24. RANKING REGULATORY INVESTMENTS IN PUBLIC HEALTH [1]

An essential role of government is to protect citizens from risks to human health, safety and the environment. Since the nation does not possess enough resources to eliminate all risks, an important performance goal for government is to deploy risk-management resources in a way that achieves the greatest public health improvement for the resources available—that is the most "cost-effective" allocation of risk-management resources. In this chapter, we demonstrate how cost-effectiveness ratios can be used to compare the payoffs from different regulatory investments in public health. We also discuss the promise and limitations of the use of cost-effectiveness analysis to inform decisions at regulatory agencies.

Using Cost-Effectiveness Ratios to Construct League Tables

A widely used tool for ranking purposes is the "league table," first used by the English to rank their soccer teams by point standings and later to rank their schools by student achievement scores. More recently, league tables have been used to rank programs, technologies, regulations and therapies aimed at saving lives and improving public health. There is a significant academic literature on the use of league tables in public health that began in the 1960s and continues to grow. OMB believes that government and the public can benefit from the insights generated by league tables.

The OMB first published a league table with the Budget in 1992. In this table, 50 risk-reducing regulations were ranked using cost per life saved as the measure of investment performance. The information in that table was based on analyses by Federal agencies and others in the 1970s and 1980s. The monetary resources required to save one "statistical" life ranged from several hundred thousand dollars to billions of dollars.

In Table 24–1 below, OMB presents a league table of 10 risk-reducing regulations based on information developed by three Federal agencies (DOT, OSHA, and EPA) in the 1995 to 2000 period. Our purpose in presenting this table is to illustrate how cost-effectiveness analysis of public health has changed over the last decade and what technical and policy issues are raised by presentation of league tables. [2]

Table 24–1. COST PER LIFE-YEAR SAVED FOR TEN SELECTED REGULATIONS

Regulation	Health or Safety	Net Costs ($2001)	Life-years saved	Cost per life-year saved ($2001)
Petroleum Refining NESHAP (EPA)	Health	<0	<10 per year	<0
Powered Industrial Truck Operating Training (OSHA)	Safety	<0	146 per year	<0
Head Impact Protection (DOT)	Safety	$390 to $516 million per year	8,360 to 10,007 per year	$50,00 to $53,000
Reflective Devices for Heavy Trucks (DOT)	Safety	$65 million (PV)	946 (PV)	$69,000
Child Restraints (DOT)	Safety	$54 to $112 million per year	370 to 515 per year	$105,000 to $331,000
Rail Roadway Workers (DOT) [a]	Safety	$227 million (PV)	434 (PV)	$523,000
Interim Enhanced Surface Water Treatment (EPA) [b]	Health	<0 to $95 million per year	140 to 640 per year	<0 to $679,000
NOx SIP Call (EPA) [c]	Health	$1265 million in 2007	1590 to 3390 per year	$373,000 to $714,000
Methylene Chloride (OSHA) [d]	Health	$112 million per year	96 per year	$1.16 million
Stage I Disinfection By-Products (EPA) [e]	Health	<0 to $764 million per year	0 to 5130 per year	<0 to infinite

Note: Net costs were calculated by subtracting from compliance costs an estimate of any non-fatality benefits such as a reduction in injuries or morbidity. PV = Present Value.

[a] The estimate does not include possible increased capacity of rail lines and improved worker morale.

[b] The estimate doe not include reduced risks from the pathogens (in addition to cryptosporidiosis) and avoided costs of averting behavior from a well-publicized outbreak.

[c] The estimate does not include a variety of potential benefit categories including possible reductions in ozone-related mortality, acute and chronic respiratory damage, nitrogen deposition in estuarine and coastal waters, damage to ecosystems and vegetation.

[d] The estimate does not include a variety of potential adverse health effects including: cancers resulting from dermal contact, central nervous system effects, and eye, nose, etc. irritation.

[e] The estimate does not include possible reductions in colon and rectal cancer and possible reductions in adverse reproductive and developmental effects.

[1] This chapter is prepared pursuant to Section 624 of the Treasury and General Government Appropriations Act, 2001, also known as the "Regulatory Right to Know Act," Public Law 106–554 (Dec. 21, 2000).

[2] The technical details that support the information presented in Table 24–1, including ratios based on a "lives saved" metric, can be found at *www.whitehouse.gov/omb* under regulatory policy or upon request.

These ten rules, which are a non-random sample of risk-related rulemakings, were selected because the regulatory analyses provided sufficient information to prepare a cost-effectiveness ratio. Many agency rules, even those with a primary purpose of protecting public health, do not provide adequate information to construct a cost-effectiveness ratio. The estimates presented in the table are based on data and estimates provided by the agencies. Where the agencies did not provide estimates of life-years saved, we calculated life-years using standard assumptions about age and life expectancies. Each of the ten rules was reviewed by OMB under Executive Order 12866; five address health issues and five address safety issues.

Interestingly, the tendency for safety rules to be more cost-effective than health rules (see Table 24–1) is consistent with the insights from the early league tables published more than a decade ago. The table also illustrates a finding not evident from the earlier league tables. The range of cost-effectiveness estimates for specific rules varies substantially. For example, the cost per life-year saved for EPA's disinfection by-products rule ranges from less than zero to infinite. The table suggests that we need to do a better job at both refining estimates of the cost-effectiveness of regulatory proposals and setting priorities for the use of the nation's limited resources to protect citizens from health, safety, and environmental risks.[3]

Which Rules Should Be Compared?

In constructing a league table, many issues arise about which rules to include. League tables are most useful if based on information about potential or proposed rules, since the decision makers can consider reallocating resources to those rulemaking opportunities that rank the highest in cost-effectiveness. The challenge is ensuring that league tables are generated early enough in the decision making process to inform regulatory priorities.

When league tables include only recently adopted (final) rules, the utility for policy makers is reduced. Once the agency has adopted a rule, it is difficult to reverse course based on a ranking reported in a league table. Moreover, it may be infeasible for an agency to adopt "more" of a final rule that ranks highly in a league table. Nonetheless, league tables of adopted rules can provide insight into their relative payoffs, which can provide a rough perspective to evaluate future rules.

An intra-agency league table compares only those rules within the jurisdiction of a particular agency. This type of table is appropriate in certain budgetary contexts where only matters in the jurisdiction of a specific agency are subject to comparison, ranking, and decision making. An inter-agency league table, such as Table 24–1, is more useful for synoptic purposes or for decision making by governmental entities with inter-agency responsibility (e.g., appropriations committees and OMB).

Identifying a Performance Measure

Early league tables in the public health field used the number of lives saved (premature deaths averted) as the metric of effectiveness. This metric has been criticized on the grounds that lives are never really saved, only extended. The expected number of life-years saved was developed as an alternative and continues to be used in the academic literature. "Life-years" gives relatively more credit to rules that reduce mortality rates early in the lifespan and less weight to rules that reduce mortality rates late in the lifespan. Although it is sometimes argued that "life-years" discriminates against the elderly, there are strong arguments that "life-years" is a better measure than "lives" of the effectiveness of regulatory alternatives.

Which Costs Should be Counted?

If one were only concerned about impacts on the Federal budget, then the only regulatory costs that would be counted would be those incurred (or saved) by a Federal agency. To reflect the full effect of a regulation, all costs to society—whether Federal, State, or private costs—should be counted when cost-effectiveness ratios are computed. This "societal perspective" on cost estimation is already embraced in OMB guidance and is widely practiced by Federal agencies and academic analysts.

Rulemakings may also yield cost savings (e.g., energy savings associated with using new technologies). It is generally accepted that the numerator in the cost-effectiveness ratio presented in a league table should be based on net costs, defined as the total cost incurred in meeting the requirements minus any cost savings. Similarly, the denominator of the ratio should reflect net life-years saved if the rule has both beneficial and adverse impacts on public health, such as the side effects of a vaccine.

Should Future Costs and Health Effectiveness be Discounted to Their Present Value?

Analysts generally agree that future costs and health effects should be discounted at the same rate, but there is a range of opinion about the appropriate rate of discount (e.g., 3 to 7 percent). If future health savings were discounted at a lower rate than future costs, then it can be shown that it always makes sense to delay adoption of a cost-effective rule. We have generally used 7 percent in our calculations, but following EPA's practice we have used a 5 percent discount rate in calculating life-years for EPA rules.

Limitations of League Tables

Generally, league tables are most helpful for comparing a set of government actions with the same primary outcome (e.g., a reduction in premature mortality risk or acres of wetlands saved). Where an action yields a variety of beneficial outcomes, the comparison be-

[3] OMB set forth its program to improve regulatory outcomes in *Making Sense of Regulation: 2001 Report to Congress on the Costs and Benefits of Regulations and Unfunded Mandates on State, Local, and Tribal Entities* (OMB 2001) available on our website at *www.whitehouse.gov/obm/inforeg/costbenefitreport.pdf* or upon request.

comes more problematic because these multiple benefits all need to be considered. Where the agency analysis provides a monetary estimate for these other benefit categories, we have subtracted the value of these benefits from the aggregate cost estimate to yield a net cost estimate. In some cases, the resulting net cost estimate for the rule is negative—that is, the other (non-mortality) benefits exceed the cost of the rule. Where the agency analysis fails to provide estimates for key benefit categories, the cost-effectiveness ratio may be overstated substantially, and thus, the regulatory action may be a more attractive candidate than suggested by the league table. For rules that have significant ecological as well as public health benefits, it is not clear how to construct a league table. Ecological benefits deserve serious consideration, but it is infeasible to express them in the same units as public health benefits. Finally, in some cases, the mortality reduction benefits may be largely ancillary to the overall effect of the rule, and the opportunity for realizing cost-effective improvements in risk reduction may be limited because the risk reduction gains are relatively small.

One of the most common ancillary benefits of lifesaving rules is a reduction in morbidity—i.e., the number of cases of nonfatal illness or injury. To account for such benefits, OMB is considering the use of new effectiveness measures that combine information on mortality and morbidity. Two such measures are already in widespread use in the academic literature. The "quality-adjusted life-year" (QALY) measure rates each year of life on a 0 to 1.0 scale based on an expert panel or patient assessment of the quality of life associated with different health states. The QALY measure is widely used in the medical literature in both the USA and Europe and has recently been recommended for use by an expert panel assembled by the U.S. Department of Health and Human Services. A close cousin to the QALY, the disability-adjusted life-year (DALY) measure, is widely used in the developing world and has been promoted by the World Health Organization and the World Bank. While the QALY measure values equally all healthy years of life, the DALY measure gives the greatest weight to healthy life-years in the prime of life, since these years—whether through work or child rearing—make a major contribution to societal production.

Strictly speaking, ranking regulatory investments based on cost-effectiveness ratios focuses on economic efficiency. Decision makers may desire (or be required) to consider other values as well (e.g., various notions of fairness and equity). There is no accepted approach to incorporating equity considerations into a league table. However, there is broad consensus that a qualitative description of equity and fairness concerns should be presented to regulators in a rulemaking process and such considerations are clearly authorized for consideration under E.O. 12866.

Taking Steps Toward Cost-Effectiveness in the Regulatory Process

OMB is in the process of taking modest steps toward greater use of cost-effectiveness and league tables in decision making. First, OMB has issued government-wide guidelines on information quality that will promote greater transparency and consistency in agency analyses of health and safety risks. The development of league tables as an analytical construct depends on achieving a degree of analytical consistency across agency evaluation of health and safety risks. Second, OMB has committed to update periodically its guidelines for regulatory analysis, which are used when OMB reviews agency rulemakings. OMB intends to use guideline revision as a vehicle to consider the analytic measures of effectiveness and performance used by agencies and the informational burdens associated with moving toward greater analytic consistency in agency practices. This multi-year process will involve analysts from multiple agencies and will include opportunities for public comment and peer review.

While this approach has been more fully developed in the public health and medical literature, it can be applied to other types of programs. One of the key challenges in extending this analysis into other areas, of course, is developing a suitable measure of the effectiveness of disparate programs directed toward enhancing other aspects of the nation's welfare (e.g., recreational opportunities). OMB encourages agencies to develop objective measures of program effectiveness that can facilitate cost-effectiveness analysis.

Attachment

This attachment presents a summary of our calculations for each of the ten regulations included in the Analytical Perspectives Chapter. Each of the ten rules was reviewed by OMB under Executive Order 12866; five address health issues and five address safety issues. These ten rules – a non-random sample of risk-related rulemakings – were selected because the regulatory analyses provided sufficient information to prepare a cost-effectiveness ratio. The estimates presented in the table are based on data and estimates provided by the agencies.

To reflect the full effect of a regulation, all quantified costs to society – whether Federal, State, or private costs – were included in calculating the cost-effectiveness ratios. It is generally accepted that the numerator in the cost-effectiveness ratio should be based on net costs, defined as the total cost incurred in meeting the requirements minus any cost savings and other non-mortality benefits.

The league table in the Analytical Perspectives Chapter uses life-years saved as the measure of "effectiveness" of these several regulatory initiatives. Where the agencies did not provide estimates of life-years saved, we calculated life-years using standard assumptions about age and life expectancies. For purposes of sensitivity analysis, we also developed a calculation of the cost per life saved for each of these rules and we have included a Table presenting the costs per life-saved.

Where the timing of the benefits and costs differ, we have generally used a 7 percent discount rate in our calculations, but following EPA's practice we adopted a 5 percent discount rate in calculating life-years for EPA rules. In addition, EPA used a 6 percent discount rate in the NO_x SIP Call in developing an annualized cost stream for the required capital expenditures for electric generating units.

Head Impact Protection

The National Highway Traffic Safety Administration (NHTSA) estimated the cost of the rule to be $640 million/year (NHTSA: FMVSS No. 201 Upper Head Impact Protection Final Economic Assessment (FEA), June 1995, p. 2). The benefits were estimated to range from 873 - 1045 fatalities and 675 - 768 serious injuries avoided per year once the entire on-road fleet is in compliance (FEA, p1). Since the benefits occur over the lifetime of a vehicle but the costs are borne when the vehicle is produced, the benefit estimates need to be discounted before they can be compared with the cost estimates. We used a 7 percent discount rate and assumed the benefits were distributed over the vehicles' lifetime in accordance with miles traveled. The corresponding present value estimates are 611 - 732 fatalities and 473 - 538 injuries annually. We valued injury reductions using estimates contained in Table A-1 of 1996 NHTSA report, "The Economic Cost of Vehicle Crashes, 1994." The resulting value of injury reductions ranges from $220 - $324 million/year. Subtracting this from the $640 million/year cost estimate yields a net cost ranging from $316 - $420 million/year. The average age of highway fatality victims is about 40 years old. A 40-year-old has a remaining life expectancy of about 39 years. Discounting these life-years (at 7 percent) to the time of the fatality yields an estimate of approximately 13.3 discounted life years of benefit per fatality avoided. Thus, the discounted number of life-years associated with fatalities avoided by this rule would range from 8,360 to 10,007. Dividing the corresponding net cost estimates by these estimates results in cost per life-year ranging from $40,000 - $43,000. Adjusting for inflation, the cost per life-year expressed in 2001 dollars is between $50,000 and $53,000. The corresponding cost per life saved estimate ranges from $665,000 to $705,000.

Child Restraints

NHTSA estimated the cost of the rule to be $152 million/year (NHTSA Office of Regulatory Analysis Plans and Policy: FMVSS No. 213 Child Restraint Systems Final Economic Assessment (FEA), February 1999, p.2, Table S-2) The benefits were estimated to range from 36 - 50 fatalities and 1,235 - 2,939 injuries avoided per year once the entire on-road fleet is in compliance (FEA, Table S-1). Since the benefits occur over the lifetime of a vehicle but the costs are borne when the vehicle is produced, the benefit estimates need to be discounted before they can be compared with the cost estimates. We used a 7 percent discount rate and assumed the benefits were distributed over the vehicles' lifetime in accordance with miles traveled. The corresponding present value estimates are 25 - 35 fatalities and 865 - 2057 injuries annually. We valued injury reductions using estimates contained in Table A-1 of 1996 NHTSA report, "The Economic Cost of Vehicle Crashes, 1994." The resulting value of injury reductions ranges from $44 - $104 million/year. Subtracting this from the $152 million/year cost estimate yields a net cost ranging from $48 - $108 million/year. The average age of fatality victims for this rule is about 3 years old. A 3-year-old has a remaining life expectancy of about 75 years. Discounting these life-years (at 7 percent) to the time of the fatality yields an estimate of approximately 14.3 discounted life years of benefit per fatality avoided. Thus, the discounted number of life-years associated with fatalities avoided by this rule would range from 370 to 515. Dividing the corresponding net cost estimates by these estimates results in cost per life-year ranging from $93,000 - $292,000. Adjusting for inflation, the cost per life-year expressed in 2001 dollars is between $105,000-$331,000. The corresponding cost per life-saved estimate ranges from $1.5 million to $4.9 million.

Conspicuity Retrofits for Heavy Trucks

The Federal Highway Administration (FHWA) estimated the cost of the rule to be $228 million over two years and benefits of $360 million over the first 10 years discounted to the time the costs are incurred (Federal Highway Administration, Costs and Benefits of Requiring Conspicuity Retrofits Regulatory Evaluation, March, 1999, p. ES-1 Table ES-1). FHWA monetized all benefits, including injuries and fatalities avoided. The benefits included 71 discounted statistical fatalities avoided which FHWA valued at $2.7 million per fatality for a total of $192 million. Thus, the value of all other benefits was $168 million and the net cost of the rule (not counting fatalities) was $60 million/year. The average age of a highway fatality victim for this rule is about 40 years old. A 40-year-old has a remaining life expectancy of about 39 years. Discounting these life-years (at 7 percent) to the time of the fatality yields an estimate of approximately 13.3 discounted life years of benefit per fatality avoided. Thus, the discounted number of life-years associated with fatalities avoided by this rule is about 946. Dividing the corresponding net cost estimates by these estimates results in cost per life-year of about $63,000. Adjusting for inflation, the cost per life-year expressed in 2001 dollars is about $69,000. The corresponding cost per life-saved is about $920,000.

Roadway Worker Protection

The Federal Railroad Administration estimated the cost of the rule to be $229 million discounted over the first 10 years and benefits to be $88 million discounted over the same period. (61FR65973), Office of Safety: Roadway Worker Protection Final Rule Regulatory Impact Analysis, September, 1996, p. 3). FRA monetized all benefits, including injuries and fatalities avoided. The benefits included 32.6 discounted statistical fatalities avoided which FRA valued at $2.7 million per fatality for a total of $62 million discounted over 10 years. Thus, the value of all other benefits was $26 million and the net cost of the rule (not counting fatalities) was $203 million (or $227 million in $2001). The average age of a fatality victim for this rule is about 40 years old. A 40-year-old has a remaining life expectancy of about 39 years. Discounting these life-years (at 7 percent) to the time of the fatality yields an estimate of approximately 13.3 discounted life years of benefit per fatality avoided. Thus, the discounted number of life-years associated with fatalities avoided by this rule is about 434. Dividing the corresponding net cost estimates by these estimates results in a cost per life-year of about $468,000. Adjusting for inflation, the cost per life-year expressed in 2001 dollars is about $523,000. The corresponding cost per life-saved is about $7.0 million.

Exposure to Methylene Chloride

OSHA estimated the benefits of this rule to be 34 lives saved per year at a net cost of $101 million/year, in 1997 dollars. [62FR1566]. Those who contract cancer from exposure to methylene chloride contract cancer after an average of 20 years. Assuming that the average worker is 40 upon first exposure, then their premature death robs them of 21.5 years of additional life, according to the life expectancy tables published by the CDC. Discounting these 21.5 life-years saved twenty years into the future at 7 percent results in a savings of 2.83 discounted life years of benefit per fatality avoided. Thus, the discounted number of life-years associated with fatalities avoided by this rule is 2.83 ·34, or approximately 96 per year. Dividing the corresponding net cost estimates by these estimates results in cost per life-year of about $1.05 million, which is $1.16 million in 2001 dollars. The corresponding cost per life-saved estimate is $12.7 million.

Powered Industrial Truck Operator Training

The Department of Labor (DOL) estimates that the benefits of this rule are $136 million per year, and the costs to be $16.9 million dollar per year, in 1993 dollars [63FR66264]. This does not include a monetized estimate of the value of loss of life or pain and suffering of injured workers. DOL estimated that this rule would prevent 11 fatalities per year. We assume that the average age of a fatality victim for this rule is about 40 years old. A 40-year-old has a remaining life expectancy of about 39 years. Discounting these life-years (at 7 percent) to the time of the fatality yields an estimate of approximately 13.3 discounted life years of benefit per fatality avoided. Thus, the discounted number of life-years associated with fatalities avoided by this rule is about 146 per year. Since the monetized non-mortality benefits exceed the costs by a considerable margin, the net costs are negative and the net cost per year of life-saved is less than zero.

Stage 1 Disinfectants/Disinfection By-Products (DBPs)

EPA estimated annual costs for this rule at $701 million in 1998 dollars. EPA also provided a range of quantified annual benefits estimates of 0 to 513 avoided fatal bladder cancer cases, and 0 to 1,719 avoided non-fatal cases [63FR69441]. EPA used a value of $587,000 for non-fatal cases. At the upper end of the range, the value for non-fatal cases alone would be about $1 billion. Since this exceeds the costs of the rule, the cost per life year saved would be negative in the most favorable situation. In the least favorable situation, the cost per life year would be infinite, since no lives would be saved if the link turns out not to be causal.

Interim Enhanced Surface Water Treatment Rule

EPA estimated annual costs of $307 million in 1998 dollars. EPA also estimated a range of 110,000 to 463,000 non-fatal cases and 14 to 64 fatal cases of cryptosporidiosis avoided per year [63FR69499]. EPA valued the non-fatal cases at $2,000 per case. At the low end, this gives a total valuation of $220 million for the non-fatal cases, leaving a net cost of $87 million for fatal cases. At the high end, the value of the non-fatal cases alone would be $926 million, which exceeds the costs of the rule, leaving a negative cost per life-saved for the fatal cases. EPA did not provide an estimate of the number of life-years per avoided fatal case. Cryptosporidiosis (a severe case of stomach flu) is generally not fatal, only in rare cases involving the elderly or persons with compromised immune systems (such as AIDS or chemotherapy patients) is it likely to be. It is probably reasonable to assume that such people would have a relatively short life expectancy even without contracting cryptosporidiosis. Using the "low-end" benefits assumption of 14 life years per case (or about 10 life years discounted), which primarily affects the elderly population, yields about 140 life years, or an upper bound of $621,000 per life year. Adjusting for inflation, the cost per life-year expressed in 2001 dollars is roughly $680,000. The corresponding cost per life-saved is about $6.8 million.

NO_x SIP Call

EPA estimated that the NO_x SIP Call would impose annual costs of $1.66 billion per year in 2007. (U.S. Environmental Protection Agency (USEPA), Regulatory Impact Analysis (RIA) for the NO_x SIP Call, FIP, and Section 126 Petitions, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., December 1998; Table ES-2) EPA also estimated that the resulting NO_x reductions would yield monetized benefits of $730 million per year associated with a variety of other health and welfare related endpoints.[1] (U.S. EPA, RIA for the NO_x SIP Call; Tables 4-9, 4-10 and 4-30) After subtracting these health and welfare benefits from the cost estimate, the net cost of the projected reduction in premature mortality is $0.93 billion per year.

EPA calculated that the expected reduction in NO_x emissions would yield a reduction of 370 premature deaths a year. EPA assumed that there would be a lag in realizing the full change in the risk of premature mortality, with 25 percent of the projected reduction in premature deaths occurring in the first year, 50 percent in the second year, and an additional incremental increase in the reduction of premature mortality of 16.7 percent in each of the subsequent three years (reaching 100 percent of the projected reduction in the fifth year). (U.S. Environmental Protection Agency, Benefits and Costs of the Clean Air Act (CAA), 1990 TO 2010, Office of Air and Radiation (1999), p.58) This lag structure coupled with a five percent discount rate yields a reduction of 342 deaths per year as an annualized stream. EPA also reports that the average number of life-years lost in PM-related premature deaths in

[1]The monetized benefit categories include: a reduction in the incidence of a variety of other health effects (e.g., chronic bronchitis, minor restricted activity days, hospital admissions), agricultural crop benefits, reductions in household soiling, commercial forest benefits, and improved visibility in Southeastern Parks. This estimate does not include monetized benefits estimates for reductions in nitrogen deposition in estuaries and premature mortality associated with exposure to ozone. EPA's Science Advisory Board raised serious concerns with these estimates and EPA did not include these as a part of its preferred estimates in more recent RIA's.

the United States is on the order of 14 years. (USEPA, Benefits and Costs of the CAA, Appendix I, p.I-25) Using a discount rate of 5 percent converts the 14 life-years to 9.9 discounted life years. Thus, the increase in life-years associated with the projected reduction in PM exposure associated with the NO_x SIP Call would yield 3390 additional life-years per year.

The cost per life-year saved is given by the following calculation: the net cost of $1660 million minus $730 million (from other monetized benefit categories) divided by 3390 life-years yields a cost of $274,000 per life year (1990$). Adjusting for inflation, the cost per life-year expressed in 2001 dollars is roughly $373,000.

The upper end estimate is based on EPA's estimate that the expected reduction in NO_x emissions would reduce short-term PM-related mortality by 152 premature deaths a year or about 1590 life years. All other assumptions and calculations are the same as outlined above for the lower end estimate. The cost per life-year for this alternative estimate is about $714,000. The corresponding cost per life-saved estimate ranges from $3.7 million to $8.3 million.

Petroleum Refining

The cost per life-year saved estimate for the Petroleum Refining NESHAP is <$0 because the non-mortality benefits of the associated VOC reductions exceed the costs of the rule.

EPA estimated the reduction in VOC emissions associated with the rule. Based on a benefit transfer value of $727 per ton, EPA estimated that the benefits of the rule ($109 million per year, 1992$) exceed the costs of the rule ($80 million per year, 1992$). EPA used a benefit transfer value of $727 per ton -- an estimate of the acute health benefits from VOC reductions in ozone nonattainment areas -- taken from a reported range of $23 to $1430 per ton of VOC from a 1989 study by the Office of Technology Assessment. (60 FR 43245) EPA calculated the benefits of VOC reductions by multiplying the average value by the expected reduction in VOC emissions from petroleum refineries located in ozone nonattainment areas. (60 FR 43245 and 43246)

EPA identified a variety of potential adverse health effects associated with the emissions from petroleum refineries, ranging from cancer (benzene, cresols), polyneuropathy (n-hexane), cataracts (naphthalene), anemia in children (naphthalene), and a variety of ozone-related health effects associated with VOC emissions. The non-cancer health effects from the HAPs typically occur at higher levels of exposure than estimated for the baseline level of emissions. (60 FR 43245) In terms of its effect on premature mortality, EPA reported that the mortality incidence associated with baseline emissions was less than one life per year. As a result, EPA determined that the cancer benefits associated with this rule were small and decided that they would not be quantified as a part of the analysis. (60 FR 43245) Therefore, we conclude that the reduction in premature mortality associated with this rule is small -- a fraction of one cancer per year.

Cost Per Life Saved For Ten Selected Regulations				
Regulation	**Health or Safety**	**Net Costs ($2001)**	**Lives saved**	**Cost per life saved ($2001)**
Petroleum Refining NESHAP (EPA)	Health	<0	<1 per year	<0
Powered Industrial Truck Operating Training (OSHA)	Safety	<0	11 per year	<0
Head Impact Protection (DOT)	Safety	$390 to $516 million per year	611-732 per year	$665, 000 to $705,000
Reflective Devices for Heavy Trucks (DOT)	Safety	$65 million (PV over 10 years)	71 (PV over 10 years)	$920,000
Child Restraints (DOT)	Safety	$54 to $122 million per year	25-35 per year	$1.5 million to $4.9million
Interim Enhanced Surface Water Treatment (EPA)	Health	<0 to $95 million per year	14-64 per year	<0 to $6.8 million
Rail Roadway Workers (DOT)	Safety	$227 million (PV over 10 years)	32.6 (PV over 10 years)	$7 million
NO_x SIP Call (EPA)	Health	$1265 million in 2007	152-342 per year	$3.7 - 8.3 million
Methylene Chloride (OSHA)	Health	$112 million per year	8.8 per year	$12.7 million
Stage I Disinfection By-Products (EPA)	Health	<0 to $764 million per year	0-402 per year	<0 to infinite

Notes: Net costs were calculated by subtracting from compliance costs an estimate of any non-fatality benefits such as a reduction in injuries or morbidity. PV = Present Value. Lives saved are discounted and/or annualized to enable comparability with the corresponding net cost estimates.