVID-19 deaths, 5-25/100 000)						
Norway	-2.6	-4.3	-2.1	235 610 (100)	102 598 (44)	63 952 (27)
Denmark	5.1	1.9	1.8	218 664 (93)	96 375 (41)	57 910 (25)
Israel	8	7.5	5.4	209 376 (89)	77 932 (33)	46 091 (20)
Germany	10.0	1.4	-0.2	202 547 (86)	97 905 (42)	63 952 (27)
Canada	13.3	-3.7	-7.6	192 009 (81)	102 598 (44)	63 952 (27)
Switzerland	17.0	-3.6	-2.7	179 545 (76)	102 598 (44)	63 952 (27)
Austria	17.1	3.2	1.4	179 208 (76)	92 042 (39)	59 375 (25)
Finland	19.1	8.7	5.4	172 706 (73)	74 116 (31)	46 264 (20)
High mortality (COVID-19 deaths, >25/100 000)						
Sweden	50.8	14.9	3.7	68 540 (29)	53 429 (23)	51 864 (22)
France	51.5	5.9	2.6	66 167 (28)	83 301 (35)	55 512 (24)
The Netherlands	55.1	0.1	-0.7	54 282 (23)	102 157 (43)	63 952 (27)
Belgium	67.8	-4.6	-6.4	12 638 (5)	102 598 (44)	63 952 (27)
United Kingdom	94.5	13.7	-1.2	-75 196 (-32)	57 659 (24)	63 952 (27)
Spain	102.2	2.1	1.8	-100 768 (-43)	95 784 (41)	57 948 (25)
United States	71.6	31.2	19.4			

^a Data on deaths are through July 25, 2020 (week 30, n = 235 610 excess US deaths compared with 145 546 reported COVID-19 deaths). Countries lacking publicly available all-cause mortality data through this time are omitted. Excess deaths were estimated by week, compared with 2015-2019, beginning when a country surpassed 1 COVID-19 case per million population. In columns 3-5, due to large sample sizes, all mortality rates are statistically significantly different from the corresponding US mortality rates ($P < .001$). Scenarios in the last 3 columns assume that compared with the country in a given row:

(A) the US had a comparable cumulative mortality rate; (B) the US excess all-cause mortality rate was unchanged until May 10 (week 20, n = 133 012 deaths), when it became comparable to the other country's death rate; and (C) the US excess all-cause mortality rate was unchanged until June 7 (week 24, n = 171 659 deaths), when it became comparable to the other country's death rate. Totals are truncated to avoid exceeding US estimated deaths. Due to reporting lags, these data include less follow-up time than Table 1, which in some cases produces lower cumulative death rates.

week fixed effects (Supplement), and estimated the difference in excess all-cause mortality between each country and the US as described above. We used R software (version 4.0.2) for all analyses.

Results | On September 19, 2020, the US reported a total of 198 589 COVID-19 deaths (60.3/100 000), higher than countries with low and moderate COVID-19 mortality but comparable with high-mortality countries (Table 1). For instance, Australia (low mortality) had 3.3 deaths per 100 000 and Canada (moderate mortality) had 24.6 per 100 000. Conversely, Italy had 59.1 COVID-19 deaths per 100 000; Belgium had 86.8 per 100 000. If the US death rates were comparable to Australia, the US would have had 187 661 fewer COVID-19 deaths (94% of reported deaths), and if comparable with Canada, 117 622 fewer deaths (59%).

While the US had a lower COVID-19 mortality rate than high-mortality countries during the early spring, after May 10, all 6 high-mortality countries had fewer deaths per 100 000 than the US. For instance, between May 10 and September 19, 2020, Italy's death rate was 9.1/100 000 while the US's rate was 36.9/100 000. If the US had comparable death rates with most high-mortality countries beginning May 10, it would have had 44 210 to 104 177 fewer deaths (22%-52%) (Table 1). If the US had comparable death rates beginning June 7, it would have had 28% to 43% fewer reported deaths (as a percentage overall).

In the 14 countries with all-cause mortality data, the patterns found for COVID-19-specific deaths were similar for excess all-cause mortality (Table 2). In countries with moderate COVID-19 mortality, excess all-cause mortality remained negligible throughout the pandemic. In countries with high COVID-19 mortality, excess all-cause mortality reached as high as 102.1/100 000 in Spain, while in the US it was 71.6/100 000. However, since May 10 and June 7, excess all-cause mortality was higher in the US than in all high-mortality countries (Table 2).

Discussion | Compared with other countries, the US experienced high COVID-19-associated mortality and excess all-cause mortality into September 2020. After the first peak in early spring, US death rates from COVID-19 and from all causes remained higher than even countries with high COVID-19 mortality. This may have been a result of several factors, including weak public health infrastructure and a decentralized, inconsistent US response to the pandemic.^{4,5}

Limitations of this analysis include differences in mortality risk: the US population is younger but has more comorbidities compared with the other countries.⁶ In addition, since late August death rates have increased in several countries, and how mortality will compare with the US throughout fall remains unknown.

Alyssa Bilinski, MSc
Ezekiel J. Emanuel, MD, PhD

Author Affiliations: Interfaculty Initiative in Health Policy, Harvard Graduate School of Arts and Sciences, Cambridge, Massachusetts (Bilinski); University of Pennsylvania Perelman School of Medicine, Philadelphia (Emanuel).

Corresponding Author: Ezekiel J. Emanuel, MD, PhD, Perelman School of Medicine, University of Pennsylvania, Medical Ethics and Health Policy, 423 Guardian Dr, Blockley Hall, Ste 1412, Philadelphia, PA 19104 (MEHPchair@upenn.edu).

Accepted for Publication: October 2, 2020.

Published Online: October 12, 2020. doi:10.1001/jama.2020.20717

Author Contributions: Ms Bilinski had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design; acquisition, analysis, or interpretation of data; and drafting of the manuscript: Both authors.

Critical revision of the manuscript for important intellectual content: Emanuel.

Statistical analysis: Bilinski.

Obtained funding: Emanuel.

Administrative, technical, or material support: Emanuel.

Supervision: Emanuel.

Conflict of Interest Disclosures: Dr Emanuel reported receiving personal fees and nonfinancial support from Blue Cross Blue Shield Minnesota, Bergen University, United Health Group, Futures Without Violence, Children's Hospital of Philadelphia, Washington State Hospital Association, the Association of Academic Health Centers, Blue Cross Blue Shield of Massachusetts, Lumeris, Roivant Sciences, Medical Specialties Distributors, Vizient University Health System Consortium, the Center for Neurodegenerative Disease Research, Genentech Oncology, the Council of Insurance Agents and Brokers, America's Health Insurance Plans, the Montefiore Physician Leadership Academy, Medical Home Network, the Healthcare Financial Management Association, Ecumenical Center-UT Health, the American Academy of Optometry, the Associação Nacional de Hospitais Privados, the National Alliance of Healthcare Purchaser Coalitions, Optum Labs, the Massachusetts Association of Health Plans, the District of Columbia Hospital Association, Washington University, Optum, Brown University, McKay Lab, the American Society for Surgery of the Hand, the Association of American Medical Colleges, America's Essential Hospitals, Johns Hopkins University, the National Resident Matching Program, Shore Memorial Health System, Tulane University, Oregon Health and Science University,

Blue Cross Blue Shield, and the Center for Global Development, as well as nonfinancial support from the Delaware Healthcare Spending Benchmark Summit, Geisinger Health System, RAND Corporation, Goldman Sachs, The Atlantic, Village MD, and Oncology Analytics. Dr Emanuel is also a venture partner at Oak HC/FT, and a partner at Embedded Healthcare LLC and COVID-19 Recovery Consulting. Ms Bilinski reported no disclosures.

Funding/Support: This research was partially funded by the Colton Foundation.

Role of the Funder/Sponsor: The Colton Foundation had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Additional Contributions: We thank David Cutler, PhD, of the Harvard University Department of Economics, for helpful feedback, for which he received no compensation.

Additional Information: Data and code are publicly available on GitHub.

1. COVID-19 data. European Centre for Disease Prevention and Control. Accessed September 25, 2020. <https://www.ecdc.europa.eu/en/covid-19/data>
2. Viglione G. How many people has the coronavirus killed? *Nature*. 2020;585(7823):22-24. doi:10.1038/d41586-020-02497-w
3. Lyu W, Wehby GL. Shelter-in-place orders reduced COVID-19 Mortality and reduced the rate of growth in hospitalizations: study examine effects of shelter-in-places orders on daily growth rates of COVID-19 deaths and hospitalizations using event study models. *Health Aff (Millwood)*. 2020;39(9):1615-1623. doi:10.1377/hlthaff.2020.00719
4. Verity R, Okell LC, Dorigatti I, et al. Estimates of the severity of coronavirus disease 2019: a model-based analysis. *Lancet Infect Dis*. 2020;20(6):669-677. doi:10.1016/S1473-3099(20)30243-7
5. Maani N, Galea S. COVID-19 and underinvestment in the public health infrastructure of the United States. *Milbank Q*. 2020;98(2):250-259. doi:10.1111/1468-0009.12463
6. Chaudhry R, Dranitsaris G, Mubashir T, Bartoszko J, Riazi S. A country level analysis measuring the impact of government actions, country preparedness and socioeconomic factors on COVID-19 mortality and related health outcomes. *EClinicalMedicine*. 2020;25:100464. doi:10.1016/j.eclim.2020.100464