Mortality Risks and Life Expectancy Losses from COVID-19 Infections by Age and Gender for the United States

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Abstract

We look at COVID-19 mortality and expected life expectancy risks by age prior to the development of pharmaceutical treatments for the SARS-CoV-2 virus. A COVID-19 infection more than doubled the annual mortality risks for Americans over sixty. Americans aged sixty or older stand to lose 153 to 222 days of life expectancy from contracting COVID-19 without the benefits of pharmaceutical treatments or vaccines.

Journal of Economic Literature Codes: G22, I1, I18, J31, J65, K32

Keywords: actuarial tables, mortality, death rates, CFR, COVID-19, IFR, SARS-CoV-2

1. Introduction

We use U.S. Census data to control for the age and gender of the population and show how a COVID-19 infection affects an individual's life expectancy and compares to a typical year's mortality. The data in this paper was compiled prior to pharmaceutical treatments or vaccines were used to treat SARS-CoV-2. Thus, we should expect that the mortality risks are less than in this paper if an individual has access to Dexamethasone, Remdesivir, monoclonal antibodies, convalescent plasma, and or any of the approved COVID-19 vaccines. This paper gives the historic risks of the virus or the risks to individuals who lack access to the treatments developed after the initial waves of the virus in 2019 and 2020.

Arias *et al.* (2021) found U.S. life expectancy at birth declined by 1.2 years in 2020, after COVID-19 reached the United States of America. Tavernise and Goodnough (2021) say that 1.2 year drop was the first full year drop in U.S. life expectancy at birth since World War II. In this paper, we look at the expected life expectancy losses of people of different age groups and genders given that they contract COVID-19. For no age group studied, do the life expectancy losses exceed one year on average.

Life expectancy losses of between 153 and 222 days can be expected for Americans over 60 with a novel coronavirus infection, according to figure 2, panel C. Americans younger than forty can expect to lose less than two weeks of life expectancy from contracting the virus. In figure 1, panel C, persons over fifty can expect COVID-19 to be about as deadly or up to 70 percent more deadly than a year's mortality risks. Persons younger than forty-years-old can expect less than half a year's mortality risk in a COVID-19 infection. Overall, the results of this paper point to sizable personal risks for individuals over sixty becoming infected with COVID-

19 in terms of the increased chance of death and reduced life expectancy. In section 2, we compare the COVID-19 death rates to annual death rates by age and gender. In section 3, we calculate the life expectancy losses from contacting SARS-CoV-2.

2. COVID-19 vs. Annual Mortality

In this section, we use the 2016 actuarial tables from the Social Security Administration to compare COVID death rates to the actuarial death rates for Americans.

[*Insert Table 1 about here***]**

Table 1 relies on data from Ferguson *et. al* (2020), Verity *et al.* (2020), and Feng *et al.* (2020). While the latter three studies do not look at deaths in the United States, Wilson (2020) and Wilson (2021) finds the IFR for U.S. population based on early 2020 New York city data is in line with Ferguson *et al.* (2020).

Column (2) of table 2 will be used to calculate the overall average death rates in column (3) of table 3.

[*Insert Table 2 about here***]**

In table 3, we use the 2016 actuarial tables from the Social Security Administration. The average annual death rates for each decade and sex are used to calculate columns (1) and (2).

Table 3, column (3) is calculated by weighting table 3, column (1) by the percent of men in the 2010 U.S. population in each age category which is 1 minus the relevant age category in table 2, column (3). Likewise, the weight of female death rates is given by the relevant age bracket in column (3) of table 2. The population-weighted average death rates for each age bracket are in column (3) of table 3.

[*Insert Table 3 about here***]**

In table 4, COVID-19 death rates are scaled by the relevant annual average mortalities in table 3. Column (1) of table 3 is divided from columns (4), (5), and (6) of table 1 to produce columns (1), (2), and (3) of table 4. Column (2) of table 3 divides columns (7), (8), and (9) of table 1 to produce columns (4), (5), and (6) of table 4. COVID-19 mortality increases as a percent of annual mortality for all age brackets up to 70 to 79 for men and 60 to 69 for women.

[*Insert Table 4 about here***]**

Spiegelhalter (2020) argues that COVID-19 is roughly equivalent to a year's risk for most age brackets in the U.K. We do not find this to be the case for the U.S. Nkhata (2020) finds that mortality rates from SARS-CoV-2 vary greatly from country to country. Another difference between Spiegelhalter (2020) and the present study is that the former uses year 7.3 mortality instead of average mortality to make that argument with United Kingdom mortality tables. It is unclear why year 7.3 of a decade age bracket is a meaningful comparison. Thus, we have used average annual mortality with the United States mortality data instead.

[*Insert Table 5 about here***]**

In table 5, the IFRs from table 1 columns (1), (2), and (3) are divided by the combined annual death rates from table 3, column (3).

In figure 1, panel A, we plot the death risks for men with COVID-19 over the average annual male mortality in columns (1), (2), and (3) of table 4. In figure 1, panel B, the relative female mortality of COVID-19 versus average annual mortality is plotted from columns (4), (5), and (6) of table 4. The combined men and women COVID-19 death risk over average annual mortality for both sexes from table 5 is plotted in figure 1, panel C. The mortality of COVID-19 is expected to be less than average mortality for age brackets below 50-years-old. At 50-years-old or above, getting COVID-19 is roughly equivalent to a year to two years' mortality risk.

[*Insert Figure 1, Panels A, B, & C about here***]**

3. COVID-19's Impact on Life Expectancy

To measure CoV-SARS-2's impact on life expectancy, let us define some terms. $p_{s,d,c}$ is the conditional probability that a person of the sex s, the decade of life (or age bracket) d, and virus severity scenario, c, will die of COVID-19 given that they are infected. This is the IFR for the sex, decade, and scenario combination. $p_{s,d,c}$ is given by columns (4), (5), (6), (7), (8), and (9) of table 1. Let $\Delta LE_{s,d,c}$ be the average days of life expectancy lost from contracting COVID-19.

$LE_{s,t}$ is the life expectancy in years of someone of the sex, *s,* age in years, *t*. *c* stands for the low IFR, expected IFR, or high IFR scenarios in table 1. $LE_{s,t} - (1 - p_{s,d,c})\, LE_{s,t}$ are the years of life expectancy lost if someone of gender, *s,* and age, *t,* contracts COVID-19 with an IFR severity *c*. $T_{d,a}$ is the beginning years of the age bracket, *d*. It is the 0^{th} year. It is year 0 in the 0 to 9 bracket and is 80 in the 80 to 89 age brackets, for example. $T_{d,\,b}$ is the 9^{th} year in an age bracket. For example, $T_{50\ to\ 59,\,b} = 59$. $T_{d,b} - T_{d,a} + 1$ is the number of years in the relevant age bracket. $T_{d,b} - T_{d,a} + 1$ is equal to 10. We assume that the year has 365.25 days. The average days of life expectancy lost for each one of the genders, for each decade of life, and in all three scenarios is calculated below:

$$\Delta LE_{s,d,c} = \frac{365.25}{10} \sum_{t=T_{d,a}}^{T_{d,b}} [LE_{s,t} - (1 - p_{s,d,c}) LE_{s,t}] \tag{1}$$

[*Insert Table 6 about here***]**

Figure 2, panels A and B are the days of life expectancy lost for each decade. The black lines are the expected IFR scenario, the dashed line is the low IFR scenario, and the dotted line is the high IFR scenario in both panels. Panel A plots columns (1), (2), and (3) of table 6. Panel B plots columns (4), (5), and (6) of table 6.

[*Insert Figure 2, Panels A, B, & C about here***]**

To plot figure 2, panel C combining both the genders let us define one more term. g_d is the percent of the population that is female and is given by table 2, column (2). Let's assume that s takes on the value m for males and f for females. Let $\Delta LE_{d,c}$ be the population-weighted average of both the gender's life expectancy by scenario and decade. It is calculated as follows:

$$\Delta LE_{d,c} = g_d \Delta LE_{f,d,c} + (1 - g_d)\Delta LE_{m,d,c} \quad (2)$$

Figure 2, panel C plots the decade and scenario pairs for equation (2). Panel C plots columns (7), (8), and (9) of table 6.

4. Conclusion

In this paper, we look at the mortality risks and life expectancy losses by age and decade that we could expect for Americans contracting COVID-19 in early 2020. Since we rely on infection fatality rate estimates compiled prior to pharmaceutical treatments for SARS-CoV-2, Americans contracting SARS-CoV-2 after widespread vaccinations and proven drug treatment interventions stand a much better chance of surviving an infection than implied by this study. We find that only Americans 50-years-old or older doubled their annual mortality risk with a COVID-19 infection. Americans younger than 50-years-old faced a disease was less deadly than annual mortality risks. Moreover, we find that only Americans over 60 could expect life expectancy losses in excess of 100 days if they contracted SARS-CoV-2. Indeed, Americans age

70-to-79-years old could, prior to proven pharmaceutical treatments, expect to lose 222 days of life expectancy from a SARS-CoV-2 infection.

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Table 1: Infection fatality rates (IFR) by age bracket and gender from Wilson (2021)

Age Group	(1) Low IFR	(2) IFR Expected	(3) High IFR	(4) Male IFR Low	(5) Male IFR Expected	(6) Male IFR High	(7) Female IFR Low	(8) Female IFR Expected	(9) Female IFR High
0 to 9	0.001%	0.002%	0.003%	0.001%	0.002%	0.004%	0.001%	0.001%	0.002%
10 to 19	0.003%	0.006%	0.009%	0.003%	0.007%	0.012%	0.002%	0.004%	0.007%
20 to 29	0.013%	0.030%	0.047%	0.017%	0.037%	0.058%	0.010%	0.022%	0.035%
30 to 39	0.036%	0.080%	0.124%	0.044%	0.099%	0.154%	0.026%	0.060%	0.093%
40 to 49	0.067%	0.150%	0.233%	0.083%	0.186%	0.290%	0.050%	0.112%	0.174%
50 to 59	0.267%	0.600%	0.933%	0.331%	0.744%	1.158%	0.199%	0.447%	0.695%
60 to 69	0.978%	2.200%	3.422%	1.213%	2.730%	4.246%	0.728%	1.639%	2.549%
70 to 79	2.267%	5.100%	7.933%	2.812%	6.328%	9.844%	1.688%	3.799%	5.909%
80+	4.133%	9.300%	14.467%	5.129%	11.539%	17.950%	3.079%	6.927%	10.776%

This table is taken from Wilson (2021), which bases the infection fatality rate ranges on Ferguson *et. al* (2020), Verity *et al.* (2020), and Feng *et al.* (2020).

Table 2: 2010 U.S. Census data on the percent of the U.S population in selected age brackets and the female percent of the population in the selected age ranges

Age Group	(1) % of US Population	(2) % of US Population that is Female
0 to 9	13.1%	48.9%
10 to 19	13.8%	48.8%
20 to 29	13.8%	49.3%
30 to 39	13.0%	50.1%
40 to 49	14.1%	50.5%
50 to 59	13.6%	51.2%
60 to 69	9.5%	52.4%
70 to 79	5.4%	55.3%
80+	3.6%	63.7%

These are the percent of the U.S. population in each age category according to the U.S. 2010 Census as recorded in Howden and Meyer (2011).

Table 3: Average annual death rates in the United States by decade

Age Group	(1) Average Annual Death Rate Men	(2) Average Annual Death Rate Women	(3) Average Annual Death Rate Combined
0 to 9	0.081%	0.068%	0.075%
10 to 19	0.044%	0.021%	0.033%
20 to 29	0.154%	0.059%	0.107%
30 to 39	0.204%	0.105%	0.155%
40 to 49	0.326%	0.203%	0.264%
50 to 59	0.763%	0.471%	0.614%
60 to 69	1.578%	0.981%	1.265%
70 to 79	3.580%	2.507%	2.987%
80 to 89	9.617%	7.371%	8.188%

These are the simple averages of the annual death rates for men and woman from actuarial data from the Social Security Administration, Office of the Chief Actuary's 2016 table. The combined column is the average annual death rates by decade weighted by the ratio of men and women in each decade of life according to the 2010 U.S. Census in Howden and Meyer (2011). For the 80-89 decade, the weight of woman and men over eighty was used to calculate the combined death rate.

Table 4: COVID-19 death rates over U.S. annual average mortality by decade for males and females

Age Group	(1) Low Male COVID Mortality Over Average Annual Death Rate	(2) Exp. Male COVID Mortality Over Average Annual Death Rate	(3) High Male COVID Mortality Over Average Annual Death Rate	(4) Low Female COVID Mortality Over Average Annual Death Rate	(5) Exp. Female COVID Mortality Over Average Annual Death Rate	(6) High Female COVID Mortality Over Average Annual Death Rate
0 to 9	1.4%	3.0%	4.7%	1.0%	2.2%	3.4%
10 to 19	7.5%	16.9%	26.3%	9.4%	21.1%	32.8%
20 to 29	10.7%	24.1%	37.5%	17.0%	38.2%	59.4%
30 to 39	21.6%	48.7%	75.7%	25.2%	56.6%	88.1%
40 to 49	25.4%	57.0%	88.7%	24.5%	55.0%	85.6%
50 to 59	43.4%	97.5%	151.7%	42.1%	94.8%	147.5%
60 to 69	76.9%	173.0%	269.1%	74.3%	167.1%	260.0%
70 to 79	78.6%	176.8%	275.0%	67.4%	151.5%	235.7%
80+	53.3%	120.0%	186.6%	41.8%	94.0%	146.2%

The COVID-19 infection fatality rates (IFR) calculated from Ferguson *et al.* (2020) and Feng *et al.* (2020) are divided by the average annual mortality by decade from the U.S. Social Security Administration, Office of the Chief Actuary's 2016 table.

Table 5: COVID-19 death rates over U.S. annual average mortality by decade

Age Group	(1) Low Combined COVID Mortality Over Average Annual Death Rate	(2) Exp. Combined COVID Mortality Over Average Annual Death Rate	(3) High Combined COVID Mortality Over Average Annual Death Rate
0 to 9	1.2%	2.7%	4.2%
10 to 19	8.1%	18.2%	28.4%
20 to 29	12.4%	28.0%	43.6%
30 to 39	23.0%	51.8%	80.5%
40 to 49	25.2%	56.8%	88.3%
50 to 59	43.5%	97.8%	152.1%
60 to 69	77.3%	173.9%	270.5%
70 to 79	75.9%	170.7%	265.6%
80+	50.5%	113.6%	176.7%

The COVID-19 infection fatality rates (IFR) calculated from Ferguson *et al.* (2020) and Feng *et al.* (2020) are divided by the average annual mortality by decade from the U.S. Social Security Administration, Office of the Chief Actuary's 2016 table and the population weights of men and women from the 2010 U.S. Census in Howden and Meyer (2011).

Figure 1, Panel A

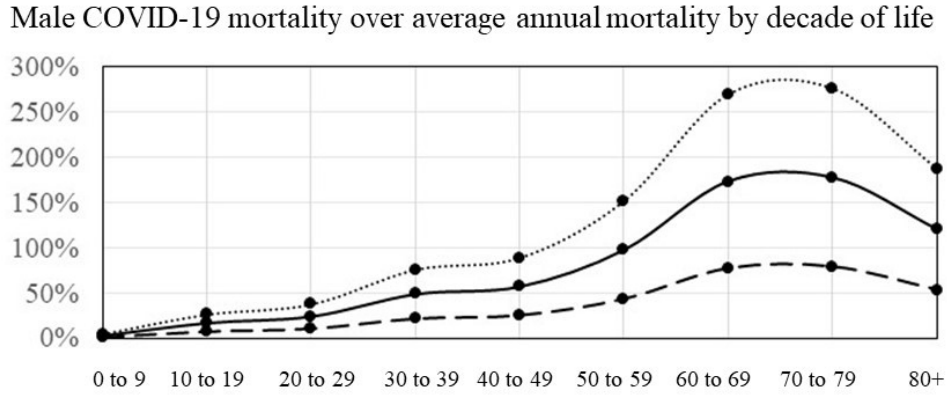

Figure 1, Panel B

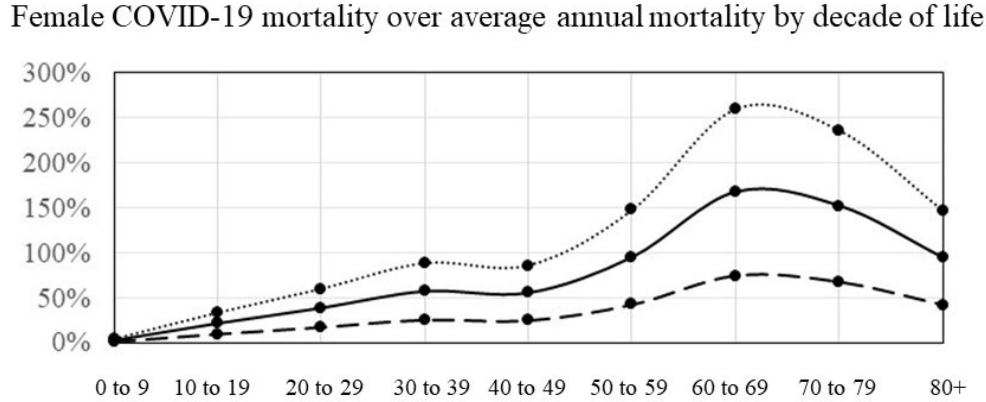

Figure 1, Panel C

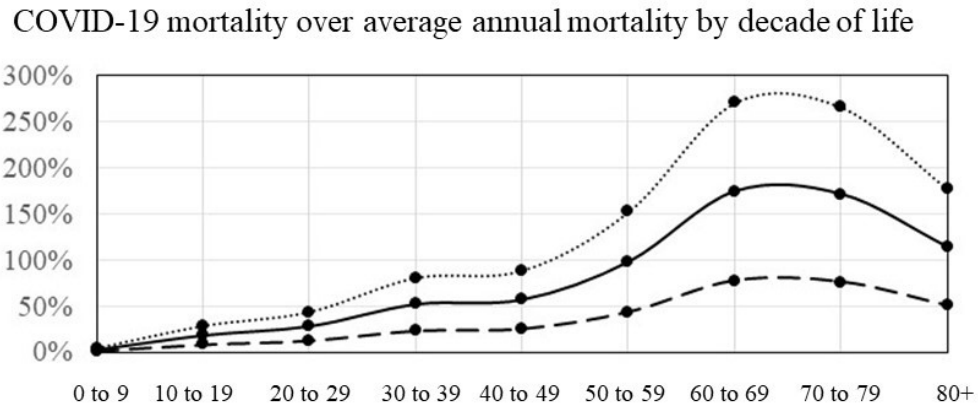

Table 6: Expected Life Expectancy Losses for U.S. Males, Females, and Both Genders from a COVID-19 Infection

Age Group	(1) Low Expected Days Life Expectancy Lost for Males from a COVID-19 Infection	(2) Expected Days Life Expectancy Lost for Males from a COVID-19 Infection	(3) High Expected Days Life Expectancy Lost for Males from a COVID-19 Infection	(4) Low Expected Days Life Expectancy Lost for Females from a COVID-19 Infection	(5) Expected Days Life Expectancy Lost for Females from a COVID-19 Infection	(6) High Expected Days Life Expectancy Lost for Females from a COVID-19 Infection	(7) Low Expected Days Life Expectancy Lost from a COVID-19 Infection	(8) Expected Days Life Expectancy Lost from a COVID-19 Infection	(9) High Expected Days Life Expectancy Lost from a COVID-19 Infection
0 to 9	0	1	1	0	0	1	0	1	1
10 to 19	1	2	3	0	1	2	1	1	2
20 to 29	3	7	11	2	5	7	3	6	9
30 to 39	7	16	25	5	10	16	6	13	20
40 to 49	10	23	37	7	16	24	9	20	30
50 to 59	31	71	110	21	48	74	26	59	92
60 to 69	81	183	284	56	125	195	68	153	237
70 to 79	119	267	415	67	186	289	90	222	345
80+	117	263	409	83	186	289	96	215	335

Figure 2, Panel A

Figure 2, Panel B

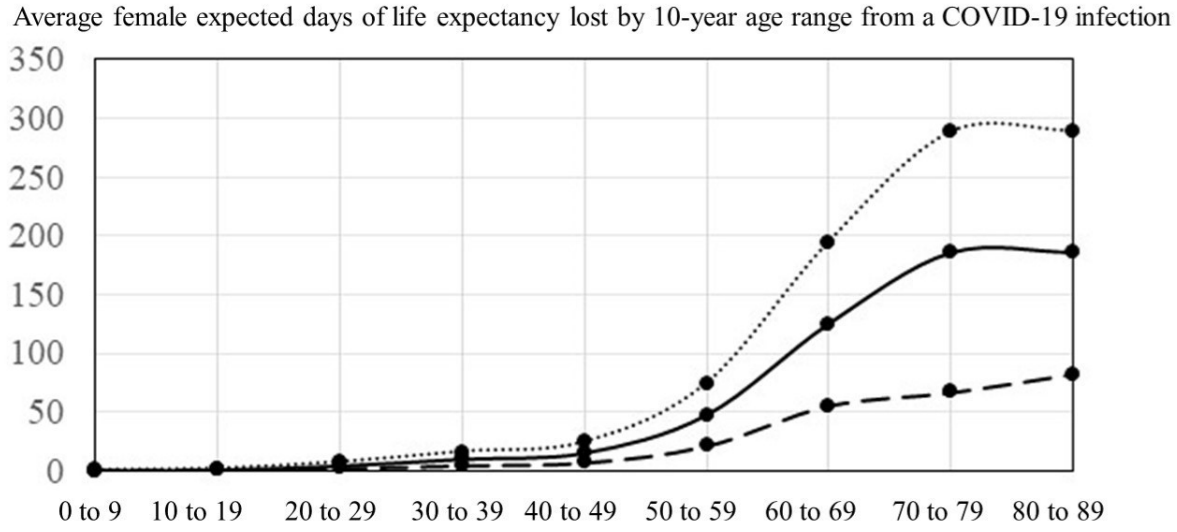

Figure 2, Panel C