

**Dying Too Soon:
How Cost-Effectiveness Analysis Can Save Lives**

by

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Executive Summary

The United States spends an enormous amount of money promoting health and safety, partly through government intervention and partly through private-sector activity. Since all of us will eventually die, public policy aimed at risk reduction is designed not to prevent deaths, but to prevent *premature* deaths. Thus one measure of the success of a policy or regulation (also referred to as an “intervention”) might be the number of *years* of life saved. For example, if an intervention averts the premature death of someone who is 45 years old and allows that person to live to age 80, then it saves 35 years of life.

A measure of “cost-effectiveness” is obtained by dividing the total cost of a particular intervention by the number of years of life saved to obtain the *cost per year of life saved*. Health promotion policies vary enormously in their cost-effectiveness, yet there is no correlation between cost-effectiveness and the way we invest our health promotion resources. For example:

- By spending \$182,000 every year for sickle cell screening and treatment for black newborns, we add 769 years collectively to their lives at a cost of only \$236 for each year of life saved.
- By spending about \$253 million per year on heart transplants, we add about 1,600 years to the lives of heart patients at a cost of \$158,000 per year of life saved.
- Equipping just 3 percent of school buses with seat belts costs about \$1.6 million per year; but since this effort will save only one child’s life every year, the cost is about \$2.8 million per year of life saved.
- We spend \$2.8 million every year on radionuclide emission control at elemental phosphorus plants (which refine mined phosphorus before it goes to other uses); but since this effort will save at most one life every decade, the cost is \$5.4 million per year of life saved.

To examine the efficiency of societal investments in saving lives, the author, along with Professor John Graham and a team of researchers at the Harvard Center for Risk Analysis, systematically gleaned from the literature annual cost and lifesaving effectiveness information for 185 interventions. This information was then supplemented with expert estimates of the extent to which each intervention was implemented. Some of these interventions had been fully implemented, some partially implemented and some not implemented at all.

- The 185 interventions cost about \$21.4 billion per year and save about 592,000 years of life.
- If that same money had been spent on the most cost-effective interventions, however, 1,230,000 years of life could have been saved — about 638,000 more years of life than under the status quo.
- Implementing the more cost-effective policies, therefore, could save twice as many years of life at no additional cost.

The radical differences in cost-effectiveness of current interventions raise the possibility of redirecting funds from less cost-effective to more cost-effective areas. For example, suppose we took away \$45,000 per year from the money we spend regulating emissions at phosphorus plants and used it to screen the 20 percent of black newborns who are not now screened for sickle cell anemia. The effect on life expectancy of phosphorus plant workers would be negligible. However, black children would gain an additional 192 years of collective life expectancy every year.

Examination of the 139 proposed government regulations for which the Harvard Life-Saving Study had data revealed no relationship between the cost-effectiveness of government regulations and their implementation:

- Regulations that were implemented cost \$4.11 billion per year and save 94,000 years of life.
- Investing the same \$4.11 billion in the most cost-effective regulations would save 211,000 years of life annually — more than double the current number.

Decision makers charged with protecting the survival of Americans implicitly or explicitly use a number of strategies. They may (1) invest in those interventions affecting the most people, (2) invest in those interventions yielding the greatest survival benefits or (3) invest in those interventions that cost the least money. We show that, if the goal is to save the most years of life, these strategies come up short. Only the strategy of (4) basing decisions on cost-effectiveness will result in the efficient allocation of scarce lifesaving resources.

Introduction

For every one of us, death is inevitable. *Premature* death, however, is not. Through some reasonable mix of public and private strategies, we can substantially reduce the chance that we will die before our time. We can exercise and eat right, avoid tobacco, wear our seat belts and make sure our smoke alarms have working batteries. When more collective action is warranted, the federal government can regulate industry so as to protect us from such hazards as exposure to certain carcinogens in the air we breathe and the water we drink. As a society, we can adopt policies to immunize our children, pass speed limit and motorcycle helmet laws and adopt uniform building codes so that structures will not collapse on us in the event of natural disasters.

All risk reduction policies have two things in common: they have economic consequences, and they save lives. Thus it makes sense to compare lifesaving interventions according to their “value for the money.”

Determining the value of a health promotion intervention requires estimating the costs as well as the benefits of that intervention. Costs are usually defined as the dollar value of the resources consumed. For example, when a physician takes the time to counsel a patient to stop smoking, the physician’s time represents a resource that is consumed, and a dollar value can be attached to that resource. From a societal perspective, all costs should be considered, regardless of who bears those costs.¹

The survival benefits of a health promotion intervention can be captured in any number of ways, but the most common measures are “lives saved” and “years of life saved.” The latter measure has the advantage of taking into account *when* a premature death is averted. For example, avoiding the premature death of a 40-year-old who then lives to be 78 would imply that 38 years of life are saved.

However, the benefits of a health promotion intervention are generally not limited to an extension of years of life. Seat belts, for example, reduce the risk of dying in serious automobile accidents, but they also prevent nonfatal injuries. Environmental regulations reduce human exposure to certain carcinogens, but they also protect the ecosystem. Medical therapy can improve patients’ survival prospects, and also affect their quality of life.

Thus public health investment decisions inevitably require making trade-offs between cost, increased life expectancy and other benefits. The technique of cost-benefit analysis (as opposed to cost-effectiveness analysis) handles these trade-offs not only by measuring the cost of the resources consumed, but also by placing a dollar value on the years of life saved and on other benefits as well. The implication is that if the monetary benefits exceed

“Are we getting our money’s worth from health and safety measures?”

“Not all health and safety measures are equally cost-effective.”

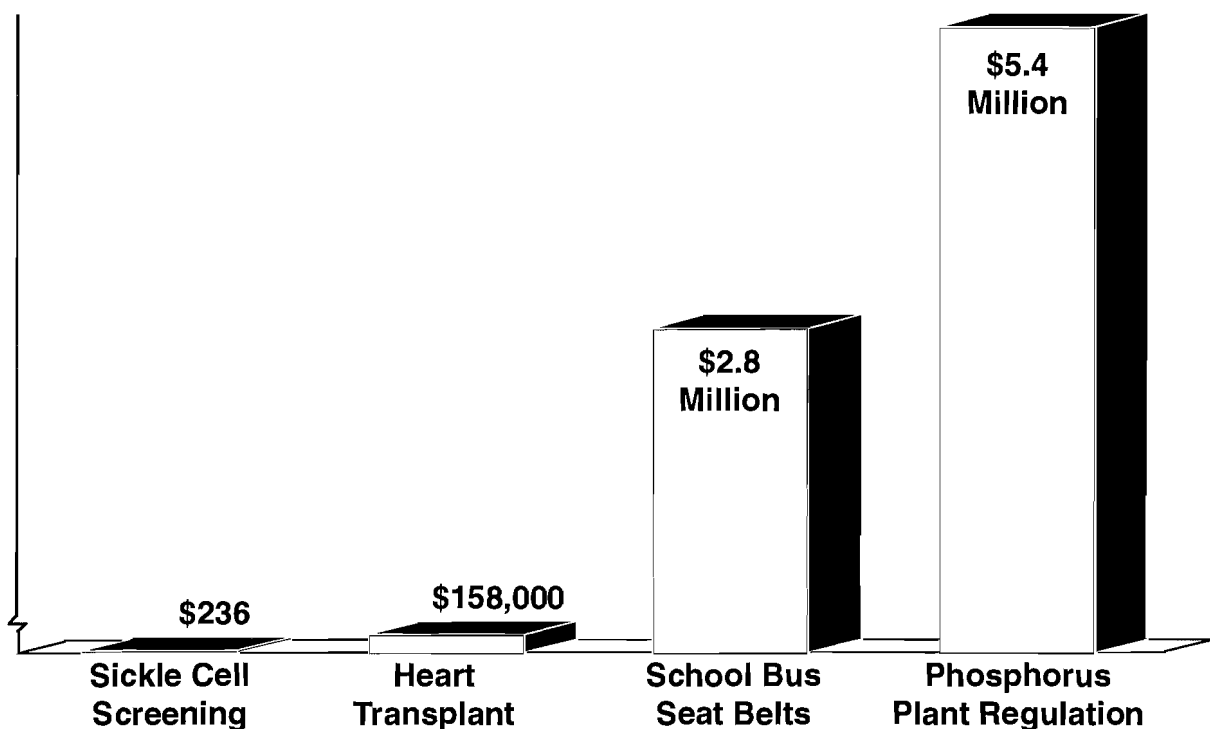
the costs, the program should be implemented. While cost-benefit analysis is theoretically sound, offering a way to trade off all of the effects of an intervention using a single metric, techniques for monetizing health and other benefits are in their infancy. Thus in this report we refer not to cost-benefit analysis, but to cost-effectiveness analysis. This technique defines costs in a similar manner, but “effectiveness” is defined simply as “life-years saved.” Of course this has the disadvantage of ignoring any other benefits of health promotion interventions. The advantage is that it temporarily sidesteps the need to place a dollar value on a year of life.²

Cost-Effectiveness of Common Interventions. Not all health and safety measures are equally cost-effective. For example [see Figure I]:

- By spending \$182,000 every year for sickle cell screening and treatment for black newborns, we add 769 years collectively to their lives at a cost of only \$236 for each year of life saved.
- By spending about \$253 million per year on heart transplants, we add about 1,600 years to the lives of heart patients at a cost of \$158,000 per year of life saved.

FIGURE I

Cost of Gaining an Additional Year of Life



“The average proposed EPA regulation costs 100 times more per year of life saved than the average proposed consumer product safety standard.”

TABLE I

Cost-Effectiveness of Proposed Regulations

<i>Regulator</i>	<i>Median Cost Per Life-year Saved</i>
Consumer Product Safety Commission (CPSC) National Highway Traffic Safety Administration (NHTSA)	\$68,000 \$78,000
Occupational Safety and Health Administration (OSHA)	\$88,000
Environmental Protection Agency (EPA)	\$7,600,000

Source: Tammy O. Tengs et al., “Five-Hundred Life-Saving Interventions and Their Cost-Effectiveness,” *Risk Analysis*, vol. 15, no. 3, June 1995, pp. 369-90.

- Equipping just 3 percent of school buses with seat belts costs about \$1.6 million per year; but since this effort saves only one child’s life every year, the cost is about \$2.8 million per year of life saved.
- We spend \$2.8 million every year on radionuclide emission control at elemental phosphorus plants (which refine mined phosphorus before it goes to other uses); but since this effort saves at most one life every decade, the cost is \$5.4 million per year of life saved.

Cost-Effectiveness of Government Regulation. Specific policies resulting from proposed government regulations vary widely in their cost-effectiveness, depending on the agency involved. For example, as Table I shows, the median proposed EPA regulation costs 100 times more per year of life saved than the median proposed highway safety or consumer product safety standard.³

How Cost-Effectiveness Analysis Can Save Lives. Because of the radical differences in cost-effectiveness that now exist, redirecting even relatively small amounts from less cost-effective to more cost-effective areas could have a noticeable impact. For example, suppose we took away \$45,000 per year from the money we spend regulating emissions at phosphorus plants and used it instead to screen the 20 percent of black newborns who are not now screened for sickle cell anemia. The effect on life expectancy of phosphorus plant workers would be negligible. However, black children would gain an additional 192 years of collective life expectancy every year.

Cost-Effectiveness as a Guide for Public Policy. This paper explores how the use of cost-effectiveness information to guide health policy

decisions can improve our survival prospects. The paper begins by clearing up a number of misconceptions about cost-effectiveness analysis. Next, it compares the use of cost-effectiveness as a guide to other strategies for making survival investment decisions. Finally, it considers how our present failure to make policy decisions based on economic efficiency results in the loss of life.

Misconceptions About Cost-Effectiveness Analysis

“Cost-effective interventions do not necessarily affect large numbers of people.”

Confusion often surrounds discussions of cost-effectiveness analysis. Some people wrongly believe that a health promotion intervention that is “cost-effective” actually saves money or is at least quite inexpensive. Others use the phrase “cost-effective” when they want to convey that an intervention is very effective or benefits a large number of people. Each of these uses leads to miscommunication and can result in bad health policy decisions.

The discussion below exposes four misconceptions related to cost-effectiveness analysis. It explains why cost-effective interventions do not necessarily affect large numbers of people, why they do not necessarily offer important survival benefits and why they are not necessarily low in cost. Further, it explains that, contrary to what common sense would suggest, we do not necessarily gravitate to the most cost-effective interventions. Some of the interventions referred to are summarized in Table II.⁴

Misconception #1: Cost-effective interventions affect large numbers of people. An intervention is not always more cost-effective simply because it affects large numbers of people. For example, compare the current practice of banning asbestos in brake blocks (the braking mechanism inside vehicle wheels) to protect exposed workers with the proposed policy of installing seat belts on school buses to protect children. Banning asbestos benefits only those few people exposed in the workplace, while school buses are ridden by millions of children each year. Yet at approximately \$29,000/life-year saved, banning asbestos in brake blocks is far more cost-effective than installing seat belts at \$2.8 million/life-year saved [see Table II]. This is, in part, because asbestos exposure is always hazardous, but fatal school bus accidents are quite rare.

Misconception #2: Cost-effective interventions are very effective. Cost-effective interventions are not necessarily those interventions which are most effective. For example, tripling the wind-resistance capabilities of new buildings to protect the occupants in the event of a hurricane would save an average of 4,616 life-years annually. Thus it could be said to be highly effective. However, because the \$12 billion annual cost would be exorbitant, the

cost per year of life saved would be \$1.3 million. On the other hand, although sickle cell screening for black newborns saves fewer years of life — 961 annually — this intervention is much less costly and therefore relatively more cost-effective, at \$236 per year of life saved.

Misconception #3: Cost-effective interventions are low cost. Just as cost-effectiveness does not always imply that the benefits are high, it also does not always imply that the costs are low. For example, screening women for breast cancer every three years from the age of 50 to 65 and treating any cases discovered would consume \$26.1 million in resources annually. Yet because mammography is relatively accurate in older women and treatment is effective when breast cancer is caught early, this intervention would save 9,764 years of life annually. Thus it is quite cost-effective at approximately \$2,700 per year of life saved. In contrast, the cost of radionuclide emission control at surface uranium mines is much less at about \$1 million annually. Yet the benefits are minuscule: only 0.24 years of life saved annually (or 1 year of life saved every 4 years). Thus the cost-effectiveness ratio is high at \$3.9 million per year of life saved.

Misconception #4: Cost-effective interventions are more likely to be implemented. It seems reasonable to suppose that decision makers would implement those health promotion activities that yield the biggest bang for the buck. Yet for the 10 interventions in Table II, there appears to be no relationship between cost-effectiveness and implementation. Although the interventions in this table are arranged in order according to cost-effectiveness, the percent of people in the target population who actually receive the intervention (shown in the “Percent Implementation” column) reveals that there’s no relationship. For example, when doctors counsel pregnant women to give up smoking, the counseling saves more money than it costs and improves the short- and long-term survival prospects of both mother and child. Of course a physician’s time is expensive, and many smokers ignore their physicians’ advice. But even taking these factors into account, cost savings occur because the lower cost of medical treatment for mother and child for those women who do quit successfully more than offsets the cost of physicians’ time. Although this counseling saves money and has important health benefits, experts estimate that only 80 percent of pregnant women who smoke receive advice to stop smoking. In contrast, radionuclide emission control at elemental phosphorus plants has a cost-effectiveness ratio of \$5.4 million per year of life saved. Despite the high cost-effectiveness ratio, this regulation is fully implemented.

Clearly, health promotion decisions are not currently based on cost-effectiveness. If they were, we could achieve a more economically efficient allocation of our limited health promotion resources, as described below.

“There is no relationship between what is cost-effective and what is implemented.”

TABLE II
Ten Life-Saving Interventions

	Full Implementation				Actual Implementation			
	People Affected	Total Annual Cost	Total Annual Life-Years Saved	Cost/Life-Year Saved	Percent Implementation	Annual Cost	Annual Life-Years Saved	Annual Life-Years Saved
1. Smoking cessation advice for pregnant women who smoke	Many	-\$72,237,187	6,568.0	≤\$0	80%	-\$57,789,750	5,254	5,254
2. Sickle cell screening for black newborns	Many	\$226,876	961.0	\$236	80%	\$181,501	769	769
3. Ban asbestos in brake blocks	Few	\$311,781	10.8	\$28,869	100%	\$311,781	11	11
4. Heart transplants	Some	\$460,048,544	2,915.0	\$157,821	55%	\$253,026,699	1,603	1,603
5. Arsenic emission control at glass manufacturing plants	Few	\$4,785,532	3.563	\$1,343,119	100%	\$4,785,532	4	4
6. Seat belts, auto center back seat	Few	\$101,602,435	52.0	\$1,943,893	5%	\$5,080,122	3	3
7. Seat belts for school buses	Many	\$52,995,773	19.2	\$2,760,197	3%	\$1,589,873	<1	<1
8. Radionuclide emission control at surface uranium mines	Few	\$940,645	0.23976	\$3,923,277	0%	\$0	0	0
9. Radionuclide emission control at elemental phosphorus plants	Few	\$2,821,935	0.5184	\$5,443,547	100%	\$2,821,935	<1	<1
10. Ban asbestos in automatic transmission components	Few	\$22,112	0.000333	\$66,402,402	100%	\$22,112	<1	<1
TOTAL						\$210,029,805	7,645	7,645

Strategies for Health Policy

When policy analysts advocate “economic efficiency,” they are suggesting that a reasonable goal of U.S. health policy is to choose the portfolio of health promotion interventions that simultaneously

- Maximizes health benefits given the resources consumed,
- Minimizes the resources consumed for the health benefits achieved, and
- Makes trade-offs between health benefits and money at a rate that reflects our true values.

Thus economic efficiency is simply getting the biggest bang for the buck, spending the fewest bucks possible for a bang and not spending more on any single bang than it is worth.

How can we achieve economic efficiency? Let’s consider four strategies that are routinely advocated, implicitly or explicitly, by those charged with making decisions that affect public health:

- Invest in the interventions affecting the most people.
- Invest in the most effective interventions.
- Invest in the least costly interventions.
- Invest in the most cost-effective interventions.

We can evaluate the wisdom of each of these four strategies by referring to the 10 interventions in Table II. Holding constant the total amount that we are currently investing annually in these interventions, we can explore the ramifications of hypothetically investing this sum using each strategy. Which strategy yields the most years of life saved given the resources consumed?

Before performing this hypothetical analysis, we first need to calculate what we are currently investing in these 10 interventions and what survival benefits we are currently realizing. We can develop a rough estimate of the level of investment in each intervention by multiplying its cost by the extent of its implementation. For example, sickle cell screening would consume \$226,876 annually if all black infants received it. Since only 80 percent of infants are currently screened, it consumes roughly \$181,501 annually (calculated as $\$226,876 \times 0.8$).

If we estimate investments in each of the 10 interventions and add them up, we find that the set consumes \$210,029,805 in annual resources and saves 7,645 life-years annually. Now, let’s hold resources constant at \$210,029,805 and consider each strategy:

“Economic efficiency means maximizing the health benefits of the dollars we spend.”

“Analysis can show which strategy saves the most years of life.”

Strategy #1: Invest in the interventions affecting the most people.

Public health professionals routinely advocate investing in the most important public health problems or the problems affecting the most people. To explore the wisdom of this strategy, we begin by ranking interventions 1 to 10 according to the number of people affected. This ranking appears in Table III. The number of children who ride school buses probably exceeds the number of black infants born in any given year, so seat belts in school buses and sickle cell screening for black infants are ranked first and second, respectively. Further, the number of black infants probably exceeds the number of women who are pregnant and smoke, and the number of these women probably exceeds the number of people who need heart transplants in any given year.

If we invest the same \$210,029,805 according to the number of people affected, we would be able to fully implement programs 7, 2 and 1. With the leftover resources, we could ensure heart transplants for 50 percent of those who need one. In total, we would save approximately 8,999 years of life.

Strategy #2: Invest in interventions that save the most lives. Now suppose we instead took the same \$210,029,805 and invested it first in those interventions yielding the greatest number of years of life saved, ignoring other considerations. To follow this strategy, we rank interventions as they appear in Table IV. We would first make sure that physicians advise pregnant women to stop smoking, saving 6,568 years of life annually. Next, we would pay for heart transplants for everyone who needs them because doing so yields 2,915 years of life. At the bottom of the list would be banning asbestos in automatic transmission components, which saves only 0.000333 years of life annually.

If we worked our way through the list from top to bottom, investing the same \$210,029,805 until it ran out, we would find that we could afford the smoking cessation program for all pregnant women, and heart transplants for 61 percent of those who needed them. Following this strategy, we would save 8,357 years of life annually.

Strategy #3: Invest in the least costly interventions. Some advocate investing in those interventions that consume the fewest resources. Table V depicts the 10 interventions ranked from low to high according the total annual cost of the program. Smoking advice for pregnant women actually saves more money than it costs, taking into account the avoided cost of treating smoking-related illnesses. Thus smoking cessation advice is ranked first. Next, banning asbestos in automatic transmission components consumes few societal resources at \$22,112. Ranked last, heart transplants would consume more than \$460 million if everyone who needed one received one.

If we invest the same \$210,029,805 in the least costly interventions first, we could fund 100 percent of every program except heart transplants, with enough left over for 26 percent of those who need transplants. The result would be 8,367 years of life saved.

TABLE III

Strategy #1: Invest in the Interventions Affecting the Most People

	Full Implementation				Strategic Implementation			
	People Affected	Total Annual Cost	Total Annual Life-Years Saved	Cost/ Life-Year Saved	Percent Implementation	Annual Cost	Annual Life-Years Saved	
7. Seat belts for school buses	Many	\$52,995,773	19.2	\$2,760,197	100%	\$52,995,773	19	
2. Sickle cell screening for black newborns	Many	\$226,876	961.0	\$236	100%	\$226,876	961	
1. Smoking cessation advice for pregnant women who smoke	Many	-\$72,237,187	6,568.0	≤\$0	100%	-\$72,237,187	6,568	
4. Heart transplants	Some	\$460,048,544	2,915.0	\$157,821	50%	\$229,044,343	1,451	
3. Ban asbestos in brake blocks	Few	\$311,781	10.8	\$28,869	0%	\$0	0	
5. Arsenic emission control at glass manufacturing plants	Few	\$4,785,532	3.563	\$1,343,119	0%	\$0	0	
6. Seat belts, auto center back seat	Few	\$101,602,435	52.0	\$1,943,893	0%	\$0	0	
8. Radionuclide emission control at surface uranium mines	Few	\$940,645	0.23976	\$3,923,277	0%	\$0	0	
9. Radionuclide emission control at elemental phosphorus plants	Few	\$2,821,935	0.5184	\$5,443,547	0%	\$0	0	
10. Ban asbestos in automatic transmission components	Few	\$22,112	0.000333	\$66,402,402	0%	\$0	0	
TOTAL						\$210,029,805	8,999	

TABLE IV

Strategy #2: Invest in Interventions That Save the Most Years of Life

	Full Implementation				Strategic Implementation			
	People Affected	Total Annual Cost	Total Annual Life-Years Saved	Cost/Life-Year Saved	Percent Implementation	Annual Cost	Annual Life-Years Saved	Annual Life-Years Saved
1. Smoking cessation advice for pregnant women who smoke	Many	-\$72,237,187	6,568.0	≤\$0	100%	-\$72,237,187	6,568	6,568
4. Heart transplants	Some	\$460,048,544	2,915.0	\$157,821	61%	\$282,266,992	1,789	1,789
2. Sickle cell screening for black newborns	Many	\$226,876	961.0	\$236	0%	\$0	0	0
6. Seat belts, auto center back seat	Few	\$101,602,435	52.0	\$1,943,893	0%	\$0	0	0
7. Seat belt for school buses	Many	\$52,995,773	19.2	\$2,760,197	0%	\$0	0	0
3. Ban asbestos in brake blocks	Few	\$311,781	10.8	\$28,869	0%	\$0	0	0
5. Arsenic emission control at glass manufacturing plants	Few	\$4,785,532	3.563	\$1,343,119	0%	\$0	0	0
9. Radionuclide emission control at elemental phosphorus plants	Few	\$2,821,935	0.5184	\$5,443,547	0%	\$0	0	0
8. Radionuclide emission control at surface uranium mines	Few	\$940,645	0.23976	\$3,923,277	0%	\$0	0	0
10. Ban asbestos in automatic transmission components	Few	\$22,112	0.000333	\$66,402,402	0%	\$0	0	0
TOTAL						\$210,029,805	8,357	8,357

Strategy #4: Invest in the most cost-effective interventions. Finally, suppose that we made investment decisions based on cost-effectiveness. Table VI ranks the interventions according to cost per life-year saved. If we followed this strategy, we would begin by making sure that physicians advised their pregnant patients to stop smoking because the cost/life-year ratio is < \$0. Next, we would make sure that all black newborns were screened for sickle cell because the cost/life-year ratio is \$236. Our last priority would be banning asbestos in automatic transmission components at a cost/life-year of more than \$66 million.

Using this strategy, we find that we could spend the same \$210,029,805 by funding the first three programs and heart transplants for 61 percent of those who need them. If we did so, we would save 9,325 years of life.

As shown in Table VII, funding the most cost-effective interventions first saves more years of life than any other strategy. Further, if we had performed a different experiment, one in which we specified a number of life-years to be saved and sought the strategy that would minimize costs, cost-effectiveness would again have proven superior. Finally, using cost-effectiveness information strategically allows us to make trade-offs between small improvements in survival (i.e., *quantity of life*) and costs (i.e., all other goods and services).

These results are not a fluke, and the superiority of the cost-effectiveness strategy is not specific to the interventions chosen for this example. *Basing welfare decisions on some measure of the relationship between costs and benefits will always prove superior to any other strategy, when the goal is to maximize benefits given the resources consumed.*

The Harvard Life-Saving Study

The lifesaving interventions referred to above represent just a fraction of those surveyed by the Harvard Life-Saving Team. Funded by that National Science Foundation, my colleagues and I amassed cost-effectiveness information for hundreds of different interventions.

Although the full data set contains cost-effectiveness estimates for 587 interventions, national annual cost and effectiveness estimates were available for only 185 of these interventions. For each, we supplemented cost-effectiveness data with information on the degree to which that intervention was implemented. [See the sidebar on Methodology of the Harvard Life-Saving Study.]

To learn more about the economic efficiency of societal investments, we contrasted the current pattern of investment in these 185 interventions with the hypothetical “optimal” pattern of investment that cost-effectiveness would

“Using cost-effectiveness information allows us to make trade-offs between survival (quantity of life) and costs (all other goods and services).”

TABLE V

Strategy #3: Invest in the Least Costly Interventions

	Full Implementation				Strategic Implementation				
	People Affected	Total Annual Cost	Total Annual Life-Years Saved	Cost/Life-Year Saved	Percent Implementation	Annual Cost	Annual Life-Years Saved	Annual Cost	Annual Life-Years Saved
1. Smoking cessation advice for pregnant women who smoke	Many	-\$72,237,187	6,568.0	≤\$0	100%	-\$72,237,187	6,568		
10. Ban asbestos in automatic transmission components	Few	\$22,112	0.000333	\$66,402,402	100%	\$22,112	<0		
2. Sickle cell screening for black newborns	Many	\$226,876	961.0	\$236	100%	\$226,876	961		
3. Ban asbestos in brake blocks	Few	\$311,781	10.8	\$28,869	100%	\$311,781	11		
8. Radionuclide emission control at surface uranium mines	Few	\$940,645	0.23976	\$3,923,277	100%	\$940,645	<0		
9. Radionuclide emission control at elemental phosphorus plants	Few	\$2,821,935	0.5184	\$5,443,547	100%	\$2,821,935	<0		
5. Arsenic emission control at glass manufacturing plants	Few	\$4,785,532	3.563	\$1,343,119	100%	\$4,785,532	4		
7. Seat belts for school buses	Many	\$52,995,773	19.2	\$2,760,197	100%	\$52,995,773	19		
6. Seat belts, auto center back seat	Few	\$101,602,435	52.0	\$1,943,893	100%	\$101,602,435	52		
4. Heart transplants	Some	\$460,048,544	2,915.0	\$157,821	26%	\$119,013,655	752		
TOTAL						\$210,029,805	8,367		

LE VI		Strategic Implementation				
Annual Years Saved	Cost/Life-Year Saved	Percent Implementation	Annual Cost	Annual Life-Years Saved		
568.0	≤\$0	100%	-\$72,237,187	6,568		
961.0	\$236	100%	\$226,876	961		
10.8	\$28,869	100%	\$311,781	11		
915.0	\$157,821	61%	\$281,728,335	1,785		
3.563	\$1,343,119	0%	\$0	0		
52.0	\$1,943,893	0%	\$0	0		
19.2	\$2,760,197	0%	\$0	0		
0.23976	\$3,923,277	0%	\$0	0		
0.5184	\$5,443,547	0%	\$0	0		
0.000333	\$66,402,402	0%	\$0	0		
			\$210,029,805	9,325		

dictate. Like the interventions in Table II, some of the 185 were implemented fully, some partially and some not at all. Further, as Figure II illustrates, there was no relationship between implementation and cost-effectiveness. We estimated the resources currently consumed by these interventions at \$21.4 billion and the life-years currently saved at 592,000.

Our research revealed that if the entire \$21.4 billion were spent on the most cost-effective interventions, and none on the cost-ineffective interventions, we could save 1,230,000 years of life annually. That is 636,000 more than the 592,000 we are currently saving. Roughly, *we could double the survival benefits of our investments at no additional cost!*

The Efficient Frontier. This phenomenon can be understood by referring to the diagram in Figure III. The curve represents the maximum number of life-years that could be saved for a given level of resources consumed. This curve is called a “cost curve” or “efficient frontier” because it represents an efficient use of resources. It would be impossible to be above the curve, because the *maximum* survival benefits for each level of resource consumption is plotted. However, it is possible to be inside the curve — by failing to maximize survival benefits for a given level of expenditures. Notice that the curve increases at a decreasing rate. This reflects “decreasing marginal returns.” That is, the first few interventions cost very little relative to the survival benefits they achieve, but as we spend more money, although we realize more survival benefits, the amount we gain with each added dollar declines.

“Basing decisions on cost-effectiveness will always save the most years of life.”

TABLE VII

Summary of the Performance of Each Strategy

	<u>Annual Cost</u>	<u>Annual Life-Years Saved</u>
Current Investment Pattern	\$210,029,805	7,645
Strategy #1: Invest in the Interventions Affecting the Most People	\$210,029,805	8,999
Strategy #2: Invest in the Most Effective Interventions	\$210,029,805	8,357
Strategy #3: Invest in the Least Costly Interventions	\$210,029,805	8,367
Strategy #4: Invest in the Most Cost-Effective Interventions	\$210,029,805	*9,325

* Maximum survival benefits

Methodology of the Harvard Life-Saving Study

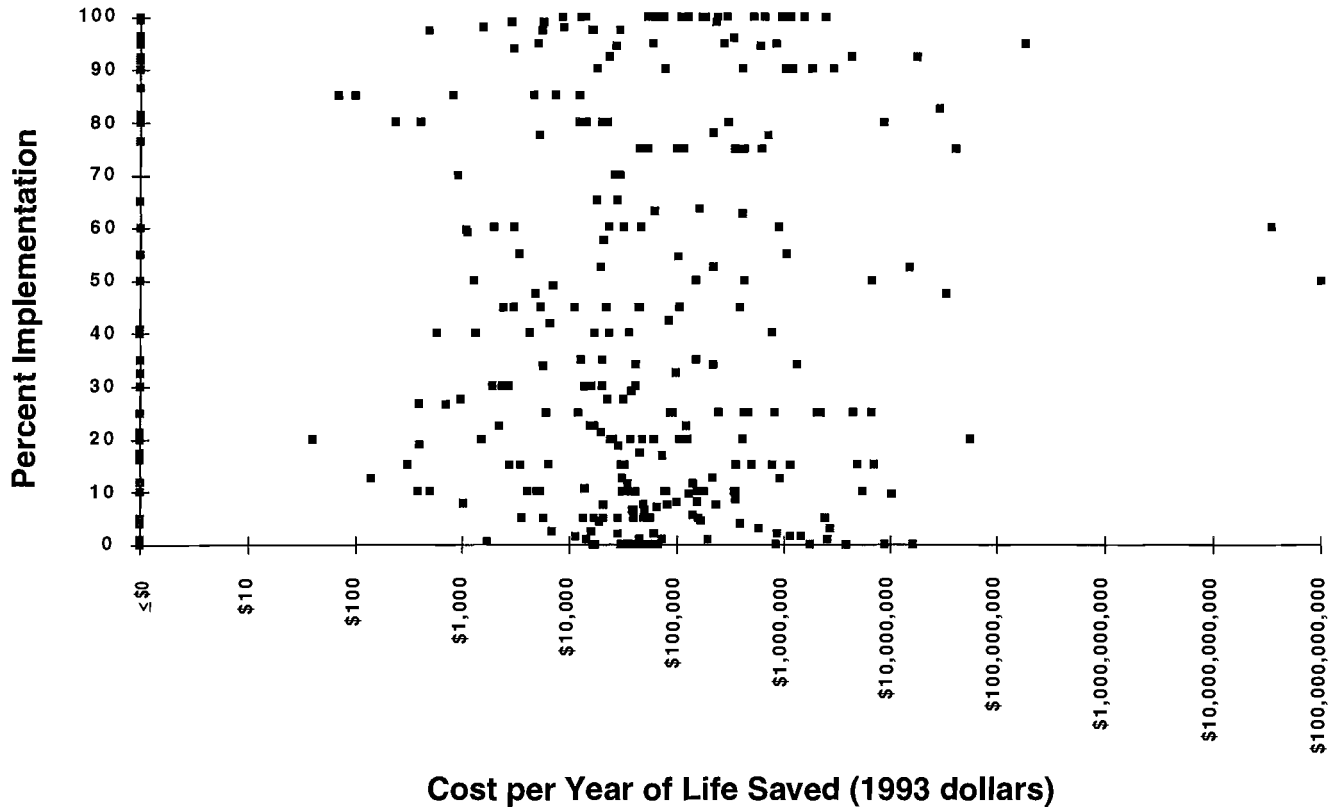
To identify cost-effectiveness information for the 587 interventions studied, a comprehensive search for publicly available economic analyses was performed. Two trained reviewers (from a total of 11 reviewers) read each document and independently recorded the nature of the lifesaving intervention, the base case intervention to which it was compared, the target population, the resources consumed by the intervention, total lives saved, total life-years saved, cost/life saved and cost/life-year saved. After working independently, the two reviewers came to a consensus on the content of the document.

To increase the comparability of cost-effectiveness estimates drawn from different economic analyses, nine definitional goals were established. When an estimate failed to comply with a goal, reviewers attempted to revise the estimate to improve compliance. The nine definitional goals were:

1. Cost-effectiveness estimates should be in the form of “cost per year of life saved.” Cost/life saved estimates should be transformed to cost/life-year by considering the average number of years of life saved when a premature death is averted.
2. Costs and effectiveness should be evaluated from the societal perspective.
3. Costs should be “direct.” Indirect costs such as forgone earnings should be excluded to avoid double-counting effectiveness measures.
4. Costs and effectiveness should be “net.” Any resource savings or mortality risks induced by the intervention should be subtracted out.
5. Future costs, lives and life-years saved should all be discounted to their present value at a rate of 5 percent.
6. Cost-effectiveness ratios should be marginal or “incremental.” Both costs and effectiveness should be evaluated with respect to a well-defined baseline alternative, usually the next best intervention.
7. Costs should be expressed in 1993 dollars using the general consumer price index.
8. Total costs, total lives saved and total life-years saved should be annual, annualized over a meaningful time horizon suggested by the author of the economic analysis or annualized over a 10-year time horizon if no time horizon was suggested. Costs, lives and life-years should reflect the total consequences of implementing the intervention nationwide.
9. Total costs, total lives saved and total life-years saved should be measured with respect to the “do nothing” alternative that involves no additional expenditure and results in no additional survival benefits relative to the status quo.

FIGURE II

Relationship Between Implementation and Cost-Effectiveness



"We currently invest in many interventions that are not cost-effective and ignore many that are."

It is clear that the efficient frontier is a good place to be. But it is not clear *where* we should be on the frontier. That choice depends upon the maximum we are willing to spend to save one year of life. If that value is approximately \$600,000, then we would want to be at point B because the slope of the curve at that point is $1/600,000$. That is, B represents the point where the last and least cost-effective lifesaving intervention funded costs \$600,000 per year of life saved. B would be the right choice if our willingness to pay was \$600,000. If we were not willing to spend as much as \$600,000/life-year, then we might choose something like point C, where the cost per year of life saved is, say, \$100,000. If our willingness to pay were even lower than that, we might choose point D, where the cost per year of life saved is \$10,000. Economists have estimated that people tend to make trade-offs between survival and money at the rate of \$3 million to \$7 million *per life saved*.⁵ A figure of \$5 million per life saved would translate into a few hundred thousand *per year of life saved*, assuming 10-20 discounted years of life saved when a premature death is averted. Thus some point between B and C might be a reasonable choice.

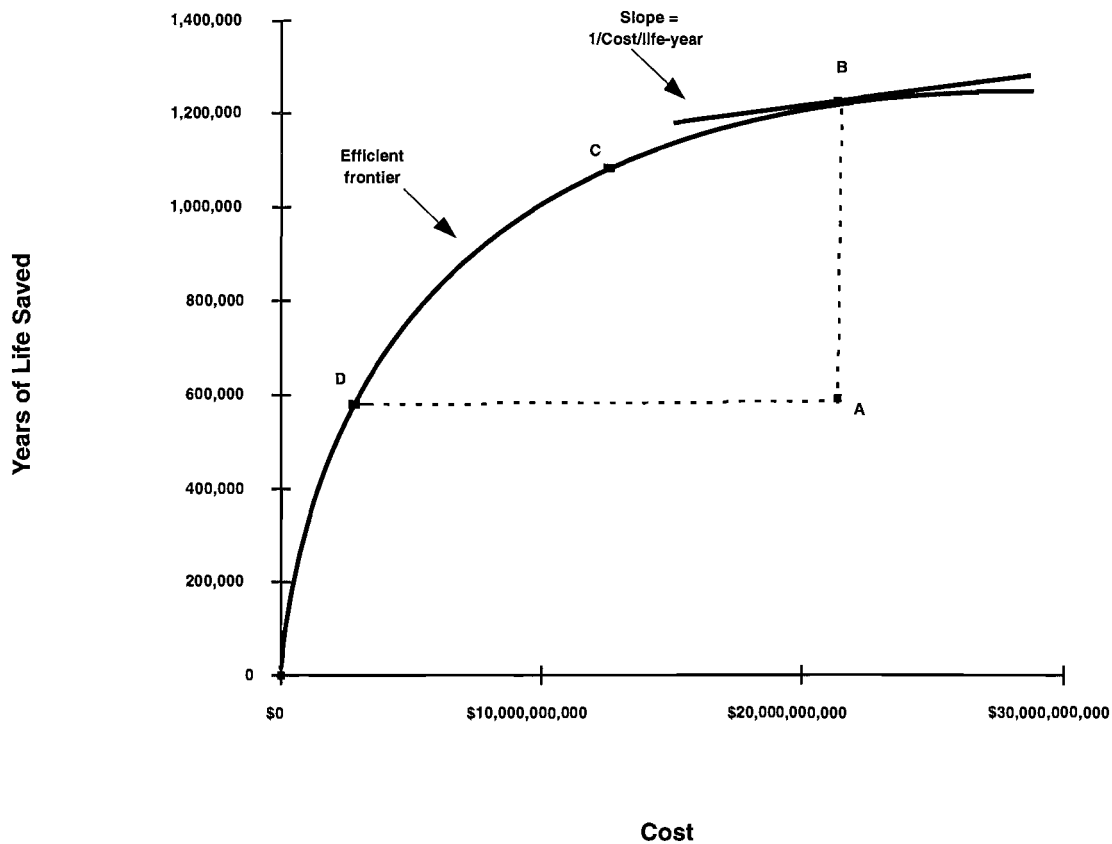
“Failure to invest wisely in lifesaving interventions costs about 60,000 lives per year.”

Unfortunately, our current pattern of investment puts us at point A, reflecting our current expenditures of \$21.4 billion and saving of 582,000 years of life. If we divide \$21.4 billion by 582,000 years of life we obtain an average of \$37,000/life-year. This result may appear attractive, but in fact we can do much better. If our current lifesaving portfolio did not ignore many cost-effective investment opportunities and contain many cost-ineffective interventions, we could be at point B, saving 1.2 million years of life. The portfolio at point B could be achieved by holding expenditures constant at \$21.4 billion, investing in all interventions with marginal cost-effectiveness ratios less than \$600,000/life-year and none of the interventions with higher marginal cost-effectiveness ratios. The vertical distance between points A and B represents the 636,000 years of life lost annually due to our failure to invest wisely in lifesaving interventions.

If we preferred to spend less than \$21.4 billion on promoting survival because, for example, we valued life-years at only \$100,000 each, we could be at point C. If this were our choice, we would spend less, yet gain survival benefits relative to the status quo.

FIGURE III

Inefficiency in Life-Saving Investments



Government Regulations and Economic Efficiency

Just as the Harvard Life-Saving Study found no relationship between cost-effectiveness and implementation of lifesaving interventions overall, it found no correlation between cost-effectiveness and implementation when it comes to government regulations.

Table I reports the median cost-effectiveness of regulations considered by several agencies. Large differences exist. Some highly cost-effective regulations have been implemented, such as the Consumer Product Safety Commission's ban on three-wheeled all-terrain vehicles. By avoiding the costs of treating injuries, this ban saves more than it costs. But other highly cost-effective regulations were considered by federal agencies and not implemented, for example, the Occupational Safety and Health Administration's workplace practice standard for electric power generation operation at \$59,000 per life-year saved. Perhaps more worrisome, a number of very cost-ineffective regulations have been implemented, such as the Environmental Protection Agency regulation controlling benzene emissions during waste operations at \$19 million per life-year saved. Wisely, other cost-ineffective regulations considered have not been implemented, including benzene emission control at chemical manufacturing process vents at \$530 million per year of life saved.

"Many proposed government regulations are not cost effective."

Because of this haphazard pattern of investment, government regulations save fewer lives than they might, given the resources consumed, and consume more resources than necessary, given the survival benefits offered. The solution is to base regulatory decisions on whether they are economically efficient. But just how important are the losses due to inefficiency? How many more years of life could be saved? How much money could be saved?

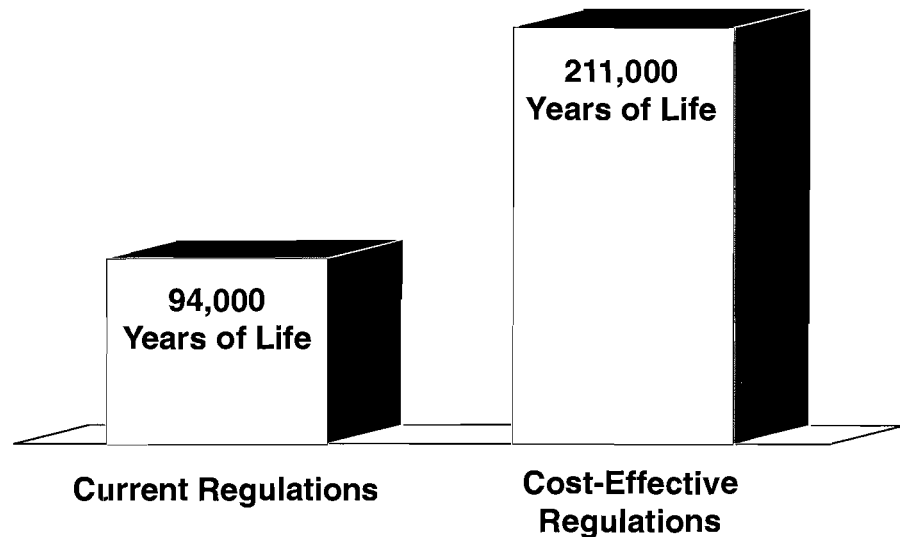
To answer these questions, we performed the same kind of hypothetical reallocation experiment described above, but restricted our investigation to the 139 government regulations for which we had data. Results indicated that the 139 regulations consume \$4.11 billion annually and save 94,000 years of life. Thus, if we divide resources consumed by years of life saved, we find an average cost of about \$44,000 per year of life saved. If we had invested the same \$4.11 billion in the most cost-effective regulations, we would be saving more than twice as many years of life — 211,000 annually, or 117,000 more than the status quo. [See Figure IV.]

Conclusion: Cost-Effectiveness Can Save Lives

This paper has demonstrated why the simple ratio of the cost of a health promotion intervention to the health benefits accrued can be very helpful in making public health decisions. It shows that cost-effective inter-

“Choosing the most cost-effective regulations would double the life-years saved.”

FIGURE IV
Applying Cost-Effectiveness to 139 Regulations



Source: T. O. Tengs and J. D. Graham, “The Opportunity Costs of Haphazard Societal Investments in Life-Saving,” in R. Hahn, ed., *Risks, Costs, and Lives Saved: Getting Better Results from Regulation* (New York: Oxford University Press, 1996).

ventions can benefit few or many; can be very or not very effective; can be expensive or inexpensive. When maximizing survival is the goal, the use of cost-effectiveness information for selecting investments outperforms other strategies, such as considering only the number of people affected, considering only the effectiveness or considering only the cost.

Because we fail to base public health decisions on cost-effectiveness, we sacrifice many lives every year. Allowing cost-effectiveness to inform those decisions will improve the allocation of scarce life-saving resources.

NOTE: Nothing written here should be construed as necessarily reflecting the views of the National Center for Policy Analysis or as an attempt to aid or hinder the passage of any bill before Congress.

Notes

- ¹ Further, costs should not be confused with prices which, due to imperfections in the economy, may or may not reflect the actual value of the resources consumed.
- ² This report also takes the “societal” perspective and thus does not differentiate between public expenditures and private, voluntary spending.
- ³ T. O. Tengs et al., “Five Hundred Life-Saving Interventions and Their Cost-Effectiveness,” *Risk Analysis*, vol. 15, no. 3, June 1995, pp. 369-90.
- ⁴ T. O. Tengs and J. D. Graham, “The Opportunity Costs of Haphazard Societal Investments in Life-Saving,” in R. Hahn, ed., *Risks, Costs, and Lives Saved: Getting Better Results from Regulation* (New York: Oxford University Press, 1996).
- ⁵ W. K. Viscusi, “The Value of Risks to Life and Health,” *Journal of Economic Literature*, vol. 31, 1993, pp. 1912-46.

About the Author

Tammy O. Tengs is an Assistant Professor in the departments of Urban and Regional Planning and Environmental Analysis and Design in the School of Social Ecology at the University of California, Irvine, and has been an Assistant Research Professor in the Center for Health Policy at Duke University. She completed her doctorate in Health Policy and Management at the Harvard School of Public Health in 1994. Before entering Harvard, she earned a master’s degree in Industrial Engineering and Operations Research at the University of Massachusetts, Amherst, and studied in the Engineering-Economic Systems Department at Stanford University. Dr. Tengs directed the four-year Life-Saving Priorities Project at the Harvard Center for Risk Analysis, supervising a team of 20 that amassed cost-effectiveness data for hundreds of lifesaving interventions. She is the principal author of the papers, “Five-hundred Life-saving Interventions and Their Cost-effectiveness” and “The Opportunity Costs of Haphazard Societal Investments in Life-saving.” When the *Wall Street Journal* published an article based on the Life-Saving project in 1994, about 20 other newspapers followed suit, and since then she has received approximately 1,500 requests for these publications. Dr. Tengs is a “decision scientist.” Her research interests include the rational allocation of societal resources devoted to averting premature death and the economic efficiency of investments in science.

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The National Center for Policy Analysis is a nonprofit, nonpartisan research institute, funded exclusively by private contributions. The NCPA developed the concept of Medical Savings Accounts, which were part of the 1996 health care bill passed by Congress. In addition to health care policy, the NCPA has made important contributions to other areas of public policy since its founding in 1983.

NCPA forecasts show that repeal of the Social Security earnings test would cause no loss of federal revenue, that a capital gains tax cut would increase federal revenue and that the federal government gets virtually all the money back from the current child care tax credit. Its forecasts are an alternative to the forecasts of the Congressional Budget Office and the Joint Committee on Taxation and are frequently used by Republicans and Democrats in Congress. The NCPA also has produced a first-of-its-kind, pro-free enterprise health care task force report, written by 40 representatives of think tanks and research institutes, and a first-of-its-kind, pro-free enterprise environmental task force report, written by 76 representatives of think tanks and research institutes.

The NCPA is the source of numerous discoveries that have been reported in the national news. According to NCPA reports:

- Blacks and other minorities are severely disadvantaged under Social Security, Medicare and other age-based entitlement programs;
- Special taxes on the elderly have destroyed the value of tax-deferred savings (IRAs, employee pensions, etc.) for a large portion of young workers; and
- Man-made food additives, pesticides and airborne pollutants are much less of a health risk than carcinogens that exist naturally in our environment.

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