Perspective

Do the Benefits of COVID-19 Policies Exceed the Costs? Exploring Uncertainties in the Age–VSL Relationship

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Numerous analyses of the benefits and costs of COVID-19 policies have been completed quickly as the crisis has unfolded. The results often largely depend on the approach used to value mortality risk reductions, typically expressed as the value per statistical life (VSL). Many analyses rely on a population-average VSL estimate; some adjust VSL for life expectancy at the age of death. We explore the implications of theory and empirical studies, which suggest that the relationship between age and VSL is uncertain. We compare the effects of three approaches: (1) an invariant population-average VSL; (2) a constant value per statistical life-year (VSLY); and (3) a VSL that follows an inverse-U pattern, peaking in middle age. We find that when applied to the U.S. age distribution of COVID-19 deaths, these approaches result in average VSL estimates of $10.63 million, $4.47 million, and $8.31 million. We explore the extent to which applying these estimates alters the conclusions of frequently cited analyses of social distancing, finding that they significantly affect the findings. However, these analyses do not address other characteristics of COVID-19 deaths that may increase or decrease the VSL estimates. Examples include the health status and income level of those affected, the size of the risk change, and the extent to which the risk is dreaded, uncertain, involuntarily incurred, and outside of one’s control. The effects of these characteristics and their correlation with age are uncertain; it is unclear whether they amplify or diminish the effects of age on VSL.

KEY WORDS: Benefit–cost analysis; COVID-19; pandemic; value per statistical life; VSL; willingness to pay

1. INTRODUCTION

Understanding the trade-off between reducing the risk of death and increasing economic costs is essential to guiding responses to the coronavirus disease 2019 (COVID-19) crisis. To value changes in the risks of U.S. COVID-19 deaths, researchers often rely on a population-average value per statistical life (VSL) estimate, at times adjusting for the age distribution of those affected. While a population-average estimate of around $10 million is well established, the appropriate adjustment for age is uncertain. We explore differing approaches to estimating the impact of age on the VSL and the implications for COVID-19 benefit–cost analyses.

In the sections that follow, we summarize the conceptual framework for valuation and the literature on the relationship between VSL and age or life expectancy. We describe the data and methods we use to explore the effects of differing adjustments for age at death. We present the results and discuss...
the implications, illustrating how differences in these estimates affect the results of COVID-19 social distancing analyses. We then consider the influence of factors other than age on VSL, which are deserving of more attention and likely to affect the value of reducing COVID-19 deaths.¹

## 2. VALUATION CONCEPTS AND RESEARCH

Benefit–cost analysis is a well-established approach that is widely used to assess the impacts of regulatory and other public policies. In the United States, two Federal agencies have developed detailed guidance for its conduct: the U.S. Environmental Protection Agency (EPA) (2010a) and the U.S. Department of Health and Human Services (HHS) (2016).² Both agencies include recommendations for valuing mortality risk reductions within more comprehensive guidance. In addition, the U.S. Department of Transportation (DOT) (2016) has issued specific guidance on estimating VSL. While these recommendations were originally developed to support the assessment of major regulations, they are applied in numerous other policy contexts.

Recognizing that every individual study will have advantages and limitations, each agency synthesizes the results of several VSL studies in developing their estimates. They apply what is often described as the “benefit transfer” framework. As is the case for other parameter values, this framework explicitly recognizes that no individual study is likely to exactly match the policy scenario; that is, to address the same population and the same risks over the same time period as the policy. In addition, the quality of the studies varies and there is not full agreement on best practices. The framework thus promotes careful consideration of the quality and applicability of the available research and assessment of uncertainty.

Although each of the three agencies developed their VSL recommendations at different times using different approaches to select and evaluate the research, the results are remarkably similar. When adjusted to 2019 dollars and income levels, the central population-average VSL estimates of all three agencies are around $10 million; recent work by Viscusi (2015, 2018a) that adjusts for publication selection bias recommends a similar best estimate. We explore the conceptual framework that underlies these estimates and alternative approaches for adjusting for age at death below.

### 2.1. Conceptual Framework

Benefit–cost analysis is based on two fundamental normative elements from welfare economics. The first is that each individual is the best, or most legitimate, judge of his or her own welfare. The second is that the impact of a policy on social welfare can be represented by the sum of the impacts across individuals. This focus on individual preferences means that it is essential to supplement conventional benefit–cost analysis with assessment of the distribution of the effects, as emphasized in the above-referenced guidance documents. Who receives the benefits and who bears the costs is an important policy consideration, especially in contexts where impacts may fall disproportionately on those who are disadvantaged.

As typically conducted, benefit–cost analysis focuses on incremental policy changes, such as a new air pollution regulation or food safety policy. It compares predicted conditions without and with the policy over time. The starting point for valuation is thus the change in individual risk attributable to the policy within a defined period, compared to the without-policy baseline. The individual risk reduction (e.g., 1 in 10,000) can then be multiplied by the number of people affected (e.g., 1,000,000) to estimate the number of statistical cases averted (100 in this example).

Under conventional economic assumptions, individual willingness to pay (WTP) is the appropriate measure of value for improvements from the status quo. WTP represents the rate at which individuals are willing to trade off spending on risk reductions against all the other things they could use that money to buy. For an individual, VSL can be derived by dividing his or her WTP by the risk reduction. A population-average VSL of $10 million indicates that the typical individual is willing to pay $1,000 to decrease his or her chance of dying in a given year by 1 in 10,000. Individual WTP can also be summed across those affected. If each of 10,000 individuals experiences a 1 in 10,000 risk reduction, and is willing to pay $1,000 for his or her risk change, the total value is $10 million (10,000 × $1,000) and one less person would be expected to die that year (10,000 × 1/10,000).

¹We focus on mortality risk reductions because they dominate the benefit estimates. Approaches for valuing morbidity are addressed in the guidance documents referenced in Section 2.
²EPA is in the process of updating its guidance but has not proposed changes to its VSL estimates.
These values vary across individuals and depend on the characteristics of the risk. We first focus on the effects of age given its importance in the COVID-19 context. We then briefly summarize other influencing factors. These include individual characteristics, such as health status and income, and risk characteristics, such as whether death is preceded by significant morbidity and is particularly dreaded.

2.2. Relationship Between VSL and Age

Benefit–cost analyses of COVID-19 policies have been completed against a backdrop of constantly evolving understanding of the risks themselves. Relatively early in the crisis, it became apparent that the elderly were disproportionately affected. As a result, researchers tend to focus on the relationship between age and the risk of death when estimating VSL.

The studies that underlie the recommended population-average VSL estimates generally focus on the trade-off between wages and occupational risks among working adults, excluding children and the elderly and those who do not participate in the labor force for reasons other than age. Most Federal agencies do not adjust VSL for the age of those affected, although the HHS (2016) guidance recommends adjustments in sensitivity analysis when the risk changes disproportionately accrue to the very old or the very young.

This lack of adjustment in part reflects uncertainty about the relationship between VSL and age, as discussed below. It also reflects public opposition to these adjustments (Cameron, 2010; Robinson, 2007). VSL is often misinterpreted as the value the government places on saving an individual's life, rather than the value that individuals themselves place on small changes in their own risks. Given this misunderstanding, it is easy to see why people might oppose any approach that appears to give greater or lesser weight to individuals with different characteristics. In addition, even if these values are correctly interpreted, these adjustments raise normative concerns, emphasizing the need to consider the distribution of the impacts as well as net benefits.

Because older individuals have fewer expected life years remaining than the average member of the population, intuition suggests that lower VSL estimates may be applicable. This intuition is behind a commonly used approach for age adjustments, which applies a constant value per statistical life year (VSLY). In contrast to the VSL, which is the rate at which the individual substitutes money for reductions in current mortality risk (within a year or other short time period), the VSLY is the rate at which he or she substitutes money for gains in life expectancy.

Although VSLY can be estimated directly from empirical research, there are relatively few such studies. A more common approach is to estimate VSLY by dividing VSL by the average (discounted) remaining life expectancy for the population studied. As discussed in Miller et al. (2006), Robinson (2007), and elsewhere, the U.S. Food and Drug Administration (a component of HHS) and other Federal agencies have at times used this approach, as have some academic researchers. A similar approach is recommended in the current HHS (2016) guidance for application in sensitivity analysis when the very young or very old are disproportionately affected by the policy.

To determine the value per statistical case, the constant VSLY that results is then multiplied by the expected years of life extension for individuals affected by the policy. Under this approach, the per-case values are lower for older individuals than for younger individuals, because they have fewer expected years of life remaining. This approach assumes that VSLY is constant and independent of the number of life years gained, implying that VSL is proportional to the individual’s remaining (discounted) life expectancy. Neither theory nor the empirical research, however, supports these assumptions. Rather, as is the case for VSL, VSLY is expected to vary depending on individual and risk characteristics.

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3 This section reflects the findings of several literature reviews focused on U.S. values. In addition to the guidance documents cited, examples include Dockins, Maguire, and Simon (2006), U.S. Environmental Protection Agency (2010b), Cropper, Hammitt, and Robinson (2011), Robinson and Hammitt (2015), Robinson and Hammitt (2016), and Viscusi (2018b). See Hammitt (2020) for more discussion of the theory and empirical research relevant to the COVID-19 context.

4 We focus on values for older individuals because they have been disproportionately affected by COVID-19 mortality risks. For children, empirical research often finds that values exceed those for the average age adult; see Robinson, Raich, Hammitt, and O’Keeffe (2019) for more detailed discussion.

5 The HHS (2016) guidance recommends the use of a constant value per quality-adjusted life year (QALY) rather than a constant VSLY. The two approaches are identical with one exception: the HHS approach adjusts future life years to reflect the expected health-related quality of life at each age. Because this quality of life decreases as one ages, dividing VSL by expected QALYs rather than expected life years results in higher values. We focus on VSLY here because it has been more widely applied.
Some instead argue that the relationship between VSL and age should follow the pattern of consumption over the lifecycle, which is typically an inverse-U distribution. For example, Murphy and Topel (2006) develop a structural model that combines theoretical expectations with data from various sources and find an inverse-U pattern. Much of the empirical work that considers the trade-off between wages and occupational risks across workers also results in an inverse-U distribution (see Aldy, 2019; Aldy & Viscusi, 2007; Aldy & Viscusi, 2008; Kniesner, Viscusi, & Ziliak, 2006; Viscusi & Aldy, 2007). One challenge in applying these findings is that the shape of the curve (the rate of increase and decrease) and the age at which VSL peaks varies.

These studies of occupational risks are generally limited to adults under age 65. Thus, a more significant challenge in the COVID-19 context is determining whether this pattern extends to older individuals. Research on values held by the elderly leads to inconsistent results. Studies focused on older workers (age 51 and above and their spouses) find that the VSL remains constant or increases with age (summarized in Evans & Smith, 2006). Cameron, Deshazo, and Stiffler (2010) find an inverse-U pattern based on simulation modeling using survey data from a sample of the U.S. adult population (regardless of age or employment status). Other survey research that considers older individuals does not find statistically significant relationships with age or finds that VSL decreases in varying patterns and amounts (Krupnick, 2007). These conflicting results suggest that there is substantial uncertainty regarding the relationship between the population-average VSL and the VSL most appropriate for older individuals beyond working age; that is, for the age group most affected by COVID-19 mortality risks.

3. DATA AND METHODS

To investigate the effects of VSL age adjustments, we rely on data from the Centers for Disease Control and Prevention (CDC) on cumulative COVID-19 deaths in the United States and test three approaches: (1) an invariant population-average VSL; (2) a constant VSL; and (3) a VSL that follows an inverse-U pattern, peaking in middle age. We describe these data and methods below.

3.1. COVID-19 Deaths

Table I provides estimates of cumulative COVID-19 deaths by age group, for February 1, 2020 through May 30, 2020. For comparison, Table I also provides estimates of all-cause mortality over the same period, as well as estimates of the total 2019 population in each age group.

As indicated by Table I, deaths are most likely to occur among the elderly (65+ years) regardless of cause; the distribution of COVID-19 deaths by age is similar to the distribution of all-cause mortality over this period (80.7% and 75.4% age 65 and over, respectively). The distribution of COVID-19 deaths is also similar to the distribution of all-cause mortality prior to the advent of COVID-19; for example, in 2018, 73.9% of all deaths occurred among those age 65 and over.

Estimates of deaths by cause are always somewhat uncertain due to difficulties inherent in determining the cause and inconsistencies in reporting. Estimating COVID-specific deaths is no exception; testing is very limited and the results are not always accurate. However, it seems reasonable to assume that COVID-19 deaths are primarily among the elderly.

The relationship between VSL and age reflects life expectancy conditional on reaching each year of age, at least in part. The majority (93%) of the COVID-19 deaths are coded as having multiple causes. It is unclear whether, in the absence of COVID-19, these individuals would have faced the same likelihood of survival as others of the same age. For simplicity, we assume those dying from COVID-19 would otherwise have the same likelihood of surviving each year of age as all members of the U.S. population who reach that age. We rely on CDC data (Arias & Xu, 2019) to estimate these survival probabilities.

3.2. Adjustments for Age

Given the age distribution of COVID-19 deaths above, we test the effects of three methods for estimating age-specific VSLs.

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6This approach follows seminal work by Shepard and Zeckhauser (1984), and has been applied, for example, to pandemic influenza in Council of Economic Advisers (2019).

7Because COVID-19 deaths are driven in part by behavioral factors, the distribution is likely to vary over time. For example, many early deaths were among elderly nursing home residents; currently, deaths among younger age groups appear to be increasing due in part to the lack of precaution at large gatherings. However, given age-related vulnerabilities and trends to-date, it seems unlikely that the distribution would shift radically toward younger age groups.
### Table I. U.S. Population (July 1, 2019) and Deaths by Age (February 1, 2020–May 30, 2020)

| Age Group | Total Population | Deaths, COVID-19 | Deaths, All Causes |
|-----------|-----------------|-----------------|-------------------|
| Under 1 year | 3,783,052 (1.2%) | 5 (0.0%) | 5,377 (0.5%) |
| 1–4 years | 15,793,631 (4.8%) | 3 (0.0%) | 1,048 (0.1%) |
| 5–14 years | 40,994,163 (12.5%) | 12 (0.0%) | 1,523 (0.1%) |
| 15–24 years | 42,687,510 (13.0%) | 106 (0.1%) | 9,442 (0.9%) |
| 25–34 years | 45,940,321 (14.0%) | 583 (0.7%) | 20,133 (2.0%) |
| 35–44 years | 41,659,144 (12.7%) | 1,524 (1.7%) | 28,975 (2.8%) |
| 45–54 years | 40,874,902 (12.5%) | 4,238 (4.8%) | 55,415 (5.4%) |
| 55–64 years | 42,448,537 (12.9%) | 10,586 (12.0%) | 131,405 (12.7%) |
| 65–74 years | 31,483,433 (9.6%) | 18,360 (20.8%) | 202,513 (19.6%) |
| 75–84 years | 15,969,872 (4.9%) | 23,612 (26.8%) | 252,786 (24.5%) |
| 85 years and over | 6,604,958 (2.0%) | 29,214 (33.1%) | 322,182 (31.3%) |
| All ages | 328,239,523 (100%) | 88,243 (100%) | 1,030,799 (100%) |

**Sources:** Total population: “Annual Estimates of the Resident Population by Single Year of Age and Sex for the United States: April 1, 2010 to July 1, 2019 (NC-EST2019-AGESEX-RES),” U.S. Census Bureau, as viewed June 4, 2020. https://www.census.gov/data/datasets/time-series/demo/popest/2010s-national-detail.html
Deaths, COVID-19 and Deaths, All Causes: “Provisional COVID-19 Death Counts by Sex, Age, and State,” National Center on Health Statistics, U.S. Centers for Disease Control and Prevention, as viewed June 4, 2020. https://data.cdc.gov/NCHS/Provisional-COVID-19-Death-Counts-by-Sex-Age-and-S/9bhg-hcku

**Notes:** CDC indicates that the number of deaths may be understated due to reporting and processing delays.

### 3.2.1. Age-Invariant VSL

As discussed earlier, Federal agencies generally do not adjust VSL for differences in age or life expectancy due to limitations and gaps in the research literature as well as concerns about how these adjustments are perceived by the public. To illustrate this approach, we rely on the central HHS (2016) VSL estimate in our analysis for three reasons: (1) it is the agency whose mission relates most directly to addressing the COVID-19 crisis (and CDC is one of its component agencies); (2) it is based on research that explicitly addresses the potential difference between values for fatal illnesses and occupational injuries (Robinson & Hammitt, 2016); and (3) the HHS VSL recommendations were developed more recently than those used by other agencies, incorporating review of newer research. The HHS estimate is also very similar to the estimates recommended by other U.S. agencies and researchers. When adjusted for real income growth and inflation to 2019 values (following the approach in HHS 2016), the central HHS VSL estimate is $10.63 million. Under the first approach, we apply this estimate to all deaths regardless of age.

### 3.2.2. Constant VSLY

Under our second approach, we apply a constant VSLY to the age-distribution of COVID-19 deaths to develop an age-weighted estimate. We calculate this VSLY by dividing the HHS central VSL estimate ($10.63 million) by the discounted life expectancy at the average age (40) of those studied as reported in HHS (2016). For each year of age, we rely on conditional survival rates from Arias and Xu (2019). Consistent with government guidance and common practice, we apply a discount rate of 3%. This results in a constant VSLY of $455,484. We then multiply this constant by the discounted life expectancy for each age group (at the mid-point age) and weight by the number of COVID-19 deaths in each group. This results in an age-weighted average of $4.47 million per COVID-19 death.

### 3.2.3. Inverse-U Relationship

Our third approach involves estimating values that follow an inverse-U pattern, peaking in middle age. We again use the HHS value as our starting point, for individuals age 40 on average. One challenge in applying this approach is that the shape of the curve and the age at which it peaks varies across studies as well as across models within studies. Because it is based on empirical data, is frequently cited, and has been used in U.S. government analyses (e.g., Council on Economic Advisers 2019), we rely on Aldy and Viscusi (2008) in our illustrative example.

Aldy and Viscusi present the results of two models. The first is cross-sectional, based on eight years of data (1993–2000). The second relies on the same data...
Table II. VSL by Age Group (in 2019 millions of dollars)

| Age Group       | Invariant VSL | Constant VSLY | Inverse-U Relationship |
|-----------------|---------------|---------------|------------------------|
| Under 1 year    | $10.63        | $13.88        | $5.38                  |
| 1–4 years       | $10.63        | $13.74        | $5.38                  |
| 5–14 years      | $10.63        | $13.37        | $5.38                  |
| 15–24 years     | $10.63        | $12.64        | $5.38                  |
| 25–34 years     | $10.63        | $11.76        | $8.50                  |
| 35–44 years     | $10.63        | $10.63        | $10.63                 |
| 45–54 years     | $10.63        | $9.19         | $10.72                 |
| 55–64 years     | $10.63        | $7.54         | $8.15                  |
| 65–74 years     | $10.63        | $5.68         | $8.15                  |
| 75–84 years     | $10.63        | $3.72         | $8.15                  |
| 85 years and over | $10.63    | $2.03         | $8.15                  |

but adjusts for cohort effects; that is, for year of birth. Both approaches result in an inverse-U distribution by age. However, the cross-sectional approach peaks at age 39, while cohort-adjusted approach peaks at age 46 and declines at a more modest rate.

In our illustrative analysis, we assume the VSL distribution by age is the same shape as the Viscusi and Aldy results, adjusting the values at each age upward by the ratio of the 2019 HHS VSL to their 2000 value for the 40-year-old age group. The Viscusi and Aldy study includes only working age adults (ages 18–62). For younger and older individuals, we assume the value is constant. In other words, we use the value for 18 year olds for all those under age 18, and the value for 62 year olds for all those above age 62, reflecting uncertainty about the extent which these values continue to decrease or increase beyond these ages.

We then weight the age-specific values by the number of COVID-19 deaths in each age group.8 Using the cross-sectional estimates results in an age-weighted average of $4.18 million per COVID-19 death; the cohort-adjusted estimates result in an age-weighted average of $8.31 million per COVID-19 death. Because the latter controls for the effects of year of birth on expected lifetime income, we rely on the cohort-adjusted result in the following section.9

4. RESULTS AND IMPLICATIONS

In Table II, we report our age-specific VSLs. These are unit values per death reported. Because the HHS central VSL estimate reflects values for the population with an average age of 40, the values are the same for this age group regardless of the approach. Under the constant VSLY approach, values decrease with age. Under our third approach, the values follow an inverse-U and level off below age 18 and above age 62.

In Table III, we report the total for all COVID-19 deaths, weighted by the number of deaths in each age group, and the average across all age groups.

To illustrate the effects of these approaches, we apply our estimates in Table II to the results of three frequently cited analyses of social distancing policies that have received substantial media attention: Thunström, Newbold, Finnoff, Ashworth, and Shogren (2020), Greenstone and Nigam (2020), and Acemoglu, Chernozhukov, Werning, and Whinston (2020). These analyses are not strictly comparable; they consider different scenarios and rely on different data sources and assumptions. Our goal is to compare the results of applying the three approaches we describe above to demonstrate the impacts on the findings, hoping to aid analysts in understanding the implications of related uncertainties as they begin to address a much broader array of policies.

Thunström et al. (2020) compare the benefits and costs of social distancing to a no mitigation scenario. They find implementing these social policies would result in a $4.18 million benefit per COVID-19 death. However, their estimates do not account for the effects of year of birth on expected lifetime income.

8In these calculations, we use the cross-sectional results by age group reported in Aldy and Viscusi (2008) for the most recent year (2000) from Tables I and II. Aldy and Viscusi do not report results by age group for the cohort-adjusted values. However, Viscusi (2013) reports the cohort-adjusted results from the 2008 study for specific years of age. We average the results he reports for the relevant ages to apply them to the age groupings for COVID-19 deaths.

9We tested the sensitivity of the results reported in Section 4 to instead relying on the $4.18 million value and found that they were very similar to the results of relying on the VSLY approach. This is not surprising given the similarity of the COVID-19 age-weighted estimates under each approach ($4.47 vs. $4.18 million).
Exploring Uncertainties in the Age–VSL Relationship

Table III. COVID-19 Age-Weighted Value (in 2019 millions of dollars)

|                                | Invariant VSL  | Constant VSLY | Inverse-U Relationship |
|--------------------------------|----------------|---------------|------------------------|
| Total value, all COVID-19 deaths | $937.6 billion | $394.8 billion | $773.4 billion         |
| Average VSL, weighted by COVID-19 deaths by age | $10.63 million  | $4.47 million  | $8.31 million          |

Table IV. Effect of Alternative Approaches on Analytic Results

| Costs                         | Lives Saved | Original Approach | Invariant VSL | Constant VSLY | Inverse-U Relationship |
|-------------------------------|-------------|-------------------|---------------|---------------|------------------------|
| Thunström et al. (2020)       | $7.2 trillion | 1.24 million      | $12.4 trillion | $13.16 trillion | $5.54 trillion        | $10.30 trillion         |
| Greenstone and Nigam (2020)   | N/A         | 1.76 million      | $7.94 trillion | $18.72 trillion | $7.88 trillion        | $14.64 trillion         |
| Acemoglu et al. (2020)        | $2.15 trillion | 8.7 million      | N/A           | $92.44 trillion | $38.93 trillion        | $72.31 trillion         |

distancing measures comes at a cost of roughly $7.2 trillion in lost gross domestic product (GDP) while saving approximately 1.24 million lives. To value these mortality risk reductions, they apply a $10 million VSL and find that net benefits total $5.2 trillion. The authors conduct a sensitivity analysis to estimate the “breakeven” VSL (i.e., the VSL in which net benefits are zero), which equals $5.85 million.

Greenstone and Nigam (2020) do not estimate costs; they only consider mortality risk reductions associated with a social distancing policy compared to no mitigation. In their featured estimates, they value these risks using Murphy and Topel’s (2006) structural model, which combines theoretical expectations and empirical data to estimate VSL by age. While this model results in an inverse-U function, it peaks at a younger age than the Aldy and Viscusi (2008) results and declines more sharply at older ages. Greenstone and Nigam find social distancing measures would save 1.7 million statistical lives at a cost of $7.2 trillion in lost GDP in comparison to the “no policy” option. They do not estimate the value of these mortality risk reductions.

In Table IV, we summarize the featured estimates from these three studies and compare them to the results using the COVID-19 age-weighted averages under our three approaches.

As illustrated by the table, the approach used to value mortality risk reductions significantly affects the results. By definition, the pattern in the benefits estimates across our three approaches follows the same pattern as in Table III. The invariant VSL leads to the largest benefits. In comparison to the invariant VSL, the constant VSLY approach reduces benefits by about 60%, and the inverse U approach reduces benefits by about 20%. These differences are large enough to change the policy implications of each study.

Whether the social distancing policy considered by Thunström et al. (2020) yields net benefits varies depending on the valuation approach. The authors use an invariant VSL but apply a somewhat lower value than we use in our analysis ($10 million rather than $10.63 million). However, both our invariant VSL and inverse-U approaches lead to positive net benefits. Under our invariant approach, the benefits increase by almost $800 billion due to differences between the VSL estimates. Benefits decrease when using the inverse-U approach, but not by a large

10Acemoglu, Chernozhukov, Werning, and Whinston (2020) report only percentage changes. We calculate the dollar value of the change in GDP based on 2019 GDP estimates reported by the U.S. Bureau of Economic Analysis (2020).
enough amount to drop below estimated costs. Under the constant VSLY approach, benefits decrease by a substantial amount and the policy no longer appears cost-beneficial.

While Greenstone and Nigam (2020) do not include a cost estimate in their calculations, the effects of our three approaches on their featured benefit estimates are significant. The benefit estimates more than double when applying the invariant VSL approach rather than their age-adjusted approach. Interestingly, their estimates are very similar ($7.94 vs. $7.88 trillion) to the results using our constant VSLY method, while applying our inverse-U estimates almost doubles the value in comparison to their inverse-U approach. This result reflects the relative steepness of their curve at older ages as well as our assumption that values level off at older ages under the inverse-U approach. As noted earlier, the additional sensitivity analyses reported by the authors also show significant variation in the results.

Acemoglu et al. (2020) have by far the largest estimates of lives saved across the three social distancing studies, which naturally increases the benefit values. Under all three approaches, we find that benefits exceed costs by an order of magnitude. However, Acemoglu et al. (2020) find that approaches other than the scenario reflected in Table IV are more cost-effective, particularly if they target higher risk, older age groups.

These illustrative calculations indicate that the approach to age-adjustment can substantially change the relationship between benefits and costs, at times altering the conclusions regarding whether a policy is cost-beneficial. Because COVID-19 deaths are concentrated among the elderly, adjusting for age reduces estimated benefits by a significant amount. However, the magnitude of the change and its implications depends on the approach used to make the adjustment.

5. OTHER INFLUENCING FACTORS

The relationship between VSL and age discussed in the preceding sections has attracted substantial attention in the COVID-19 context. However, many additional individual and risk attributes are likely to influence these values. The impact of several attributes is uncertain and may be counterbalancing to an unknown extent.

It is challenging to determine the population-average VSL appropriate for valuing COVID-19 risk reductions without more work on understanding the influence of these other attributes. It is also difficult to ascertain the extent to which these attributes interact with age; they may increase or decrease the VSL by the same proportion over the lifecycle or may dampen or amplify the effects of age on the VSL. We briefly summarize the research on key attributes here; more detailed discussion is provided in the reviews cited earlier.

Individual characteristics that may be particularly important in the COVID-19 context include pre-existing health impairments and income (or, more accurately, wealth). There is increasing evidence that COVID-19 deaths occur disproportionately among those with conditions, such as diabetes mellitus, chronic lung disease, and cardiovascular disease (CDC COVID-19 Response Team, 2020). The impact of impaired health on VSL is ambiguous. This ambiguity results from the trade-off between spending to increase the likelihood of survival and conserving wealth for expenditure on other goods or services. The effects are potentially counterbalancing: an individual may value risk reductions more if he or she is in good health, but good health may also provide more opportunities for other expenditures.

There is substantial evidence that individual WTP per unit of risk reduction, and hence VSL, increases with income. In the COVID-19 context, income is important in three respects. First, lower income individuals may be more significantly affected by COVID-19 risks, in part because it is more difficult for them to undertake protective measures. For example, they may live in more crowded conditions and may have a stronger need to continue working regardless of the safety of their commute and work environment. However, Federal agencies and others generally do not adjust VSL for within-population income differences. They adjust only for changes in population-average income over time due to the equity and other concerns discussed earlier in the age context.11

The two other income-related concerns may affect the population-average values. The COVID-19 epidemic is decreasing earnings, which means individuals have less money to spend on risk reductions as well as other things, potentially reducing the VSL. In addition, income constrains individuals’ ability to

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11 Whether this approach is in fact equitable is debatable. For example, if the costs of a policy fall primarily on the poor, but a population-average VSL is used to value benefits, the policy may appear cost-beneficial even though the costs those affected accrue may exceed the value to they place on the benefits they receive.
pay a greater amount for larger risk reductions. For example, while a typical individual may be willing to pay $1,000 for a 1 in 10,000 risk change, it would be difficult for many to pay $10,000 for a 1 in 1,000 risk change, and impossible for most to pay $100,000 for a 1 in 100 risk change. The relevance of this concern depends on the without and with policy scenarios as discussed earlier. A study that compares an uncontrolled scenario to a scenario with fully effective controls will yield a much larger risk reduction than a study that considers an incremental change.

The variation in VSL across types of risks is uncertain. The occupational risks that underlie many VSL estimates lead to relatively immediate death from injury. For example, Gentry and Viscusi (2016) estimate that 82% of all occupational deaths occur within a day of injury; the average number of days between injury and death is 4.22. In contrast, COVID-19 deaths may be preceded by a longer period of pain and suffering, including severe breathing difficulties and ventilator use. While such morbidity prior to death will likely increase the value placed on reducing the risk, the amount of increase is uncertain. In addition, the characteristics and magnitudes of many risks addressed in the VSL literature are relatively well understood. COVID-19 risks are not. Some research suggests that risks perceived as more dreaded and ambiguous, and less controllable and voluntary, may increase VSL by as much as a factor of two (Robinson et al., 2010).

Finally, the treatment of other-regarding preferences, including altruism, raises difficult issues in the benefit–cost analysis context that are unresolved. As noted earlier, typically benefit–cost analysis focuses on self-regarding preferences. However, with COVID-19, it is difficult to separate concern for one’s own well-being from concerns about the well-being of others. Contagion means that we may value reductions in the risks that accrue to others both for their own sake and because of the likelihood that we in turn could be infected. In addition, if others are not able to work, our own access to goods and services may be affected in addition to their income. The net effect of these attributes is difficult, if not impossible, to estimate without more research.

6. CONCLUSIONS

Benefit–cost analysis is a well-established and widely used approach for informing policy decisions. It has served this purpose in the COVID-19 context, emphasizing the importance of the crisis and highlighting key trade-offs. Many of the studies completed to-date compare COVID-19 impacts with no policy response to a widespread and fully effective policy (such as a national social distancing policy with 100% compliance). As time goes on, we are seeing more analyses that address realistic incremental policy changes. Such studies likely provide a more useful guide to action, particularly if they include reasonable assumptions about behavioral responses. For example, some people will adhere to social distancing recommendations regardless of government requirements, while others will ignore these recommendations even if social distancing is required. These responses in turn have potentially important ramifications for the costs and benefits of the policy.

Given that the goal of these analyses is to provide an evidence base for decision making, it seems essential for analysts to explore the sensitivity of their results to key assumptions. For policies where mortality risk reductions are an important contributor to overall benefits, our illustrative analysis of the effects of age adjustments is one example of the importance of investigating uncertainty. Other individual and risk attributes are also relevant and their implications should be addressed quantitatively or at least discussed in qualitative terms. At times, uncertainty in the VSL may not significantly affect the magnitude of the net benefits nor change whether the benefits of a policy exceed its costs. In other cases, this uncertainty may have important ramifications that should be considered by decisionmakers.

In addition, we believe that it is essential to accompany benefit–cost analysis with analysis of the distribution of the impacts. We care about extent to which those who are disadvantaged are disproportionately affected by both COVID-19 risks and by the economic consequences of policy actions. These factors must be taken into account in decision making.

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