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The Opportunity Cost of COVID-19 Deaths in the USA

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Abstract: The U.S. is currently the country with the highest number of COVID-19 deaths. By the second week of October 2021, over 700,000 people in the U.S. had died after contracting the virus. When estimating the cost and benefit of a COVID-19 prevention measure, the value of a statistical life (VSL) has been widely used as an approximation for the value of a lost life. However, VSL arguably overstates the costs of deaths caused by COVID-19 because VSL captures the private individual's benefit, and it is the same for everyone regardless of where they live, their productivity, their age, and their gender. In this study, rather than looking at the cost of life loss due to COVID-19, we focus on the opportunity costs of COVID-19 deaths to society. The opportunity cost of COVID-19 deaths is defined as the combination of direct medical costs and the costs of lost potential lifetime earnings. Our analysis focuses on the period from March 2020 to October 2021. We then quantify the average opportunity cost of COVID-19 deaths across the U.S. and by state level.

Keywords: COVID-19; opportunity costs; loss of lifetime earnings; economic policy

1. Introduction

By the second week of October 2021, the Coronavirus disease (COVID-19) outbreak had spread to six continents and had contributed to over 4.9 million deaths worldwide. The United States (U.S.) had the highest number of COVID-19 deaths at the time. From March 2020 to October 2021, over 700,000 people in the U.S. have died after contracting the virus. Figure 1 shows the COVID-19 death rate per 100,000 population by state. The disease not only puts a high cost on the U.S. healthcare system but also causes economic loss to society by causing premature deaths. This study estimates the opportunity cost of premature deaths caused by COVID-19 nationwide and by the state from the start of the pandemic to October 2021, when vaccines against COVID-19 were widely available and the vaccination rate in the U.S. reached its steady level of over 40 percent[1]. The estimate might be used to assess the cost–benefit of COVID-19 mitigation strategies.

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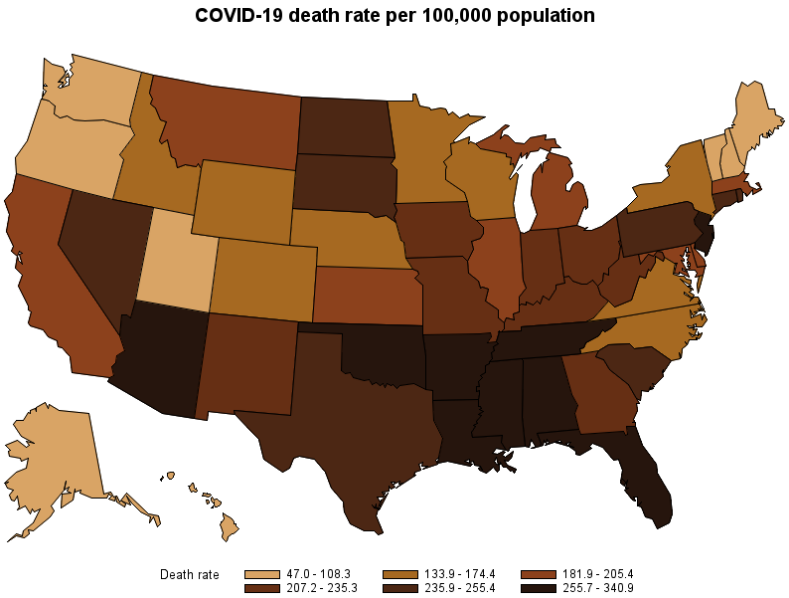


Figure 1. COVID-19 death rate by state, March 2020–October 2021.

2. Data and Method

Although it is impossible to put a value on human life, economists have used the Value of a Statistical Life (VSL) to monetize the trade-off between life and mortality risk when it comes to analyzing the cost and benefit of a safety measure. However, using VSL as a tool to analyze the cost and benefit of COVID-19 measures might be inaccurate (Adler 2020; Adler et al. 2021; Colmer 2020; Sweis 2022). The value of a Statistical Life is not the value of a life itself. VSL actually approximates how much people are willing to pay to save an additional life. For instance, if we consider a village with a population of 1000 individuals, and these residents face an annual mortality risk of 0.1% due to flood, then, on average, one person from that village will succumb to the flood yearly. Suppose all residents in the village are willing to contribute USD 100 annually to build and maintain a floodwall to eliminate the mortality risk. In that case, collectively, they would be willing to spend USD 100,000 to save one "statistical life". In this case, the value of a statistical life is USD 100,000.

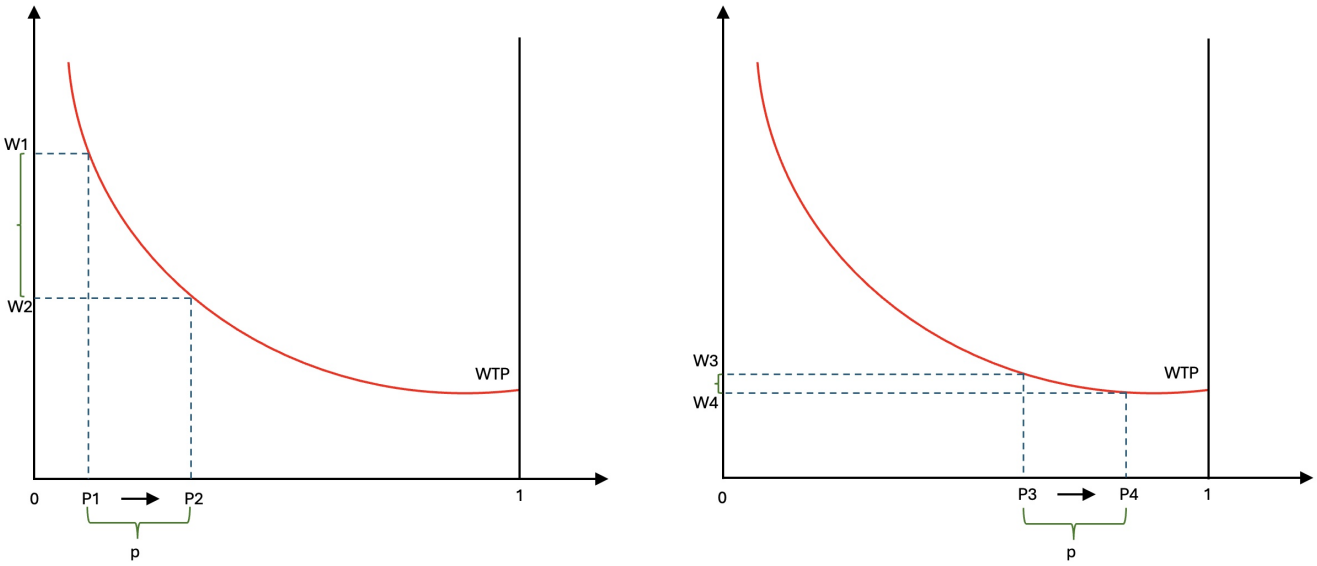
Despite its popularity, VSL is also criticized as an uncertain tool for analyzing the cost and benefit of public policies and mitigation for various reasons. The main criticism of VSL approximates private individuals' willingness to pay for a small reduction in fatality risk (Adler 2020; Allen 2020); however, willingness to pay for risk reduction links to the nature of the risk and how risk-averse people are toward that risk (Colmer 2020; Viscusi 2010). Hence, VSL varies depending on the type of risks. For example, the U.S. Department of Transportation (DOT) recommends a VSL of USD 11.6 million per life (2020 dollar), while the U.S. Environmental Protection Agency (EPA) recommends a VSL of USD 9.3 million per life (2020 dollar)[2].

Willingness to pay for risk reduction also varies depending on different factors such as age differences (Herrera-Araujo and Rochaix 2020; Viscusi 2010), and baseline health (Herrera-Araujo and Rochaix 2020). Consider the example illustrated in Figure 2, in which the horizontal axis represents the survival rate, ranging from 0 (death) to 1 (survive), and the vertical axis represents the monetary trade-off. Note that people who have low survival rates face higher mortality risk. Figure 2a,b illustrate the trade-offs to increase survival rate (decrease risk) by the same amount p for people with high mortality risk and low mortality risk, respectively. Figure 2 shows that people with high mortality risk are willing to spend more to reduce the same amount of risk compared to people with low risk, $[W_1 - W_2] > [W_3 - W_4]$.

COVID-19's magnitude of risk is different than other risks researchers have used to estimate VSL (Colmer 2020). For example, the level of risk aversion toward COVID-19

might be very different with age since most COVID-19 deaths occur at age 65 or older. Therefore, the use of a single VSL for people of different ages, genders, and health baselines is uncertain.

In this study, rather than examining the cost of lives caused by COVID-19, we monetize the economic costs (opportunity costs) to society due to lives lost to COVID-19 through direct medical expenses (direct cost) and the loss of future earnings (indirect cost). The direct costs of COVID-19 deaths are the consumption of medical resources spent on decedents, which can be funded through government (Medicare, Medicaid), health insurance providers, or individual finance. The indirect opportunity cost of COVID-19 deaths is the decedents' potential loss of lifetime earnings. These direct and indirect costs are considered a loss to society.



(**a**) (**b**)

Figure 2. Willingness to pay to reduce fatality risk for high-risk group (**a**) and low-risk group (**b**).

2.1. Data

In this study, we employ 3 data sets to estimate the economic costs of COVID-19 deaths, i.e., Provisional COVID-19 Deaths by Place of Death (National Center for Health Statistics 2021a), Provisional COVID-19 Deaths by Sex and Age (National Center for Health Statistics 2021b), and the 2021 Micro Census data IPUMS (Ruggles et al. 2021). Our paper did not include the collection of any data that is not publicly available, nor did we engage any live participants in this study. It is an analysis of secondary, publicly available data.

The Provisional COVID-19 Deaths by Places of Death data provide the numbers of COVID-19 deaths by state and place of death, including healthcare settings and non-healthcare setting locations such as hospitals, hospice facilities, nursing homes, emergency rooms, dead on arrival, or at-home. The Provisional COVID-19 Deaths by Sex and Age data provide the numbers of COVID-19 deaths by state, gender, and age group. The 2021 Micro Census data are employed to calculate the average earnings by the state of residency, age, and gender.

2.2. Direct Medical Cost

The medical cost of death by COVID-19 varies by location of death, including but not limited to at home, in a healthcare setting such as an emergency room, a hospital after inpatient admission, a nursing home, or a hospice facility.

Since there are no publicly available data on the cost of treating COVID-19 at the national or state level, we rely on recent research on individual-based models that estimate the cost of COVID-19 and pneumonia treatments for different severity levels. According to current research, the medical cost of treating one single case of symptomatic COVID-19 is USD 3045 (Bartsch et al. 2020). However, the medical costs of treating COVID-19 patients with severe symptoms who seek medical care from healthcare settings are higher. Medical costs of COVID-19 treatments in healthcare settings are applied based on three health states: medically attended, hospitalized, and ventilated (Chen et al. 2020). Death can occur in any of the three states. The average medical cost of treating pneumonia without complication is USD 10,065 (Chen et al. 2020; Rae et al. 2020)[3], the cost of treating pneumonia with severe symptoms and complications is ranging from USD 20,920[4] to USD 63,060[5] (Rae et al. 2020).

For deaths that occurred at home or other unspecified locations, we assume the decedents had symptomatic infection with SARS-CoV-2 but were not admitted to a hospital. Therefore, we assign the medical cost to treat symptomatic COVID-19 infection, USD 3045, as the only medical cost associated with these deaths (Bartsch et al. 2020).

For deaths that occurred upon arrival, the medical cost associated with the death is USD 3552, which combines the cost of treating symptomatic infection (USD 3045) and the cost of one ambulance trip (USD 507[6]).

For deaths that occurred at an emergency room or outpatient, we assume the decedents received some medical treatment for pneumonia without complication; hence, they were not admitted to a hospital. Therefore, we assign USD 10,065 as the cost associated with the death that occurred at an emergency room.

For inpatients with more severe symptoms and complications who need to be admitted to a hospital, the cost of inpatient treatment is estimated at USD 20,920 (Rae et al. 2020). However, around 10% of COVID-19 inpatients might require more intensive care (Oliveira et al. 2021), which costs USD 63,060 (Rae et al. 2020) on average. Therefore, the weighted average cost of inpatient treatment is 0.9 × USD 20,920 + 0.1 × 63,060 = USD 25,134. We then assign this weighted average cost of inpatient treatment as the medical cost associated with deaths occurring in a hospital, a nursing home, or a hospice facility.

Table 1 presents the medical costs of COVID-19 deaths by place of death. According to the National Center for Health Statistics (2021a), 86.87% of all COVID-19 deaths in the U.S. occurred at a hospital, a nursing home, or a hospice facility, 3.34% of the deaths occurred at a hospital's emergency room, 7.66% of the deaths occurred at decedents' homes, 0.09% of the deaths occurred in an ambulance upon arrival, 2.4% of the deaths' locations are not specified (Table 2). The total medical cost associated with COVID-19 death by October 2021 was over USD 16 billion (Table 2).

Table 1. Direct medical cost of COVID-19 death by place of death.

Place of Death	Medical Expense (USD)
Healthcare setting, inpatient	25,134
Hospice facility	25,134
Nursing home/long-term care facility	25,134
Healthcare setting, outpatient, or emergency room	10,065
Healthcare setting, dead on arrival	3552
Decedent's home	3045
Other	3045
Place of death unknown	3045

Using the numbers of COVID-19 deaths by place of death at the state level from The Provisional COVID-19 Deaths by Places of Death data (National Center for Health Statistics 2021a), we calculated the total medical cost and the average medical cost per death related to COVID-19 deaths for each state (Table 3). The average direct medical cost for each state ranges from USD 20,367 to USD 23,929, depending on the state's distribution of places of death.

Table 2. The counts and medical cost of COVID-19 deaths in the U.S. by place of deaths, March 2020–October 2021.

Place of Death	COVID-19 Death Counts	Share of Death by Place of Death	Medical Expense per COVID-19 Death (USD)	Total Medical Expense (USD)
Healthcare setting, inpatient	479,481	67.25%	25,134	12,051,275,454
Nursing home/long-term care facility	118,568	16.63%	25,134	2,980,088,112
Decedent's home	54,600	7.66%	3045	166,257,000
Healthcare setting, outpatient or emergency room	23,824	3.34%	10,065	239,788,560
Hospice facility	21,299	2.99%	25,134	535,329,066
Other	14,382	2.02%	3045	43,793,190
Healthcare setting, dead on arrival	676	0.09%	507	342,732
Place of death unknown	113	0.02%	3045	344,085
Total	712,943	100.00%	95,109	16,017,218,199

Table 3. The total and average medical costs of COVID-19 deaths by state, March 2020–October 2021.

State	Total Deaths	Total Direct Medical Cost (USD)	Average Medical Cost per Death (USD)
Alabama	14,684	335,914,596	22,879
Alaska	568	12,524,487	21,446
Arizona	18,278	384,108,627	21,013
Arkansas	8239	188,017,356	22,809
California	73,095	1,591,595,313	21,774
Colorado	8068	176,695,824	21,890
Connecticut	8600	200,212,527	23,237
Delaware	1922	44,267,790	22,701
District of Columbia	1560	35,602,461	22,605
Florida	55,324	1,252,787,364	22,644
Georgia	23,787	535,474,761	22,505
Hawaii	847	18,157,230	21,616
Idaho	3047	65,395,074	21,392
Illinois	24,724	555,282,804	22,454
Indiana	15,585	358,367,985	22,977
Iowa	6765	156,720,924	23,142
Kansas	6033	137,273,445	22,754
Kentucky	10,036	227,707,896	22,691
Louisiana	12,400	279,503,703	22,526
Maine	1189	27,613,206	23,107
Maryland	11,228	249,875,100	22,245
Massachusetts	14,233	328,443,684	23,052
Michigan	20,031	449,865,921	22,455
Minnesota	8390	187,674,723	22,356
Mississippi	10,092	224,361,516	22,243
Missouri	14,472	332,890,197	22,983
Montana	2112	47,708,052	22,557
Nebraska	3287	72,741,297	22,070
Nevada	7583	171,019,257	22,538
New Hampshire	1479	33,950,337	22,785
New Jersey	25,846	597,093,870	23,096
New Mexico	4762	101,993,496	21,414
New York	27,029	624,404,730	23,093
North Carolina	18,194	415,735,065	22,836
North Dakota	1864	44,627,640	23,929
Ohio	25,973	597,228,924	22,981
Oklahoma	10,786	239,988,789	22,242
Oregon	4183	88,417,209	21,142
Pennsylvania	30,657	716,436,012	23,363

Table 3. *Cont.*

State	Total Deaths	Total Direct Medical Cost (USD)	Average Medical Cost per Death (USD)
Rhode Island	2793	64,983,651	23,267
South Carolina	12,673	286,061,691	22,546
South Dakota	2224	52,683,147	23,509
Tennessee	17,946	406,048,833	22,626
Texas	71,557	1,594,115,499	22,278
Utah	3256	68,389,461	20,991
Vermont	280	6,355,032	22,066
Virginia	12,847	293,500,485	22,832
Washington	7676	168,565,422	21,926
West Virginia	3709	86,712,153	23,341
Wisconsin	9355	190,410,807	20,367
Wyoming	937	20,379,852	21,452

2.3. Cost of Loss Lifetime Production (Indirect Cost)

Cost of loss lifetime production is defined as the loss of potential lifetime earnings from premature death. The loss of lifetime earnings is estimated as the discounted sum of expected annual income over the individual's remaining potential working time from the age of death to the official retirement age (67 years old). We apply the commonly used method to estimate the loss of lifetime earnings from the existing literature, including Finkelstein et al. (2006), O'Dea and Tucker (2005), Doran et al. (2015), and Lawrence and Miller (2014) with a discount rate of 3% and the historical rate of increase in productivity of 1.4%. Lifetime earnings for someone whose gender is b, died at age a, in state s is estimated as:

$$Earnings_{a,b,s} = \sum_{i=a}^{67} P_{a,b}(i) \times I_{i,b,s} \times \left(\frac{1+g}{1+r}\right)^{(i-a)} \quad (1)$$

where $P_{(a,b)}(i)$ denotes the probability that someone of age a and gender b will survive until age i; $I_{(i,b,s)}$ denotes the average annual market income for someone of age i and gender b in state s in 2020; g denotes the rate of increase in productivity, which is 1.4%; r denotes the 3% discount rate.

Since the loss of lifetime earnings is calculated as the discounted sum of expected annual income over an individual's remaining potential working years from the age of death to the official retirement age, individuals who pass away at younger ages experience a greater loss of potential lifetime earnings compared to those who pass away at older ages. For instance, a woman who passes away at age 20 is projected to lose an average of USD 1.52 million in lifetime earnings, while a woman who passes away at age 45 is expected to lose USD 1.06 million in lifetime earnings[7].

Although it would be ideal to calculate an individual's loss of lifetime earnings using the individual's age at death, gender, and state of residency, we do not have access to fatality data at the individual level. Instead, we employ the Provisional COVID-19 Deaths by Sex and Age data, which is publicly available. The data provides the numbers of COVID-19 deaths by state, gender, and eight different age groups. Therefore, for each age group of a specific gender and state of residency, we must use the group's average potential loss of lifetime earnings. In Figure 3, we show the average loss of potential lifetime earnings in the U.S. by age group. Overall, women's potential lifetime earnings are less than men's for all ages. Since people who die at age 75 or older are no longer in their working age, their potential loss of lifetime earnings is zero.

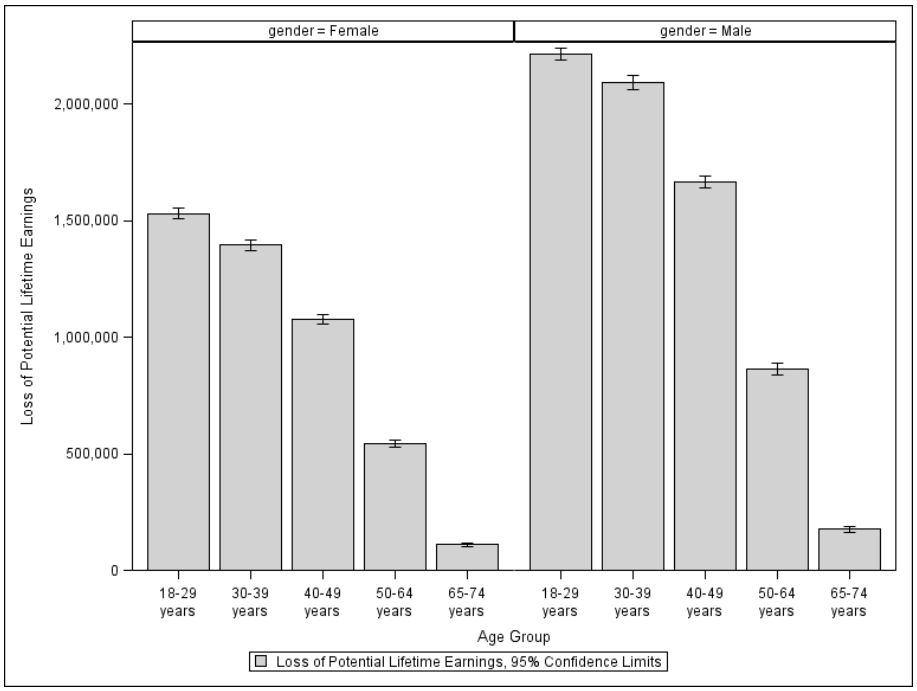


Figure 3. Loss of potential lifetime earnings in the U.S. by age group and gender.

Table 4 presents the counts and share of COVID-19 deaths in the U.S. by age group. 76.2% of all COVID-19 deaths in the U.S. occurred in people aged 65 or older, and 0.62% of the deaths occurred in the group of people aged under 30.

Table 4. The counts and shares COVID-19 deaths in the U.S. by age group, March 2020–October 2021.

Age Group	COVID-19 Deaths Count	Share of Deaths by Age Group
0–29 years	3888	0.62%
30–39 years	11,313	1.59%
40–49 years	28,190	3.95%
50–64 years	125,812	17.65%
65–74 years	160,596	22.53%
75–84 years	187,611	26.32%
85 years and over	195,007	27.35%
Total	712,930	100.00%

Using the numbers of COVID-19 deaths by sex and age at the state level from The Provisional COVID-19 Deaths by Sex and Age data (National Center for Health Statistics 2021b), we calculated the total indirect cost of COVID-19 deaths (Table 5) and the average indirect cost per COVID-19 death for each state (Table 6).

Since the indirect cost of COVID-19 deaths is defined as the loss of potential lifetime earnings, different states with different economic prosperity and per capita income levels will face different indirect costs. The average indirect cost of COVID-19 deaths for each state ranges from USD 73,104 (Vermont) to USD 587,831 (District of Columbia), depending on the state's age distribution of COVID-19 deaths and the state's economic prosperity (Table 6). The total indirect cost of COVID-19 deaths for each state ranges from USD 20.5 million (Vermont) to USD 27.1 billion (California), depending on the state's number of deaths, the state's age distribution of COVID-19 deaths, and the state's economic prosperity (Table 5).

Table 5. The total indirect cost of COVID-19 deaths by state, March 2020–October 2021.

State	Total Deaths	Total Indirect Cost of COVID-19 Deaths (USD)	95% CI (USD)
Alabama	14,684	4,166,435,191	(3,008,062,021–5,324,808,362)
Alaska	568	172,974,401	(125,693,564–220,255,239)
Arizona	18,278	5,513,321,292	(4,069,500,344–6,957,142,239)
Arkansas	8239	1,847,881,101	(1,334,086,446–2,361,675,757)
California	73,095	27,122,357,050	(20,387,642,264–33,857,071,836)
Colorado	8068	2,056,001,128	(1,460,383,688–2,651,618,569)
Connecticut	8600	1,715,996,791	(1,096,085,580–2,335,908,002)
Delaware	1922	363,730,295	(225,093,804–502,366,787)
District of Columbia	1560	917,015,700	(675,362,756–1,158,668,643)
Florida	55,324	15,029,803,511	(11,160,848,564–18,898,758,459)
Georgia	23,787	7,533,575,696	(5,514,238,899–9,552,912,493)
Hawaii	847	320,845,112	(248,437,213–393,253,011)
Idaho	3047	533,566,711	(359,187,737–707,945,684)
Illinois	24,724	6,210,397,909	(4,378,844,507–8,041,951,310)
Indiana	15,585	2,678,413,892	(1,780,999,247–3,575,828,537)
Iowa	6765	919,033,884	(605,718,766–1,232,349,001)
Kansas	6033	1,189,520,409	(836,463,614–1,542,577,203)
Kentucky	10,036	2,036,789,887	(1,375,667,622–2,697,912,152)
Louisiana	12,400	3,509,160,327	(2,545,290,376–4,473,030,279)
Maine	1189	153,858,219	(96,475,528–211,240,911)
Maryland	11,228	3,355,095,618	(2,416,361,021–4,293,830,214)
Massachusetts	14,233	2,463,564,315	(1,584,595,310–3,342,533,319)
Michigan	20,031	4,456,499,910	(3,091,646,691–5,821,353,129)
Minnesota	8390	1,284,212,967	(866,977,370–1,701,448,563)
Mississippi	10,092	2,666,618,278	(1,950,576,501–3,382,660,055)
Missouri	14,472	3,018,362,233	(2,072,834,084–3,963,890,382)
Montana	2112	377,640,221	(265,480,985–489,799,456)
Nebraska	3287	582,168,786	(408,242,400–756,095,172)
Nevada	7583	2,361,469,117	(1,721,398,266–3,001,539,969)
New Hampshire	1479	139,598,641	(78,470,328–200,726,954)
New Jersey	25,846	7,873,263,304	(5,641,688,514–10,104,838,093)
New Mexico	4762	1,499,079,119	(1,138,029,657–1,860,128,581)
New York	27,029	6,050,728,632	(4,086,848,330–8,014,608,935)
North Carolina	18,194	4,053,054,159	(2,838,413,869–5,267,694,450)
North Dakota	1864	322,261,046	(209,097,142–435,424,949)
Ohio	25,973	4,260,379,605	(2,823,622,302–5,697,136,908)
Oklahoma	10,786	2,638,626,283	(1,865,616,320–3,411,636,246)
Oregon	4183	1,000,980,660	(730,818,499–1,271,142,820)
Pennsylvania	30,657	5,242,045,789	(3,486,172,086–6,997,919,493)
Rhode Island	2793	366,845,074	(223,971,222–509,718,926)
South Carolina	12,673	3,305,364,218	(2,372,581,409–4,238,147,028)
South Dakota	2224	326,797,818	(216,801,414–436,794,222)
Tennessee	17,946	4,916,620,765	(3,504,777,870–6,328,463,659)
Texas	71,557	26,425,551,735	(20,080,170,825–32,770,932,644)
Utah	3256	1,098,311,127	(830,605,869–1,366,016,385)
Vermont	280	20,468,996	(9,929,398–31,008,593)
Virginia	12,847	3,259,055,656	(2,279,464,560–4,238,646,752)
Washington	7676	2,196,722,323	(1,592,870,169–2,800,574,477)
West Virginia	3709	631,812,769	(408,989,376–854,636,163)
Wisconsin	9355	1,501,094,490	(1,022,729,795–1,979,459,184)
Wyoming	937	198,660,395	(130,313,534–267,007,256)

Table 6. The average indirect costs of COVID-19 deaths by state, March 2020–October 2021.

State	Total Deaths	Loss of Potential Lifetime Earnings (Indirect Cost) per Death (USD)	95% CI (USD)
Alabama	14,684	283,740	(204,853–362,627)
Alaska	568	304,532	(221,291–387,773)
Arizona	18,278	301,637	(222,645–380,629)
Arkansas	8239	224,285	(161,923–286,646)
California	73,095	371,056	(278,920–463,193)
Colorado	8068	254,834	(181,009–328,659)
Connecticut	8600	199,535	(127,452–271,617)
Delaware	1922	189,246	(117,114–261,377)
District of Columbia	1560	587,831	(432,925–742,736)
Florida	55,324	271,669	(201,736–341,601)
Georgia	23,787	316,710	(231,817–401,602)
Hawaii	847	378,802	(293,314–464,289)
Idaho	3047	175,112	(117,882–232,342)
Illinois	24,724	251,189	(177,109–325,269)
Indiana	15,585	171,858	(114,277–229,440)
Iowa	6765	135,851	(89,537–182,165)
Kansas	6033	197,169	(138,648–255,690)
Kentucky	10,036	202,948	(137,073–268,823)
Louisiana	12,400	282,997	(205,265–360,728)
Maine	1189	129,401	(81,140–177,663)
Maryland	11,228	298,815	(215,209–382,422)
Massachusetts	14,233	173,088	(111,332–234,844)
Michigan	20,031	222,480	(154,343–290,617)
Minnesota	8390	153,065	(103,335–202,795)
Mississippi	10,092	264,231	(193,279–335,182)
Missouri	14,472	208,566	(143,231–273,901)
Montana	2112	178,807	(125,701–231,913)
Nebraska	3287	177,113	(124,199–230,026)
Nevada	7583	311,416	(227,008–395,825)
New Hampshire	1479	94,387	(53,056–135,718)
New Jersey	25,846	304,622	(218,281–390,963)
New Mexico	4762	314,800	(238,981–390,619)
New York	27,029	223,861	(151,202–296,519)
North Carolina	18,194	222,769	(156,008–289,529)
North Dakota	1864	172,887	(112,177–233,597)
Ohio	25,973	164,031	(108,714–219,348)
Oklahoma	10,786	244,634	(172,966–316,302)
Oregon	4183	239,297	(174,712–303,883)
Pennsylvania	30,657	170,990	(113,715–228,265)
Rhode Island	2793	131,344	(80,190–182,499)
South Carolina	12,673	260,819	(187,215–334,423)
South Dakota	2224	146,941	(97,483–196,400)
Tennessee	17,946	273,968	(195,296–352,639)
Texas	71,557	369,294	(280,618–457,970)
Utah	3256	337,319	(255,100–419,538)
Vermont	280	73,104	(35,462–110,745)
Virginia	12,847	253,682	(177,432–329,933)
Washington	7676	286,181	(207,513–364,848)
West Virginia	3709	170,346	(110,269–230,422)
Wisconsin	9355	160,459	(109,324–211,594)
Wyoming	937	212,018	(139,075–284,960)

2.4. Total Economic Costs of COVID-19 Deaths

The state-level total opportunity cost of COVID-19 deaths is the combination of the state's total direct medical cost and total loss of production due to COVID-19 deaths. The

total economic costs of COVID-19 deaths by state in Table 7 are the summation of state-level total direct costs (from Table 3) and indirect costs (from Table 5).

Table 7. The total costs of COVID-19 deaths by state, March 2020–October 2021.

State	Total Direct Medical Cost (USD)	Total Indirect Cost of Loss Potential Lifetime Earnings (USD)	Total Cost (USD)
Alabama	335,914,596	4,166,435,191	4,502,349,787
Alaska	12,524,487	172,974,401	185,498,888
Arizona	384,108,627	5,513,321,292	5,897,429,919
Arkansas	188,017,356	1,847,881,101	2,035,898,457
California	1,591,595,313	27,122,357,050	28,713,952,363
Colorado	176,695,824	2,056,001,128	2,232,696,952
Connecticut	200,212,527	1,715,996,791	1,916,209,318
Delaware	44,267,790	363,730,295	407,998,085
District of Columbia	35,602,461	917,015,700	952,618,161
Florida	1,252,787,364	15,029,803,511	16,282,590,875
Georgia	535,474,761	7,533,575,696	8,069,050,457
Hawaii	18,157,230	320,845,112	339,002,342
Idaho	65,395,074	533,566,711	598,961,785
Illinois	555,282,804	6,210,397,909	6,765,680,713
Indiana	358,367,985	2,678,413,892	3,036,781,877
Iowa	156,720,924	919,033,884	1,075,754,808
Kansas	137,273,445	1,189,520,409	1,326,793,854
Kentucky	227,707,896	2,036,789,887	2,264,497,783
Louisiana	279,503,703	3,509,160,327	3,788,664,030
Maine	27,613,206	153,858,219	181,471,425
Maryland	249,875,100	3,355,095,618	3,604,970,718
Massachusetts	328,443,684	2,463,564,315	2,792,007,999
Michigan	449,865,921	4,456,499,910	4,906,365,831
Minnesota	187,674,723	1,284,212,967	1,471,887,690
Mississippi	224,361,516	2,666,618,278	2,890,979,794
Missouri	332,890,197	3,018,362,233	3,351,252,430
Montana	47,708,052	377,640,221	425,348,273
Nebraska	72,741,297	582,168,786	654,910,083
Nevada	171,019,257	2,361,469,117	2,532,488,374
New Hampshire	33,950,337	139,598,641	173,548,978
New Jersey	597,093,870	7,873,263,304	8,470,357,174
New Mexico	101,993,496	1,499,079,119	1,601,072,615
New York	624,404,730	6,050,728,632	6,675,133,362
North Carolina	415,735,065	4,053,054,159	4,468,789,224
North Dakota	44,627,640	322,261,046	366,888,686
Ohio	597,228,924	4,260,379,605	4,857,608,529
Oklahoma	239,988,789	2,638,626,283	2,878,615,072
Oregon	88,417,209	1,000,980,660	1,089,397,869
Pennsylvania	716,436,012	5,242,045,789	5,958,481,801
Rhode Island	64,983,651	366,845,074	431,828,725
South Carolina	286,061,691	3,305,364,218	3,591,425,909
South Dakota	52,683,147	326,797,818	379,480,965
Tennessee	406,048,833	4,916,620,765	5,322,669,598
Texas	1,594,115,499	26,425,551,735	28,019,667,234
Utah	68,389,461	1,098,311,127	1,166,700,588
Vermont	6,355,032	20,468,996	26,824,028
Virginia	293,500,485	3,259,055,656	3,552,556,141
Washington	168,565,422	2,196,722,323	2,365,287,745
West Virginia	86,712,153	631,812,769	718,524,922
Wisconsin	190,410,807	1,501,094,490	1,691,505,297
Wyoming	20,379,852	198,660,395	219,040,247

3. Results

By October 2021, COVID-19 has contributed to 712,943 deaths in the U.S. The total economic cost of all the COVID-19 deaths is estimated at USD 197.9 billion. Of the total cost, 8.1%, or USD 16.02 billion, are direct medical costs, and 91.9% of the total cost, or USD 181.9 billion, comes from the decedents' loss of potential lifetime earnings (Table 8).

Table 8. Economic cost of COVID-19 deaths, March 2020–October 2021.

Cost	Mean (USD)	95% CI (USD)
Total Direct medical cost of COVID-19 deaths	16,017,218,199	NA
Total Indirect cost of COVID-19 deaths	181,883,632,555	(131,234,177,661–232,533,087,449)
Total economic cost of COVID-19 deaths	197,900,850,754	(147,251,395,860–248,550,305,648)

Figure 4 shows the total economic costs of COVID-19 deaths by state. The three states that suffer the highest cost of COVID-19 deaths are California (USD 28.7 billion), Texas (USD 28.02 billion), and Florida (USD 16.3 billion). The three states that have the lowest cost of COVID-19 deaths are Vermont (USD 26.8 million), New Hampshire (USD 173.5 million), and Maine (USD 181.5 million).[8]

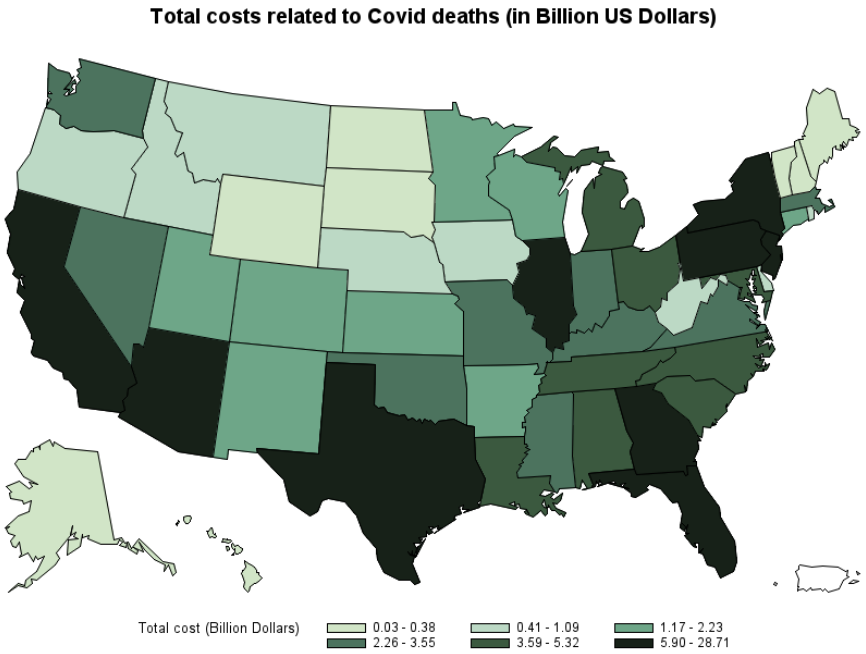


Figure 4. Total economic cost of COVID-19 deaths by state, March 2020–October 2021.

The average economic cost of COVID-19 death in the U.S. by the second week of October 2021 is estimated at USD 277,587 per death (Table 9). However, the state-level average economic cost per death varies depending on each state's count of COVID-19 deaths by place of death, age, gender, and economic prosperity. Figure 5 shows the average economic cost per death by state. Hawaii, California, and Texas are the states with the highest average economic cost per COVID-19 death. Vermont, New Hampshire, and Maine are the states with the lowest average economic cost per COVID-19 death[9].

Table 9. Average economic cost per COVID-19 death, March 2020–October 2021.

Average Cost	Mean (USD)	95% CI (USD)
Average direct medical cost per death	22,466	NA
Average indirect cost per death	255,121	(184,077–326,165)
Average total economic cost per death	277,587	(206,543–348,631)

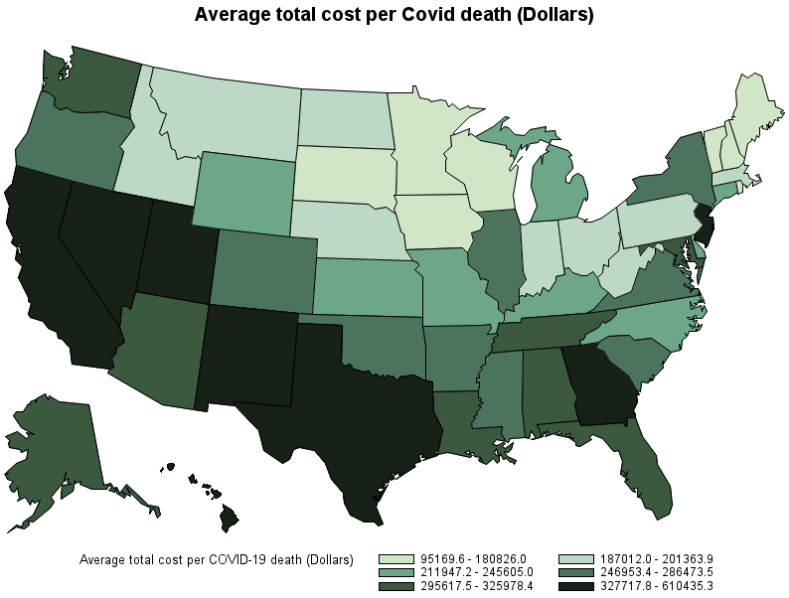


Figure 5. Average economic cost per COVID-19 death by state by the second week of October 2021.

Figure 6 shows the economic cost of COVID-19 deaths per 100,000 population by state—that is, the share of the cost state's residents have to shoulder. The three states with the highest cost per 100,000 population are Mississippi (USD 97.63 million), Texas (USD 96.64 million), and New Jersey (USD 91.19 million). The three states with the lowest per capita cost are Vermont (USD 4.17 million), New Hampshire (USD 12.6 million), and Maine (USD 13.32 million). [10]

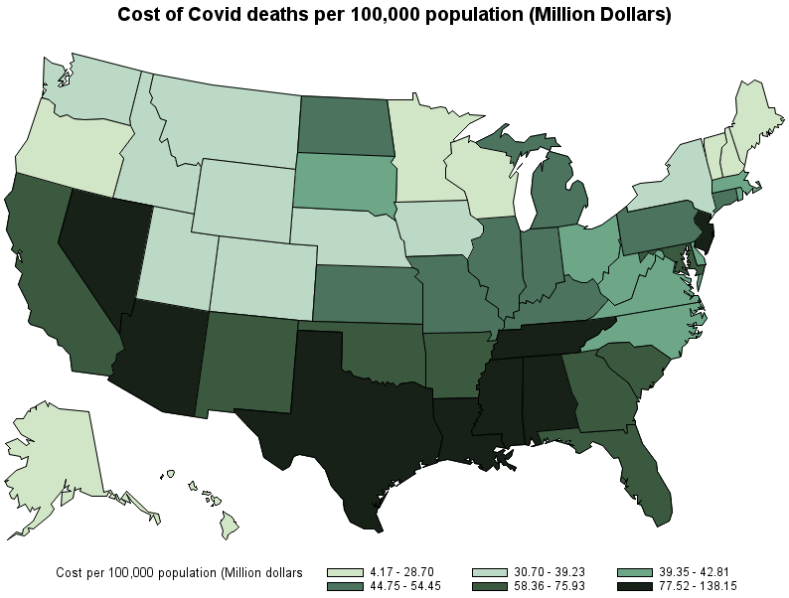


Figure 6. Economic cost from COVID-19 deaths per 100,000 population by state, March 2020–October 2021.

4. Discussion

Our study encountered limitations due to the lack of data on the cost of COVID-19 treatment. The lack of readily and comprehensive data on the cost of COVID-19 treatment stems from several factors. First, the decentralized structure of the U.S. healthcare system leads to differences in billing practices, reimbursement rates, and healthcare delivery models among various states and healthcare providers. Second, the extent of insurance coverage for COVID-19 treatment varies among individuals, healthcare systems, insurance policies, and how health insurance providers negotiate with healthcare providers. Third, collecting accurate and comprehensive data on healthcare costs, particularly amid a rapidly evolving pandemic, presents significant challenges. In addition, healthcare cost data often contain sensitive information about patients, healthcare providers, and insurance providers, limiting the accessibility and sharing of detailed cost data. Therefore, we must rely on individual-based model estimations and the costs of treating different severity levels of pneumonia as approximations for the cost of treating COVID-19 patients.

5. Conclusions

We estimate the opportunity cost of COVID-19 deaths based on the direct medical cost and the loss of future earnings from premature deaths. According to our estimation, the U.S. has suffered a cost of USD 197.9 billion in COVID-19 deaths. The total cost of COVID-19 deaths varies with a person's age, gender, state of residency, and the location where their death occurred. Of those USD 197.9 billion, 91.9% is from the indirect cost of loss of potential lifetime earnings, and 8.1% is from the estimated direct medical cost of treating COVID-19 symptoms and complications. On average, each COVID-19 death costs society USD 277,587.

This estimation does not consider the economic cost of COVID-19 infection and recovery, nor the potential cost of lost future productivity from COVID-19 survivors. Given that COVID-19 deaths have disproportionately impacted older individuals, the estimated impact on the loss of lifetime production is not as great as it might be for a pandemic affecting a younger population.

Since the magnitude of COVID-19 risk is different than sudden deaths from accidents, our study provides officials and lawmakers with another method to evaluate the costs and benefits of COVID-19 measures and policies as an alternative to the value of a statistical life.

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Data Availability Statement: This study used publicly available data sources, including IPUMS USA: Version 11.0, CDC Provisional COVID-19 Deaths by Sex and Age data, and CDC Provisional COVID-19 Deaths by Place of Death and State data. IPUMS USA: Version 11.0 can be found at: https://www.ipums.org/projects/ipums-usa/d010.v11.0 (accessed on 20 March 2024). CDC Provisional COVID-19 Deaths by Sex and Age data can be found at: https://data.cdc.gov/NCHS/Provisional-COVID-19-Deaths-by-Sex-and-Age/9bhg-hcku/about_data (accessed on 20 March 2024). CDC Provisional COVID-19 Deaths by Place of Death and State data can be found at: https://data.cdc.gov/NCHS/Provisional-COVID-19-Deaths-by-Place-of-Death-and-/uggs-hy5q/about_data (accessed on 20 March 2024).

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Loss of potential lifetime earning in the U.S. by age and gender.

Age	Gender	Loss of Potential Lifetime Earning (USD)	Standard Error (USD)	Lower CI (USD)	Upper CI (USD)
18	Female	1,491,318	36,166	1,418,676	1,563,961
19	Female	1,507,960	36,731	1,434,184	1,581,735
20	Female	1,521,910	37,038	1,447,517	1,596,302
21	Female	1,533,211	37,613	1,457,663	1,608,760
22	Female	1,542,393	38,180	1,465,706	1,619,079
23	Female	1,549,078	38,673	1,471,401	1,626,754
24	Female	1,550,817	38,854	1,472,775	1,628,858
25	Female	1,549,554	39,006	1,471,208	1,627,899
26	Female	1,542,359	39,089	1,463,846	1,620,871
27	Female	1,533,498	39,156	1,454,852	1,612,145
28	Female	1,522,975	39,013	1,444,616	1,601,334
29	Female	1,510,721	38,842	1,432,705	1,588,738
30	Female	1,495,709	38,521	1,418,337	1,573,080
31	Female	1,478,225	38,015	1,401,870	1,554,579
32	Female	1,458,376	37,343	1,383,370	1,533,382
33	Female	1,437,059	36,801	1,363,142	1,510,977
34	Female	1,413,570	36,184	1,340,892	1,486,248
35	Female	1,388,798	35,588	1,317,317	1,460,279
36	Female	1,360,836	34,680	1,291,180	1,430,493
37	Female	1,331,105	33,943	1,262,928	1,399,281
38	Female	1,302,007	33,012	1,235,701	1,368,313
39	Female	1,270,837	32,319	1,205,921	1,335,753
40	Female	1,238,919	31,846	1,174,956	1,302,883
41	Female	1,206,101	30,475	1,144,890	1,267,313
42	Female	1,170,229	29,349	1,111,280	1,229,179
43	Female	1,136,711	28,736	1,078,994	1,194,429
44	Female	1,100,249	27,794	1,044,424	1,156,075
45	Female	1,062,874	26,762	1,009,122	1,116,626
46	Female	1,023,312	25,526	972,040	1,074,583
47	Female	982,417	24,537	933,132	1,031,701
48	Female	942,120	23,343	895,234	989,006
49	Female	900,531	22,095	856,152	944,910
50	Female	858,772	20,953	816,686	900,857
51	Female	817,467	20,269	776,756	858,179
52	Female	773,234	19,476	734,115	812,353
53	Female	729,986	18,082	693,667	766,305
54	Female	687,783	17,155	653,327	722,240
55	Female	643,948	16,143	611,523	676,373
56	Female	597,605	14,645	568,190	627,020

Table A1. *Cont.*

Age	Gender	Loss of Potential Lifetime Earning (USD)	Standard Error (USD)	Lower CI (USD)	Upper CI (USD)
57	Female	551,248	13,893	523,343	579,154
58	Female	503,938	12,551	478,728	529,147
59	Female	457,291	11,598	433,996	480,587
60	Female	409,558	10,714	388,038	431,078
61	Female	360,688	9238	342,134	379,242
62	Female	310,316	7945	294,358	326,274
63	Female	261,319	6528	248,207	274,432
64	Female	210,944	5370	200,158	221,730
65	Female	162,147	4341	153,428	170,867
66	Female	111,039	3257	104,497	117,581
67	Female	56,373	1913	52,530	60,216
18	Male	2,139,678	42,682	2,053,948	2,225,407
19	Male	2,165,305	43,438	2,078,057	2,252,552
20	Male	2,186,859	44,180	2,098,120	2,275,598
21	Male	2,204,880	44,945	2,114,606	2,295,154
22	Male	2,220,791	45,724	2,128,950	2,312,631
23	Male	2,232,759	46,541	2,139,279	2,326,239
24	Male	2,239,213	47,028	2,144,754	2,333,672
25	Male	2,243,386	47,404	2,148,173	2,338,600
26	Male	2,240,402	47,620	2,144,755	2,336,049
27	Male	2,234,852	47,874	2,138,695	2,331,009
28	Male	2,226,448	47,897	2,130,244	2,322,652
29	Male	2,216,546	47,959	2,120,217	2,312,875
30	Male	2,203,549	47,786	2,107,569	2,299,530
31	Male	2,187,653	47,571	2,092,103	2,283,203
32	Male	2,167,701	47,295	2,072,706	2,262,696
33	Male	2,143,765	46,897	2,049,570	2,237,960
34	Male	2,117,179	46,224	2,024,336	2,210,022
35	Male	2,089,500	45,707	1,997,695	2,181,305
36	Male	2,055,806	45,133	1,965,153	2,146,458
37	Male	2,018,999	43,949	1,930,725	2,107,273
38	Male	1,980,941	43,219	1,894,133	2,067,750
39	Male	1,939,040	42,232	1,854,215	2,023,865
40	Male	1,894,646	41,165	1,811,964	1,977,328
41	Male	1,850,927	40,350	1,769,883	1,931,972
42	Male	1,800,477	38,529	1,723,090	1,877,865
43	Male	1,751,618	37,192	1,676,915	1,826,321
44	Male	1,696,515	35,389	1,625,434	1,767,597
45	Male	1,643,458	34,268	1,574,628	1,712,288
46	Male	1,590,482	33,447	1,523,303	1,657,662

Table A1. *Cont.*

Age	Gender	Loss of Potential Lifetime Earning (USD)	Standard Error (USD)	Lower CI (USD)	Upper CI (USD)
47	Male	1,532,628	32,514	1,467,322	1,597,935
48	Male	1,473,357	31,168	1,410,754	1,535,959
49	Male	1,413,613	30,130	1,353,095	1,474,132
50	Male	1,350,678	29,070	1,292,289	1,409,067
51	Male	1,283,763	27,019	1,229,494	1,338,033
52	Male	1,218,855	25,578	1,167,480	1,270,229
53	Male	1,150,315	23,333	1,103,450	1,197,180
54	Male	1,083,208	21,923	1,039,174	1,127,243
55	Male	1,015,618	20,718	974,004	1,057,231
56	Male	944,036	18,804	906,268	981,804
57	Male	872,973	17,747	837,327	908,619
58	Male	801,887	16,513	768,719	835,054
59	Male	729,080	15,256	698,437	759,723
60	Male	654,849	13,908	626,913	682,785
61	Male	576,965	12,202	552,456	601,473
62	Male	500,863	10,661	479,450	522,276
63	Male	422,833	9503	403,744	441,921
64	Male	345,665	8785	328,020	363,310
65	Male	263,179	6151	250,825	275,533
66	Male	177,665	4847	167,929	187,402
67	Male	90,807	2660	85,464	96,150

Table A2. The economic (opportunity) cost of COVID-19 deaths by state, March 2020–October 2021.

State	COVID-19 Deaths per 100,000 Population	Total Cost of COVID-19 Deaths (USD)	Average Cost of COVID-19 Deaths (USD)	Cost of COVID-19 Deaths per 100,100 Population (USD)
Alabama	292	4,502,349,787	306,619	89,610,000
Alaska	77	185,498,888	325,978	25,290,000
Arizona	256	5,897,429,919	324,354	82,900,000
Arkansas	274	2,035,898,457	247,094	67,600,000
California	185	28,713,952,363	394,271	72,890,000
Colorado	140	2,232,696,952	276,724	38,670,000
Connecticut	239	1,916,209,318	222,772	53,140,000
Delaware	194	407,998,085	211,947	41,210,000
District of Columbia	226	952,618,161	610,435	138,150,000
Florida	257	16,282,590,875	295,617	75,930,000
Georgia	222	8,069,050,457	340,959	75,720,000
Hawaii	58	339,002,342	400,418	23,290,000
Idaho	166	598,961,785	196,504	32,570,000

Table A2. *Cont.*

State	COVID-19 Deaths per 100,000 Population	Total Cost of COVID-19 Deaths (USD)	Average Cost of COVID-19 Deaths (USD)	Cost of COVID-19 Deaths per 100,100 Population (USD)
Illinois	193	6,765,680,713	274,809	53,030,000
Indiana	230	3,036,781,877	194,835	44,750,000
Iowa	212	1,075,754,808	158,994	33,720,000
Kansas	205	1,326,793,854	219,923	45,160,000
Kentucky	223	2,264,497,783	225,640	50,260,000
Louisiana	266	3,788,664,030	305,523	81,340,000
Maine	87	181,471,425	152,509	13,320,000
Maryland	182	3,604,970,718	321,060	58,360,000
Massachusetts	202	2,792,007,999	196,140	39,720,000
Michigan	199	4,906,365,831	244,935	48,690,000
Minnesota	147	1,471,887,690	175,420	25,790,000
Mississippi	341	2,890,979,794	286,474	97,630,000
Missouri	235	3,351,252,430	231,549	54,450,000
Montana	195	425,348,273	201,364	39,230,000
Nebraska	168	654,910,083	199,182	33,390,000
Nevada	244	2,532,488,374	333,954	81,570,000
New Hampshire	107	173,548,978	117,173	12,600,000
New Jersey	278	8,470,357,174	327,718	91,190,000
New Mexico	225	1,601,072,615	336,214	75,610,000
New York	134	6,675,133,362	246,953	33,040,000
North Carolina	174	4,468,789,224	245,605	42,810,000
North Dakota	239	366,888,686	196,816	47,090,000
Ohio	220	4,857,608,529	187,012	41,170,000
Oklahoma	272	2,878,615,072	266,876	72,700,000
Oregon	99	1,089,397,869	260,440	25,710,000
Pennsylvania	236	5,958,481,801	194,353	45,820,000
Rhode Island	255	431,828,725	154,611	39,350,000
South Carolina	248	3,591,425,909	283,365	70,170,000
South Dakota	251	379,480,965	170,450	42,800,000
Tennessee	260	5,322,669,598	298,522	77,520,000
Texas	246	28,019,667,234	393,611	96,640,000
Utah	100	1,166,700,588	358,310	35,660,000
Vermont	44	26,824,028	95,170	4,170,000
Virginia	149	3,552,556,141	276,514	41,160,000
Washington	100	2,365,287,745	308,106	30,700,000
West Virginia	207	718,524,922	193,687	40,060,000
Wisconsin	159	1,691,505,297	180,826	28,700,000
Wyoming	162	219,040,247	233,470	37,970,000

Notes

[1] See: https://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=102643 (accessed on 28 May 2024)
[2] This value is adjusted to the 2020 dollar from the reported USD 7.4 million in 2006 dollars.
[3] This cost is inflated to 2020 dollars from a reported USD 9763 cost of treating pneumonia without complication (Chen et al. 2020; Rae et al. 2020).
[4] This cost is inflated to the 2020 dollar from reported USD 20,292 cost of treating pneumonia with ventilator in 2018 (Rae et al. 2020).
[5] This cost is inflated to 2020 dollars from reported USD 61,168 cost of treating pneumonia with ventilator in 2018 (Rae et al. 2020).
[6] This average cost of a one-way ambulance trip is adjusted to 2020 dollars from reported 2015 U.S. dollar costs of USD 463 (Peterson et al. 2021).
[7] See Table A1 for the calculated potential loss of lifetime earnings in the U.S. by gender and age.
[8] See Table A2.
[9] See Note 8.
[10] See Note 8.

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