Appendix D:

Updating Value per Statistical Life (VSL) Estimates for Inflation and Changes in Real Income

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This appendix supplements the U.S. Department of Health and Human Services (HHS) 2016 *Guidelines for Regulatory Impact Analysis*. It was drafted by Lisa A. Robinson (Harvard T.H. Chan School of Public Health) with assistance from Jennifer R. Baxter and William Raich (Industrial Economics, Incorporated). It was prepared under the leadership of Amber Jessup and updated under the leadership of Aaron Kearsley and Scott Douglas of the HHS Office of the Assistant Secretary for Planning and Evaluation (ASPE). Jennifer Baxter was the IEc project director and Mathematica Policy Research was the prime contractor. In addition to Amber Jessup, Aaron Kearsley, and Scott Douglas, we thank Trinidad Beleche and Steve Murphy (ASPE) as well as Elizabeth Buck, Emily Galloway, Elizabeth Quin, and Kevin Wood (U.S. Food and Drug Administration) for providing substantial useful information and helpful comments.

As is the case with the 2016 *Guidelines*, this appendix represents HHS's current thinking on the conduct of regulatory impact analysis. It does not establish any requirements for any person and is not binding on HHS, any HHS agencies, or the public. Analysts may use an alternative approach if it satisfies the requirements of the applicable executive orders, statutes, and regulations. To discuss an alternative approach, please contact the HHS Office of the Assistant Secretary for Planning and Evaluation.

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Appendix D:
Updating Value per Statistical Life Estimates

In 2016, the U.S. Department of Health and Human Services (HHS) issued its *Guidelines for Regulatory Impact Analysis* (hereafter *Guidelines*) under the leadership of its Assistant Secretary for Planning and Evaluation (ASPE) and Analytics Team. In Chapter 3, "Assess Benefits," the *Guidelines* discuss the approach used to value mortality risk reductions, commonly referred to as the value per statistical life (VSL). In addition, that chapter discusses the approach used to value morbidity risk reductions, noting that at times a constant value per quality-adjusted life year (QALY) estimate is used in developing these estimates. That constant value per QALY also should be used in sensitivity analysis when valuing mortality risk reductions, if regulation largely affects the very young or the very old.

The *Guidelines* recommend low, central, and high VSL estimates for application in HHS regulatory impact analyses, which are used to derive recommended low, central, and high value per QALY estimates. As noted in the *Guidelines*, both the VSL and the value per QALY estimates should be updated annually to reflect the effects of inflation and changes in real income.

After providing background information, this appendix describes the process for updating these values, reports the estimates in 2020 dollars, and illustrates their application. It is intended to aid analysts and stakeholders in understanding the calculations and the results. Analysts may also wish to incorporate extracts from this appendix into the documentation for individual regulatory analyses. ASPE has created an Excel workbook that can be used to explore the calculations in more detail and to update these values, which is available upon request.

D.1 Background

The aim of the HHS *Guidelines* is to aid analysts in assessing the impacts of proposed and final regulations as required under Executive Order 12866 (Clinton 1993) and Executive Order 13563 (Obama 2011). The HHS *Guidelines* build on guidance issued by the U.S. Office of Management and Budget (OMB) in *Circular A-4* (OMB 2003).

As discussed in *Guidelines* Chapter 3, in benefit-cost analysis the value of an improvement, such as a decrease in the risk of dying or becoming ill, is based on individual willingness to pay (WTP). In other words, the value is derived from how much money affected individuals would exchange for the risk reduction they would achieve, given their budget constraints and preferences for spending on other goods and services.

These WTP estimates are typically converted to VSL estimates when valuing expected changes in the number of deaths. The VSL terminology is frequently misinterpreted, however. VSL is not the value that the analyst, the researcher, or the government places on saving an individual from certain death. Rather it reflects research on the extent to which individuals are each willing to exchange money for small changes in their own risks within a defined time period. We make such decisions frequently in our day-to-day lives, for example by choosing a safer job or purchasing a safer car.

If on average a member of the U.S. population is willing to pay $1,000 for a 1 in 10,000 reduction in their own risk in a given year, the equivalent VSL can be calculated by dividing individual WTP by the risk change:

$1,000 WTP ÷ 1/10,000 risk change
= $10.0 million VSL

In other words, 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 also can be summed across those affected. If each of 10,000 individuals is willing to pay $1,000 for a 1 in 10,000 reduction in his or her chance of dying in a given year, the total expected value of that risk reduction is $10 million (10,000 x $1,000) and one less person would be expected to die that year (10,000 x 1/10,000).

The conceptual framework for valuing nonfatal illnesses or injuries is the same as the framework for fatalities. Estimates of WTP for a change in morbidity risk are converted into estimates of the value per statistical case, using the same approach.

For valuing changes in expected deaths, the *Guidelines* recommend low, central, and high VSL estimates. For valuing changes in expected cases of nonfatal illness, it is not possible to recommend estimates for each possible type of illness. These policies potentially affect a wide range of nonfatal health conditions that vary in severity, duration, and other characteristics.

The *Guidelines* instead provide a framework for estimating these values. Analysts should first review the literature to determine whether suitable WTP estimates of reasonable quality are available for the morbidity risk reductions of concern. If not, the *Guidelines* recommend that analysts use monetized quality-adjusted life years (QALYs) as a proxy. In this case, a constant value per QALY is multiplied by the expected change in health-related quality of life (HRQL) to estimate the value per statistical case.

This constant value per QALY is derived from HHS' recommended VSL estimates.[1] Its derivation assumes that VSL reflects the present value of future life years for the average individual included in the underlying studies, adjusting for the expected quality of life at each age.[2] This constant value per QALY can also be used in sensitivity analysis to value changes in life expectancy when mortality risk reductions disproportionately affect the very young or the very old, as discussed in more detail in *Guidelines* Chapter 3.

[1] Regardless of whether WTP or monetized QALY estimates are used for valuation, costs that are not included in these estimates can be added to reflect the total impact of the health condition on social welfare. These costs may include, for example, medical costs covered by insurance and caregiving provided by friends and family. See *Guidelines* Chapter 3 for more discussion.

[2] As discussed in *Guidelines* Chapter 3, this approach relies on several simplifying assumptions. The *Guidelines* explore these assumptions in more detail, including their relationship to theoretical expectations and empirical research.

Both the VSL estimates and the value per QALY derived from these estimates should be updated each year for inflation and real income growth. We discuss the steps involved in this calculation and report the values in 2020 dollars in the following sections, then illustrate their application.

D.2 Adjusting Estimates for Inflation and Changes in Real Income

To estimate VSL, HHS currently relies on the results of a criteria-driven review reported in Robinson and Hammitt (2016). That review provides population-average values in 2013 dollars at 2013 income levels, which range from $4.2 million to $13.7 million with a mid-point of $9.0 million. HHS uses these values as the basis of its low, high, and central VSL estimates respectively.

Applying these VSL estimates in HHS regulatory impact analysis requires updating them for inflation and for changes in real income. The inflation adjustment reflects economy-wide changes in prices; i.e., changes in the total amount of goods and services a dollar can buy (see *Guidelines* Chapter 5). In contrast, the adjustment for real income reflects the changes in the resources individuals have available to spend on risk reductions and other goods and services. If real income increases, individual WTP per unit of risk reduction and hence the VSL are also expected to increase.

As discussed in Guidelines *Chapter 3*, HHS assumes that VSL increases at the same rate as real income, i.e., that VSL income elasticity is 1.0. This means, for example, that VSL would increase 5 percent if income increases 5 percent.

Presumably, an individual's WTP for mortality risk reductions reflects their current and expected future income as of the year in which the payment would be made, including their ability to borrow, preferences for saving and spending, and current and future expected needs.[3] The idea is similar to how we might think about any current or future purchase. For example, if I want to buy a new car five years hence rather than today, presumably I would consider whether my income as well as other factors will differ then from current levels.

Guidelines Chapter 5 indicates that VSL estimates should first be adjusted for inflation to the dollar year used in the regulatory analysis as well as for changes in real income. Because the annual data needed for these adjustments are not available until after the end of the calendar year, analysts rely on estimates from the year prior to the year in which the analysis is conducted or earlier. This means, for example, that 2020 is likely to be used as the dollar year for an analysis initiated in the year 2021.

Guidelines Chapter 2 notes that regulatory analyses typically predict impacts over 10 to 20 years unless the regulation has an earlier sunset date. To avoid the need to estimate future inflation, *Guidelines* Chapter 5 indicates that the same dollar year should be used throughout the analysis. In other words, if

[3] Ideally, the VSL income adjustment would be based on lifetime wealth rather than current earnings and would consider all income sources. The VSL studies from which the base values and income elasticities are derived generally focus on earnings rather than wealth or total income, however, because earnings are more easily measured. Thus the income adjustment discussed in this appendix also uses earnings in the calculations.

2020 is the dollar year, and the analysis predicts impacts from 2023 through 2032, impacts in each year would be expressed in 2020 dollars.

The base year usually differs from this dollar year. The base year is the year in which regulatory impacts are likely to first accrue. In most cases, it will be the year in which the regulation goes into effect. In some cases, the base year may be earlier if regulated entities begin compliance activities in advance; in other cases, it may be later if regulated entities can defer compliance.

The base year is used when calculating present values. To continue the example, an analysis conducted in 2021 may use 2020 as the dollar year and 2023 as the base year when calculating present values, assuming 2023 is when the regulatory requirements first apply.

This means the VSL estimates should be updated to the appropriate dollar year (2020 in this example). That value would not be subsequently adjusted for predicted inflation (over the 2020 to 2032 time period in the example). The VSL estimates should be adjusted for predicted subsequent changes in real income in most cases, however. As noted earlier, presumably an individual's WTP for risk reductions reflects his or her expected income as of the year in which the payment is made. In other words, the VSL estimates applied in the year 2032 would be expressed in 2020 dollars but would be adjusted for expected changes in real income between 2020 and 2032.

In some cases, this adjustment for future changes in real income may be too small to noticeably affect the analytic results, given that real income grows at a relatively small rate (typically between 1 and 2 percent per year). If the effect of adjusting for future changes in real income beyond the base year is negligible, analysts may choose to not make this adjustment to simplify the presentation. Continuing the above example, in such cases the VSL for 2023 base year would be used in future years.

Note that at times the change in risk does not occur in the same year that the costs accrue; e.g., if actions taken to reduce exposure do not manifest as changes in risk until several years in the future. To estimate the effects of this delay on individual WTP, discounting is used to account for the timing of the risk reductions, applying the same discount rates as used elsewhere in the analysis. This adjustment is discussed in more detail in section D.4.

Once VSL estimates are calculated for the appropriate year, a constant value per QALY can be derived for use in estimating the value of morbidity risk reductions and in sensitivity analysis of the value of mortality risk reductions, as discussed earlier. The resulting adjustments thus include two major components.

1. Update the low, central, and high VSL estimates.
2. Derive low, central, and high constant value per QALY estimates.

We describe each step below, using 2020 as the dollar year and assuming the analysis predicts impacts through the year 2032 as an example. The subsequent sections provide the results and examples of their application.

D.2.1 Update the low, central, and high VSL estimates

We first adjust the VSL estimates to the specified dollar year (step 1a), accounting for past inflation and changes in real income. We then adjust the VSL estimates for future years (step 1b), accounting for predicted changes in real income.

Step 1a: Adjust VSL estimates to the specified dollar year. Figure D.1 provides the equation for updating the low, central, and high VSL estimates to the appropriate dollar year.[4]

Figure D.1. Step 1a, Adjust VSL estimates to the specified dollar year

$$VSL_{(year\ y)} = VSL_{(year\ x)} * (inflation\ index_{(year\ y)} / inflation\ index_{(year\ x)}) * (real\ income_{(year\ y)} / real\ income_{(year\ x)})^{elasticity} \quad (equation\ 1)$$

Where:

- $VSL_{(year\ y)}$ = the value of mortality risk reductions in the specified dollar year (e.g., 2020).
- $VSL_{(year\ x)}$ = the value of mortality risk reductions in the reference year (2013, from Robinson and Hammitt 2016).
- Inflation index = Consumer Price Index for All Urban Consumers (CPI-U).[5]
- Real income = Current Population Survey (CPS) data on weekly earnings.[6]
- Income elasticity = the proportional change in VSL given a change in income, 1.0 from Chapter 3 of the HHS *Guidelines*.[7]

Step 1b: Adjust VSL estimates for future changes in real income. The low, central, and high VSL estimates derived under Step 1a can then be adjusted for changes in real income in future years. For this step, the inflation adjustment drops out of the equation. The source of the income data is different in this case because predicted rather than actual values are needed.

[4] For consistency with the underlying data sources, in equation 1 we express inflation and the change in real income as ratios. The HHS *Guidelines* instead express these changes as annual rates, as in equation 2.

[5] For more information on the CPI, see https://www.bls.gov/cpi/.

[6] For more information on the CPS, see https://www.census.gov/programs-surveys/cps.html.

[7] Because an income elasticity of 1.0 means that VSL changes at the same rate as income, the elasticity can be dropped out of the equation. However, we include it here to clarify the relationship to the *Guidelines* and to the VSL literature more generally.

Figure D.2. Step 1b, Adjust VSL estimates for future changes in real income

$$VSL_{(year\ z)} = VSL_{(year\ y)} * (1+real\ income\ growth\ rate)^{elasticity*(z-y)}$$

(equation 2)

Where:

- $VSL_{(year\ z)}$ = the value of mortality risk reductions in a future year (e.g., 2023).
- $VSL_{(year\ y)}$ = the value of mortality risk reductions in the specified dollar year (e.g., 2020).
- Real income growth rate = predicted annual rate from the Congressional Budget Office (CBO) long-term growth forecast.[8]
- Income elasticity = the proportional change in VSL given a change in income, 1.0 from *Guidelines* Chapter 3.

The resulting estimates can then be used to value mortality risk reductions in each year. This calculation involves multiplying the expected change in deaths in each year by the appropriate VSL, as illustrated in section D.4.

D.2.2 Derive low, central, and high constant value per QALY estimates

We next derive constant value per QALY estimates from the VSL estimates for the specified dollar year (step 2a), based on the VSL estimates from Step 1a. We then adjust these estimates for future years to account for predicted changes in real income (step 2b), based on the VSL estimates from Step 1b.

Step 2a: Derive constant value per QALY estimates for the specified dollar year. The VSL estimates can then be converted to low, central, and high constant values per QALY. Based on data reported in the studies used to develop the VSL estimates, analysts should assume that the average individual in the VSL studies is 40 years of age. Estimating expected QALYs requires combining data on conditional survival rates for each subsequent year of age with data on health-related quality of life (HRQL) at each age. Expected QALYs are then discounted to their present value using the same discount rates as applied elsewhere in the analysis (3 percent and 7 percent, as discussed in *Guidelines* Chapter 5).[9]

[8] CBO publications are available here: https://www.cbo.gov/data/publications-with-data-files.

[9] Throughout this appendix, we do not discount impacts that occur in the initial year.

Figure D.3. Step 2a, Derive constant value per QALY estimates for the specified dollar year

$$vQALY_{(year\ y)} = \frac{VSL_{(year\ y)}}{\sum PV(survival\ rate_{(age\ a)} * HRQL_{(age\ a)})}$$

(equation 3)

Where:

- $VSL_{(year\ y)}$ = the value of mortality risk reductions in the specified dollar year (e.g., 2020).
- $vQALY(_{year\ y)}$ = the constant value per QALY in the specified dollar year (e.g., 2020).
- PV = present value, using an annual real discount rate of 3 or 7 percent.
- Survival $rate_{(age\ a)}$ = likelihood of survival conditional on reaching each year of age from age 40 onwards, from Centers for Disease Control and Prevention (CDC) life tables.[10]
- $HRQL_{(age\ a)}$ = health-related quality of life by year of age, for men and women combined, from Hanmer et al. (2006), Table 3, U.S. EQ-5D estimates.

Step 2b: Adjust the value per QALY estimates for future changes in real income. The low, central, and high value per QALY estimates derived under Step 2a can then be adjusted for changes in real income in future years (e.g., subsequent to the year 2020). With the exception of the data on future income, the inputs into the calculations are the same as under step 2a. Analysts should use the same survival rates and HRQL estimates in all years. This means the value per QALY will grow at the same rate as the VSL; the estimate of future QALYs for an individual age 40 will not change from year to year.

As a result, the constant value per QALY can be most easily updated by dividing the VSL for each year (from step 1b) by this estimate of future QALYs, discounted using the same rates. The equation is provided in Figure D.4; it is identical to the equation in Figure D.3 except for the change in year.

Figure D.4. Step 2b, Adjust the value per QALY estimates for future changes in real income

$$vQALY_{(year\ z)} = \frac{VSL_{(year\ z)}}{\sum PV(survival\ rate_{(age\ a)} * HRQL_{(age\ a)})}$$

(equation 4)

Where:

- $VSL_{(year\ z)}$ = the value of mortality risk reductions in a future year (e.g., 2032).
- $vQALY_{(year\ z)}$ = the constant value per QALY in a future year (e.g., 2032).
- PV = present value, using an annual real discount rate of 3 or 7 percent.
- Survival $rate_{(age\ a)}$ = likelihood of survival conditional on reaching each year of age from age 40 onwards, from Centers for Disease Control and Prevention (CDC) life tables.
- HRQL = health-related quality of life by year of age, for men and women combined, from Hanmer et al. (2006), Table 3, U.S. EQ-5D estimates.

These constants can then be multiplied by the expected change in QALYs to estimate the value per statistical case for cases of nonfatal illnesses (or injuries), where the expected change in QALYs is equal to the change in HRQL associated with the illness multiplied by its duration. They can also be used be

[10] For more information on CDC's life tables, see https://www.cdc.gov/nchs/nvss/life-expectancy.htm#publications.

used in sensitivity analysis to value changes in life expectancy when mortality risk reductions disproportionately affect the very young or the very old, as discussed in more detail in *Guidelines* Chapter 3 and illustrated below in Section D.4.

D.3 Estimates in 2020 Dollars

In this section, we report the results of applying these steps in 2020 dollars. For ease of presentation, we round the results. Analysts may wish to use the unrounded values in their calculations, which can be easily copied from the Excel workbook developed by ASPE.

D.3.1 VSL estimates in 2020 dollars

Step 1a: Adjust VSL estimates to the specified dollar year. For this calculation, we apply equation 1 from Figure D.1 to estimate VSL in 2020 dollars at 2020 income levels. As reported in Table D.1, the input data include the following.

- The VSL in the reference year (2013) includes low, central, and high estimates of $4.2 million, $9.0 million, and $13.7 million.
- The CPI-U increased from 232.957 in 2013 to 258.811 in 2020, about a 1.11 percent increase.[11]
- The CPS indicates that real earnings increased from about $333 to $380 per week between 2013 and 2020, a 14.1 percent increase.[12]
- VSL income elasticity is 1.0.

Using these input values, the 2020 VSL estimates range from $5.3 million to $17.4 million, with a central estimate of $11.4 million. These estimates can be applied to mortality risk reductions that occur in 2020 without further adjustment.

Table D.1. VSL estimates updated for inflation and real income growth from 2013 to 2020[a]

VSL	2013 estimate (2013 dollars)[b]	2020 estimate (2020 dollars)
Low	$4.2 million	$5.3 million
Central	$9.0 million	$11.4 million
High	$13.7 million	$17.4 million

a. All calculations use the same number of significant digits as reported in the source data but are rounded for presentation purposes.
b. From Robinson and Hammitt (2016)

Step 1b: Adjust VSL estimates for future changes in real income. For changes in mortality risks expected to occur in subsequent years, we use equation 2 in Figure D.2 to adjust for predicted changes in real income. We assume real income will grow by 0.8 percent per year, based on the CBO (2021) estimate of the growth in real earnings per worker for the period 2021-2051. Because we assume VSL income elasticity is 1.0, the change in the VSL is the same as the change in income: a 0.8 percent increase per

[11] CPI-U reported annual values downloaded from https://www.bls.gov/cpi/data.htm using the "one screen data search" option on April 1, 2021, series CUUR0000SA0,CUUS0000SA0.
[12] CPS data downloaded from https://www.bls.gov/webapps/legacy/cpswktab2.htm on April 1, 2021, series LEU0252881600.

year. The estimate for the appropriate year can then be applied to the expected change in deaths occurring in that year. Table D.2 presents yearly VSL estimates for the 2020 to 2049 time period in 2020 dollars.

Table D.2. VSL estimates for changes in mortality risks occurring in 2020 through 2049 (2020 dollars)[a,b]

Year	Low VSL Estimate	Central VSL Estimate	High VSL Estimate
2020	$5.3 million	$11.4 million	$17.4 million
2021	$5.4 million	$11.5 million	$17.5 million
2022	$5.4 million	$11.6 million	$17.6 million
2023	$5.5 million	$11.7 million	$17.8 million
2024	$5.5 million	$11.8 million	$17.9 million
2025	$5.5 million	$11.9 million	$18.1 million
2026	$5.6 million	$12.0 million	$18.2 million
2027	$5.6 million	$12.1 million	$18.4 million
2028	$5.7 million	$12.2 million	$18.5 million
2029	$5.7 million	$12.3 million	$18.7 million
2030	$5.8 million	$12.4 million	$18.8 million
2031	$5.8 million	$12.5 million	$19.0 million
2032	$5.9 million	$12.6 million	$19.1 million
2033	$5.9 million	$12.7 million	$19.3 million
2034	$6.0 million	$12.8 million	$19.4 million
2035	$6.0 million	$12.9 million	$19.6 million
2036	$6.0 million	$13.0 million	$19.7 million
2037	$6.1 million	$13.1 million	$19.9 million
2038	$6.1 million	$13.2 million	$20.0 million
2039	$6.2 million	$13.3 million	$20.2 million
2040	$6.2 million	$13.4 million	$20.4 million
2041	$6.3 million	$13.5 million	$20.5 million
2042	$6.3 million	$13.6 million	$20.7 million
2043	$6.4 million	$13.7 million	$20.9 million
2044	$6.4 million	$13.8 million	$21.0 million
2045	$6.5 million	$13.9 million	$21.2 million
2046	$6.6 million	$14.0 million	$21.4 million
2047	$6.6 million	$14.3 million	$21.5 million
2048	$6.7 million	$14.4 million	$21.7 million
2049	$6.7 million	$14.4 million	$21.9 million

a. All calculations use the same number of significant digits as reported in the source data but are rounded for presentation purposes.
b. 2020 VSL estimates From Table D.1; 2021 to 2049 estimates reflect 0.8 percent increase in real income per year, based on CBO (2021).

D.3.2 Constant value per QALY estimates in 2020 dollars

Step 2a: Derive a constant value per QALY for the specified dollar year. To derive a constant value per QALY for the appropriate dollar year, we apply equation 3 from Figure D.3 to VSL estimates for that year. As noted earlier, this process requires incorporating estimates of population-average survival rates and HRQL conditional on year of age. We use the most recent life tables from CDC (Arias and Xu 2020) to estimate survival rates and Hanmer et al. (2006) to estimate HRQL for each year of age. We apply the same discount rates as used elsewhere in the analysis to estimate the present value of future QALYs; i.e., 3 percent and 7 percent.[13]

Using a 3 percent discount rate, the present value of future QALYs on average for an individual age 40 is 19.6 QALYs; using a 7 percent rate, the present value of future QALYs on average for an individual age 40 is 11.8 QALYs.[14]

Table D.3 presents the results for 2020. These values should be used when estimating the value of impacts that occur in that year as appropriate; i.e., when monetized QALYs are used to value morbidity risk reductions and when sensitivity analysis is needed to address mortality risk reductions that disproportionately affect the very young or the very old.[15]

Table D.3. Value per QALY estimates for impacts occurring in 2020 (2020 dollars)[a]

	VSL Estimate[b]	Value per QALY[c] 3 percent discount rate	Value per QALY[c] 7 percent discount rate
Low	$5.3 million	$270,000	$450,000
Central	$11.4 million	$580,000	$970,000
High	$17.4 million	$880,000	$1,470,000

a. All calculations use the same number of significant digits as reported in the source data but are rounded for presentation purposes.
b. VSL estimates from Table D.1.
c. Calculated based on the present value of future QALYs on average for an individual age 40; 19.6 QALYs using a 3 percent discount rate, and 11.8 QALYs using a 7 percent discount rate, based on Arias and Xu (2020) and Hanmer et al. (2006).

Step 2b: Adjust the value per QALY estimates for future changes in real income. For subsequent years, we use equation 4 from Figure D.4 to adjust the value per QALY for predicted growth in real income, dividing the VSL estimates for each year by the expected QALYs: 19.6 QALYs at a 3 percent discount rate or 11.8 QALYs at a 7 percent rate.

Because we again assume real income will grow by 0.8 percent per year and apply a VSL income elasticity of 1.0, the change in the constant value per QALY is the same as the change in income: 0.8

[13] The rationale for discounting to reflect time preferences is discussed in more detail in *Guidelines* Chapter 5.

[14] Results rounded for presentation purposes; unrounded results are used in all calculations.

[15] When an effect that would occur in a given year (i.e., 2020 in this case) impacts future year health (or longevity), the future year impacts should be discounted to the year in which the effect occurs. For example, if a regulation is expected to avert 10 cases of a chronic disease in the year 2023, and that disease is expected to impair the health of each affected individual for the subsequent 40 years, the present value of these future effects over the 40 year period would be discounted to year 2023 when estimating the value per case.

percent per year. The tables below present yearly values in 2020 dollars; Table D.4a reports the results using a 3 percent discount rate and Table D.4b reports the results using a 7 percent discount rate. The estimate for the appropriate year can then be applied when monetized QALYs are used to value morbidity risk reductions and when sensitivity analysis is needed to address mortality risk reductions that disproportionately affect the very young or the very old.

Table D.4a. Value per QALY estimates for risk changes occurring in 2020 through 2049 (2020 dollars, 3 percent discount rate)[a]

Year	Value per QALY Low (3 percent discount rate)	Value per QALY Central (3 percent discount rate)	Value per QALY High (3 percent discount rate)
2020	$270,000	$580,000	$880,000
2021	$270,000	$590,000	$890,000
2022	$280,000	$590,000	$900,000
2023	$280,000	$590,000	$910,000
2024	$280,000	$600,000	$910,000
2025	$280,000	$600,000	$920,000
2026	$280,000	$610,000	$930,000
2027	$290,000	$610,000	$930,000
2028	$290,000	$620,000	$940,000
2029	$290,000	$620,000	$950,000
2030	$290,000	$630,000	$960,000
2031	$300,000	$630,000	$970,000
2032	$300,000	$640,000	$970,000
2033	$300,000	$640,000	$980,000
2034	$300,000	$650,000	$990,000
2035	$310,000	$650,000	$1,000,000
2036	$310,000	$660,000	$1,000,000
2037	$310,000	$670,000	$1,010,000
2038	$310,000	$670,000	$1,020,000
2039	$320,000	$680,000	$1,030,000
2040	$320,000	$680,000	$1,040,000
2041	$320,000	$690,000	$1,050,000
2042	$320,000	$690,000	$1,050,000
2043	$330,000	$700,000	$1,060,000
2044	$330,000	$700,000	$1,070,000
2045	$330,000	$710,000	$1,080,000
2046	$330,000	$710,000	$1,090,000
2047	$340,000	$720,000	$1,100,000
2048	$340,000	$730,000	$1,110,000
2049	$340,000	$730,000	$1,110,000

a. All calculations use the same number of significant digits as reported in the source data but are rounded for presentation purposes.

b. 2020 value per QALY estimates from Table D.2; 2021 to 2049 estimates reflect 0.8 percent change in income per year, based on CBO (2021).

Table D.4b. Value per QALY estimates for risk changes occurring in 2020 through 2049 (2020 dollars, 7 percent discount rate)[a]

Year	Value per QALY Low (7 percent discount rate)	Value per QALY Central (7 percent discount rate)	Value per QALY High (7 percent discount rate)
2020	$450,000	$970,000	$1,470,000
2021	$450,000	$970,000	$1,480,000
2022	$460,000	$980,000	$1,500,000
2023	$460,000	$990,000	$1,510,000
2024	$470,000	$1,000,000	$1,520,000
2025	$470,000	$1,010,000	$1,530,000
2026	$470,000	$1,010,000	$1,540,000
2027	$480,000	$1,020,000	$1,560,000
2028	$480,000	$1,030,000	$1,570,000
2029	$480,000	$1,040,000	$1,580,000
2030	$490,000	$1,050,000	$1,590,000
2031	$490,000	$1,060,000	$1,610,000
2032	$500,000	$1,060,000	$1,620,000
2033	$500,000	$1,070,000	$1,630,000
2034	$500,000	$1,080,000	$1,650,000
2035	$510,000	$1,090,000	$1,660,000
2036	$510,000	$1,100,000	$1,670,000
2037	$520,000	$1,110,000	$1,690,000
2038	$520,000	$1,120,000	$1,700,000
2039	$520,000	$1,120,000	$1,710,000
2040	$530,000	$1,130,000	$1,730,000
2041	$530,000	$1,140,000	$1,740,000
2042	$540,000	$1,150,000	$1,750,000
2043	$540,000	$1,160,000	$1,770,000
2044	$550,000	$1,170,000	$1,780,000
2045	$550,000	$1,180,000	$1,800,000
2046	$560,000	$1,190,000	$1,810,000
2047	$560,000	$1,200,000	$1,820,000
2048	$560,000	$1,210,000	$1,840,000
2049	$570,000	$1,220,000	$1,850,000

a. All calculations use the same number of significant digits as reported in the source data but are rounded for presentation purposes.
b. 2020 value per QALY estimates from Table D.2; 2021 to 2049 estimates reflect 0.8 percent change in income per year, based on CBO (2021).

D.4 Examples of Application

In this section, we provide examples of the application of the values derived in Section D.3 above. For simplicity, in these calculations we focus on the central values provided in Tables D.1 through D.4, applying a 3 percent discount rate where relevant. In addition, analysts should test the sensitivity of the results to the low and high values provided in those tables and present the results using a 7 percent discount rate (see *Guidelines* Chapters 5 and 8).[16] The final example includes a table that can be used to summarize the results using the full range of parameter estimates.

An important issue throughout these examples is the need to identify the year for which the values are being estimated. In the previous section, we report values for risk reductions that occur in the designated year. In this section, we include examples that adjust these values to approximate the effect of selected characteristics of the risk change. The VSL used as the basis of these adjustments should be the estimate for the year for which WTP is being estimated (conceptually, the year in which the payment would be made), reflecting expected real income in that year. This year is presumably the same year that the regulatory costs associated with the risk change are incurred. In the examples, we use the term "analytic year" to refer to the year in which the costs and benefits accrue.

These examples are not intended to be comprehensive; different regulations will pose different challenges. Analysts should consult with ASPE and other experts in determining how to best apply these estimates within a particular context. As noted earlier, ASPE has developed an Excel workbook to aid in the calculations of the estimates reported previously in section D.3, which is available upon request. That workbook also includes data that can be used as inputs into the calculations described below; however, these calculations generally require developing a supplementary worksheet tailored to the particular context.

In these examples, we assume the regulation will become effective in 2023 and remain in effect for five years; the analysis therefore covers 2023 through 2027, and 2023 is the base year for estimating present values.[17] We use the term "analytic year" to reference the year in which the impacts accrue; 2023 through 2027 in the example. All values are reported in 2020 dollars. As in the preceding tables, we use unrounded values in the calculations but present rounded values for ease of presentation and interpretation.

1. Mortality risk reductions, base case: In this case, we assume that the regulation reduces the number of expected deaths by 100 in each year. The calculations are straightforward. We simply multiply the number of cases in each year by the VSL for that year. We then calculate the present value as of the base year (2023) using a 3 percent discount rate.

[16] The implementation of this sensitivity analysis will depend on the context, including the extent to which uncertainty in the estimates of the change in expected deaths and cases of illness are quantified and the importance of the VSL estimates to the overall results (e.g., in determining whether net benefits are positive). *Guidelines* Chapter 6 discusses the assessment of uncertainty in more detail.

[17] As noted earlier, we do not discount impacts that occur in the initial year.

Table D.5. Example, Mortality risk reductions, base case (2020 dollars)

Analytic Year	Deaths Averted	VSL, Analytic Year[a]	Total Value[b]
2023	100	$11.7 million	$1.17 billion
2024	100	$11.8 million	$1.18 billion
2025	100	$11.9 million	$1.19 billion
2026	100	$12.0 million	$1.20 billion
2027	100	$12.1 million	$1.21 billion
Total	**500**	**Net present value**[c]	**$5.60 billion**

a. VSL central estimates (see Table 2); all calculations based on unrounded values then rounded for presentation purposes.
b. VSL estimate for analytic year multiplied by deaths averted.
c. 3 percent discount rate.

2. Mortality risk reductions, cessation lag. In this example, we again assume that, in each year of implementation, the regulation reduces the number of expected deaths by 100. However, we assume there is a significant delay between when the costs are incurred and when the risk reduction becomes manifest, as is the case with latent illnesses such as many cancers. Analysts should not necessarily assume that the latency period (the lag between increased exposure and increased deaths or illnesses) is the same as the cessation lag (the lag between decreased exposure and decreased deaths or illnesses); these lags may differ in some cases.

We use discounting in this context to reflect time preferences; generally individuals prefer to receive benefits sooner rather than later so are willing to pay less for improvements that accrue in the future. This means individual preferences for spending in the current year to reduce risks in the same year are likely to differ from preferences for spending in the current year to reduce risks in the future. The empirical evidence on individual WTP for future risk reductions is limited and inconsistent, however. Discounting is simply used to approximate the effects of this time lag.

This is a different adjustment than the adjustments for changes in real income that are the focus of the previous sections. The idea in this case is that regulatory costs incurred in a designated year lead to a risk change sometime in the future. The adjustment for changes in real income discussed earlier instead assumes that both the costs and the risk change occur in the same future year. This means that for the cessation lag, we use the VSL estimate for the year in which the costs would be incurred.

To illustrate, in the previous example we apply a VSL of $11.7 million for the risk changes that occur in 2023, assuming that the risk changes result from the costs incurred in that year.[18] If instead there is a three-year lag between when the costs are incurred and when the risk change manifests, we would still use a VSL estimate of $11.7 million but would discount it to reflect the three-year delay.

[18] In reality, the risk reductions may not all accrue within the same year that the associated costs are incurred; e.g., some may accrue in the following year especially in cases where the death results from illness rather than injury. This type of short lag is difficult to estimate and not likely to noticeably affect the analytic results, however. The cessation lag adjustment is intended for application in those cases where the scientific evidence suggests that the lag period is likely to be relatively long; i.e., measured in years rather than in days, weeks, or months.

This calculation involves estimating the present value in 2023 of a future payment of $11.7 million in 2026.[19] In other words, the income levels in 2023, not 2026, are relevant to calculating the value, since 2023 is when the payment would be made. Again, the idea is simply to use discounting to approximate the reduction in value associated with the delay in when the risk reduction accrues.

We illustrate the results in Table D.6 below assuming a three-year cessation lag. We use the term "analytic year" to refer to the year in which the costs are incurred and the term "VSL, with cessation lag" to reflect the effects of discounting the VSL estimate for that year to reflect the three-year lag.[20] The "deaths averted" column thus reflects the change in expected deaths three years in the future. We then multiply the number of cases in each year by the VSL estimate adjusted for cessation lag in that year to estimate the total value. We again calculate the present value as of the base year (2023), using a 3 percent discount rate throughout.

Table D.6. Example, Mortality Risk Reductions, 3-year cessation lag (2020 dollars)[a]

Analytic Year[b]	Deaths Averted[c]	VSL, with cessation lag[d]	Total Value[e]
2023	100	$10.7 million	$1.07 billion
2024	100	$10.8 million	$1.08 billion
2025	100	$10.9 million	$1.09 billion
2026	100	$11.0 million	$1.10 billion
2027	100	$11.0 million	$1.11 billion
Total	**500**	**Net present value**	**$5.12 billion**

a. All results reported using a 3 percent discount rate; calculations based on unrounded values then rounded for presentation purposes.
b. The analytic year is the year in which costs are incurred.
c. The deaths averted are the expected changes in deaths associated with the analytic year. In the example, this expected change in deaths would occur three years in the future.
d. The VSL for the analytic year (see Table D.2) discounted over the three-year lag period at a 3 percent discount rate; see text for more discussion.
e. VSL estimate with cessation lag multiplied by cases averted.

3. Mortality risk reductions, sensitivity analysis for age differences. In this example, we again assume that the regulation reduces the number of expected deaths by 100 in each year. However, we assume that the deaths are disproportionately among the elderly in this case. For simplicity, we assume that those affected are all age 75. In reality, the deaths are likely to be distributed over a range of ages and this full distribution of age-specific values should be used in the analysis.

As noted earlier, we assume that the average age that underlies the population-average VSLs (reported in Tables D.1 and D.2) is 40. In this example, our goal is to estimate VSL instead for an individual age 75. These calculations require estimating expected future QALYs per statistical case at the age affected (75 in the example), using the same data sources as used to derive the constant value per QALY in section

[19] Discounting is discussed in detail in *Guidelines* Chapter 5. ASPE has developed an Excel workbook for calculating discounted present values and annualized values that is available upon request and can be used to develop these estimates.

[20] Alternatively, discounting deaths averted rather than the VSL estimates over the same time period would lead to the same result. We discount the VSL estimates to emphasize the underlying concept; i.e., we expect that individual WTP for a future risk reduction will be less than individual WTP for a current risk reduction due to time preferences.

D.3.[21] We then multiply the results by the constant value per QALY for the analytic year (see Table D.4), which leads to a VSL estimate adjusted for age.[22] We again calculate the present value as of the base year (2023) using a 3 percent discount rate.

Table D.7. Example, Mortality risk reductions, sensitivity analysis, age 75 (2020 dollars)[a]

Analytic Year	Deaths Averted	Expected Future QALYs, per case[b]	Value per QALY[c]	VSL, with age adjustment[d]	Total Value[e]
2023	100	7.94 QALYs	$590,000	$4.7 million	$0.47 billion
2024	100	7.94 QALYs	$600,000	$4.7 million	$0.47 billion
2025	100	7.94 QALYs	$600,000	$4.8 million	$0.48 billion
2026	100	7.94 QALYs	$610,000	$4.8 million	$0.48 billion
2027	100	7.94 QALYs	$610,000	$4.9 million	$0.49 billion
Total	**500**			**Net present value[F]**	$2.25 billion

a. All calculations based on unrounded values then rounded for presentation purposes.
b. Present value of future QALYs on average for an individual age 75 (3 percent discount rate), based on Arias and Xu (2020) and Hanmer et al. (2006).
c. Value per QALY in analytic year (see Table D.4).
d. Excepted future QALYs multiplied by the value per QALY.
e. VSL estimate with age adjustment multiplied by deaths averted.
f. 3 percent discount rate.

These estimates are rough proxies for the value individuals may place on small changes in their own risks given their age and hence should be reported only in sensitivity analysis. The relationship between VSL and age is uncertain due to gaps and inconsistencies in the underlying research, as discussed in the HHS *Guideline*s (Chapter 3) and Robinson and Hammitt (2016).

4. Morbidity risk reductions, using monetized QALYs. In this example, we instead focus on nonfatal illnesses assuming that monetized QALYs are used as a proxy for WTP. We assume that the regulation reduces expected cases by 50 in each year, and that each averted case leads to a gain of 0.2 QALYs in that year.

For simplicity, we assume that the duration of the averted case would be one year; cases of longer duration require discounting future impacts to the analytic year. In addition, we assume that the affected individuals would not die from another cause during that year. If baseline survival rates are likely to noticeably affect the results, analysts may use CDC's life tables (e.g., Arias and Xu 2020) to adjust for these effects. Furthermore, we assume that the average person affected is age 40; i.e., the same as in the VSL studies. In reality, the ages of those affected may differ and the QALY gain may vary by age, in which case these differences should be reflected in the analysis.

[21] If we performed these calculations instead for individuals age 40, the result would equal the VSL estimates in Table D.2, since the value per QALY calculations assume the average individual in the underlying studies is age 40.

[22] An alternative approach would be to calculate the present value of the total change in QALYs across all cases, then multiply by the value per QALY. We use deaths averted and report VSL estimates adjusted for age instead to emphasize that the intent is to test the sensitivity of the results to adjusting population-average VSL estimates for age.

Table D.8. Example, morbidity risk reductions (2020 dollars)[a]

Analytic Year	Nonfatal Cases Averted	Change in QALYs, per case[b]	Value per QALY[c]	Value per statistical case[d]	Total Value[e]
2023	50	0.2 QALYS	$590,000	$120,000	$5.9 million
2024	50	0.2 QALYS	$600,000	$120,000	$6.0 million
2025	50	0.2 QALYS	$600,000	$120,000	$6.0 million
2026	50	0.2 QALYS	$610,000	$120,000	$6.1 million
2027	50	0.2 QALYS	$610,000	$120,000	$6.1 million
Total	**250**			**Net present value[f]**	$28.3 million

a. All calculations based on unrounded values then rounded for presentation purposes.
b. Change in QALYs assumes one-year duration.
c. Value per QALY in analytic year from Table D.4.
d. The value per statistical case equals the change in QALYs multiplied by the value per QALY.
e. Value per statistical case multiplied by cases averted.
f. 3 percent discount rate

5. Summary Table. Once the calculations illustrated above are completed as relevant, the results should be summarized in a table for inclusion in the regulatory impact analysis document along with the supporting data and calculations. Table D.9 provides an example of such a table, including the results from Table D.5 and Table D.8 using a 3 percent discount rate. In this table, we express the results in billions of dollars for internal consistency.

Table D.9. Example, summary table, mortality and morbidity risk reductions (2020 dollars)[a]

Analytic Year	Deaths Averted	Nonfatal Cases Averted[b]	Total Value, Deaths Averted	Total Value, Nonfatal Cases Averted	Grand Total
2023	100	50	$1.17 billion	$0.006 billion	$1.17 billion
2024	100	50	$1.18 billion	$0.006 billion	$1.18 billion
2025	100	50	$1.19 billion	$0.006 billion	$1.19 billion
2026	100	50	$1.20 billion	$0.006 billion	$1.20 billion
2027	100	50	$1.21 billion	$0.006 billion	$1.21 billion
Total	**500**	**250**			
		Net present value (3 percent discount rate)	**$5.60 billion**	**$0.028 billion**	**$5.63 billion**

a. All calculations based on unrounded values then rounded for presentation purposes; see Tables D.5 and D.8 and related text for more detail.
c. In this example the illness is hypothetical; otherwise, the name of the illness would be included here.

A similar table, that reports the results using a 7 percent rate, should also be provided. In the latter case, the value of nonfatal risk reductions should be derived using the values per QALY calculated using the 7 percent rate (see Table D.4b), rather than the values using a 3 percent rate (see Table D.4a) which are applied in the example in Table D.8.

As discussed in Chapter 8 of the HHS *Guidelines*, the analysis must be clearly and comprehensively documented, describing the analytic approach and the results as well as the implications of uncertainties and nonquantified effects. This documentation should be written so that members of the lay public can understand the analysis and conclusions. It should also provide enough detail so that competent analysts could ideally reconstruct the analysis, or at least at minimum explore the implications of changing key assumptions.

To support these goals, analysts may wish to include some information from this appendix in the regulatory impact analysis document to aid in explaining the approach. This appendix may also be included in the rulemaking docket to provide more detailed information.

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