Needless to say, people who face risks that entail a high probability of death are willing to pay extraordinarily large sums to reduce the probability. Those that face low risks are typically unwilling to pay anything at all to reduce those risks. Accordingly, a public policy that would allocate funds to maximize the number of lives saved conflicts sharply with the willingness-to-pay criterion. Information about their survival probabilities always increases willingness of individuals to pay for life saving. Risk-averse individuals may reject insurance for the treatment of fatal diseases that is fairly priced, even if they plan to pay for the treatment if they get sick; this result has implications regarding the choice of treatment or prevention. If the objective of public policy is to save the largest number of lives, then the allocation of funds must be made before individuals are affected by life-threatening risks.

INTRODUCTION

Economists who have worked in the area of health economics have generally offered policymakers two pieces of advice. First, policymakers have been urged to equate the productivity of various expenditures at the margin. In this spirit economists have frequently pointed to large discrepancies in costs per life saved among different life-saving programs financed by the government as an example of serious misallocations of resources. A reallocation, it is argued, could increase lives saved while holding expenditures constant.

A second bit of advice commonly offered to policymakers is to allocate resources in a way that approximates the allocation which would occur in a market setting. Thus, consumers’ willingness to pay should be used as an indicator of their valuation of different programs.

In recent years, economists have forged a link between these two pieces of advice. They show that consumers have implicitly signaled what they think a life is worth by their willingness to pay for...
certain life-saving programs. Using the guide provided by consumers' willingness to pay, the policymaker can allocate expenditures across programs so as to maximize the number of lives saved.

For example, suppose that an individual is willing to pay $500 to increase his survival chances by one in one thousand. A thousand such individuals would be willing, collectively, to pay $500,000 for a program that increased each of their survival chances by one in one thousand. If implemented, the program would be expected to reduce the number of deaths by one among the group of one thousand people; but it is unclear exactly who would be saved. In that sense, it is a "statistical life" that would be saved, at a cost (hence at a value) of $500,000.

The willingness-to-pay approach would then suggest that any program should be adopted if its cost is less than $500,000 and should be rejected if its cost is more than $500,000. More broadly, this approach suggests that expenditures on each health or safety program should be increased or decreased until the marginal cost of an additional statistical life saved is equal to the value of a statistical life. Such a policy would maximize the expected number of lives saved, given the level of aggregate expenditures on health and safety.

There is considerable appeal to this approach because of both its theoretical basis and the relative simplicity of its application. Moreover, the idea that a value must be placed on lives saved seems to be gaining acceptance among noneconomists. For example, Dr. Robert Grossman, acting director of the dialysis program at the University of Pennsylvania Hospital, has stated:

I can see us in the next few years having programs for people with heart disease, people with cancer, and it's something we can't afford. I don't even know if we can afford this [the dialysis program]. The question is, how much is a life worth?²

But the link between the two approaches, attractive though it might be to the economists who favor it, turns out to be neither secure nor simple. In their private decisions, many individuals appear to be grossly inconsistent in determining the added amounts they are willing to pay to increase their survival chances; for reducing some types of risk they are prepared to pay quite a lot, and for other risks of equal magnitude, very little. For instance, people who refuse to pay for routine examinations for the early detection of cancer are willing to pay large sums for apparently ineffective cancer treatments such as laetrile. Indeed, the private preference for treatment over prevention is frequently decried by physicians and policymakers. To develop a public policy that makes sense, we begin by exploring why this seemingly irrational pattern of behavior exists.

INDIVIDUAL DEMAND FOR LIFE SAVING

The term "life saving" as it is used here is, of course, a misnomer. Lives cannot really be saved; they can only be prolonged. Nevertheless, the effectiveness of various programs can be stated
simply and efficiently by various measures of lives saved, without excessive loss of generality.

Measuring the effectiveness of different programs by lives saved does have one drawback, however; it ignores the quality of those lives. Saving young people may be more valuable than saving old ones; saving the healthy more valuable than the ill. But we will pass by these problems in this analysis by pretending to consider societies that are composed of an identical mix of people.²

Finally, we assume that all individuals are completely rational persons who seek to maximize economic utility in their own lifetime and who place no value on building up the amount of wealth they would leave to their heirs. Some of the analytical results we present here are sensitive to these assumptions.

The Value of Life Saving

Define \( V \) as the rate at which the individual will trade money for increases in the probability of survival. In another study, one of us working with a colleague found \( V \) to be roughly \( \$400,000 \) in 1978 dollars; other researchers have obtained higher estimates.³ If \( V \) is roughly \( \$400,000 \), according to the approach suggested earlier, all life-saving projects that are undertaken should be operated at the level at which the last life saved cost just \( \$400,000 \).

But what if some lives are worth more than others, either to their owners or to society? Then saving 50 valuable lives may be considerably more efficient than saving 100 less valuable lives. For example, the lives of the wealthy may be no more valuable to society than the lives of the poor; but the wealthy may be willing to buy more life saving for themselves, just as they purchase more of everything else.

Even in a society in which all members have identical wealth, some lives may still be more valuable than others. Much like a wealth distribution, there exists a distribution of survival probabilities. Assuming that life saving is like any other economic good, individuals with lower survival probabilities should be willing to pay more than individuals with higher survival probabilities for an increase in the probability of life. This is stated formally in proposition 1.

**Proposition 1**: The amount an individual will pay for a given increase in the probability of survival, \( \Delta p \), is inversely related to the level of \( p \).*

(For the derivation of proposition 1, see the Appendix.)

The importance of proposition 1 is illustrated by a simple numerical example.

**Example 1**

Consider a society of 25 people in which everyone has the utility function \( p \ln(X+1) \) where \( p \) is the probability of living and \( X \) is

*In contrast to this proposition, willingness to pay may be higher for changing \( p \) from 0.99 to 1.0 than for changing \( p \) from 0.98 to 0.99 since there is no anxiety attached to certainty. Such a modification would not affect our results, however.
wealth. Assume that the society is divided into two groups. Before a life-saving program is instituted, group S (for sick) has 10 members each with \( p = 0.2 \), while group H (for healthy) has 15 members each with \( p = 0.7 \). Assume too that the wealth of each is $10.

A program can be provided to either group at the same total cost, and will increase the survival rate of either group by 0.1, If the decision is to be determined by willingness to pay, which group should be treated?

Table 1 displays the amount an individual with the posited utility function will pay for a 0.1 increase in \( p \), as \( p \) varies from 0 to 0.9. For our present purposes, the figures in Table 1 opposite the \( p \) values of 0.2 and 0.7 are the relevant ones.

The division of society into two groups can be thought of as two different diseases, with the group S disease more likely to be fatal. The specification that treatment costs are identical is mainly a specification that substantial economies of scale exist in the application of the treatment; for instance, all the costs may be in research. If the willingness-to-pay criterion is used, then the treatment should be provided to group S; each of the 10 members of that group would pay $6.05 for a total of $60.50, whereas the 15 members of group H would pay at most $42.75.

But note that the choice of group S does not maximize the number of lives expected to be saved. Providing treatment for group S yields an expected outcome of one life saved, while providing treatment for group H will save 1.5 lives. The number of lives saved is not maximized because the members of group S value an increase in their survival chances more than those in group H.

Table 1. Willingness of people in example 1 to pay for life-saving program.*

<table>
<thead>
<tr>
<th>Probability of survival without program, ( p )</th>
<th>Maximum amount individual would pay for 0.1 increase in ( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$10.00</td>
</tr>
<tr>
<td>0.1</td>
<td>7.68</td>
</tr>
<tr>
<td>0.2</td>
<td>6.05</td>
</tr>
<tr>
<td>0.3</td>
<td>4.96</td>
</tr>
<tr>
<td>0.4</td>
<td>4.19</td>
</tr>
<tr>
<td>0.5</td>
<td>3.62</td>
</tr>
<tr>
<td>0.6</td>
<td>3.19</td>
</tr>
<tr>
<td>0.7</td>
<td>2.85</td>
</tr>
<tr>
<td>0.8</td>
<td>2.57</td>
</tr>
<tr>
<td>0.9</td>
<td>2.35</td>
</tr>
</tbody>
</table>

*Assumptions: Individuals maximize \( pU(X), U(X) = \ln(X + 1) \) over an initial endowment of wealth amounting to $10.00.
The reason why lives saved is not maximized in the previous example is that, unlike most goods, there are very sharp limitations on the extent to which survival probabilities can be traded in the marketplace. If a good is traded freely, according to a familiar proposition from economics, everyone who consumes a positive quantity of the good values an extra unit of the good equally. In life saving, however, marginal valuations differ among individuals because they cannot make trades with one another in order to equate those valuations. If a person in our numerical example gets very sick, thereby reducing his $p$ from 0.9 to 0.2, Table 1 tells us that he would pay up to $6.05 to increase his survival probability to 0.3. If it were possible to do so, Table 1 asserts that others whose $p$ was 0.9 would be willing to give up 0.1 of their survival chances for anything over $3.84 (this figure is not shown in Table 1 since payments for decreases in $p$ are calculated slightly differently). Of course, current technologies (aside from some transplant operations) are not ordinarily available to permit such trades. Accordingly, the criterion of amount spent does not maximize the lives saved.

The point will be a little clearer perhaps, by analogy to another scarce nontradeable commodity. For example, an economy will not maximize the number of gallons of drinking water it can produce for a given expenditure. Inasmuch as transport facilities do not exist for transporting water over long distances, a gallon of water in Palo Alto, California, could well be valued at more than a gallon of water in Rochester, New York. A plan to provide an extra million gallons of water to Palo Alto would not seem unreasonable just because five million gallons could be provided to Rochester for the same price.

The reader may be troubled by our assumption that life-saving chances cannot be traded. Cannot individuals, for instance, adjust their lifestyles and thus "trade" to alter their survival probability? While there are, in fact, many ways an individual can regulate the safety level he or she faces, our assumption that trade will not occur is reasonable on two grounds.

First, when faced with a substantial probability of death from a disease, any adjustments the individual might make would be small relative to the risk from the disease. A healthy male aged 35 faces a total risk of death in one year of about 0.002. Even if he works in a very risky occupation, the risk of dying is unlikely to increase by more than 0.005. Thus, any changes in lifestyle that were decided rationally would be trivial.

Second, even if healthy individuals could make significant changes in their lifestyles in order to lower the risk of dying that would exist once they had contracted the disease, if they obey our behavioral assumptions they would not choose to do so. Assume that an individual faces two independent sources of mortal risk which we will call discretionary and nondiscretionary. The nondiscretionary risk might be a disease and the discretionary risk might stem from an occupational choice. Let $\phi_1$ be the probability that the individual will die from the nondiscretionary risk and $\phi_2$,
be the probability he will die from the discretionary risk. Then the probability of death, $\phi$, is the union of $\phi_1$ and $\phi_2$ or $\phi = \phi_1 + \phi_2 - \phi_1\phi_2$. Will an individual's choice of $\phi_2$ depend on $\phi_1$? Will a person with a disease that might be fatal take any more or less risk in his everyday life? On our assumptions, the answer is no—the two risks remain independent. This follows directly from our assumption that individuals maximize expected utility, that is, the product of $p$ and the utility of wealth.

**Proposition 2:** The amount of money necessary to compensate an individual for taking some risk $\phi_2$ does not depend on the level of other independent risks he faces, $\phi_1$.

(For the derivation of proposition 2, see the Appendix.)

It may be helpful to compare propositions 1 and 2. Proposition 1 states that as the probability of survival decreases, willingness to pay will increase for any absolute increase in this probability. Proposition 2 states that regardless of the probability of survival, willingness to pay will remain the same for any percentage increase in this probability.*

**IDENTIFIED LIVES**

Saving statistical lives has only a limited appeal; but saving identified lives can have much greater drawing power. Thomas Schelling was the first writer to make the important distinction between identified and statistical lives:

Let a six-year-old girl with brown hair need thousands of dollars for an operation that will prolong her life until Christmas, and the post office will be swamped with nickels and dimes to save her. But let it be reported that without sales tax the hospital facilities of Massachusetts will deteriorate and cause a barely perceptible increase in preventable deaths—not many will drop a tear or reach for their checkbooks.

The girl in the above example is "identified" in the sense that she has poorer than average chances of survival; and that a program can be named that will help her. The girl's life is identified because her personal plight provokes sympathy and a willingness by others to pay that is not stimulated by the anonymous and impersonal statistical life. The importance of this effect is illustrated by the attempt of charities to base their fund-raising activities on identified lives, as with the annual selection of a "poster child" in the historical March of Dimes drive against polio.

In this article we are not concerned with the fund-raising power of the identified life but only with the willingness of individuals to

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*This follows from proposition 2 because $\phi_1$ just acts as a scaling factor. Note that $p = 1 - \phi$ since $p$ is the probability of life and $\phi$ is the probability of death. Suppose that $\phi_1 = 0$ so there is no nondiscretionary risk and $\phi_2 = 0.1$. Then the effect of $\phi_2$ is to reduce $p$ from 1.0 to 0.9, a 10% reduction. If $\phi_1$ had been 0.5 instead, then $p$ would have gone from 0.5 to 0.45 [$p = 1 - \phi = 1 - (\phi_1 + \phi_2 - \phi_1\phi_2) = 1 - (0.5 + 0.1 - 0.05) = 0.45$], also a 10% reduction.
pay for improvements in their own survival probabilities. In that narrower context, the phenomenon of the identified life continues to exhibit great power. Once an individual is identified as exposed to special risks within a statistical class, the individual's willingness to pay increases.

Identification is considered here as identical with information. Ultimately, some individuals will get cancer, will get heart disease, or will be involved in automobile accidents. Information about the assignment of individuals to these health status categories will be labeled "individual information." Lives are "unidentified" if each individual attributes the same probability of assignment to each health status category as all other individuals. Simultaneously, programs can be listed that will increase survival rates of cancer, heart disease, and accident victims. Information about the distribution of (expected) benefits across health status categories will be labeled "project information." A project is "unidentified" if the survival rates of persons in all health categories are expected to be affected equally.

The framework used here centers on these health status categories. We wish to ask one question using this framework: What kinds of information will alter the value of a life?

Individual Information

Consider a program that will save exactly one life from some group of \( N \) people. Proposition 1 tells us that the lower the average probability of survival, \( \bar{p} \), the more this group will pay for the program. We now wish to investigate another issue. Holding \( \bar{p} \) constant, what happens to willingness to pay as information regarding the distribution of the individual probabilities \( p_i \) is varied? What is needed is a scale measuring the amount of such information. We have developed such a scale which we call \( I \). When \( I = 0 \), no information exists regarding individuals; every individual believes his \( p_i \) is equal to the average \( \bar{p} \). As information increases, \( I \) approaches 1.0, though it is undefined if anyone actually faces certain death. Various values for \( I \) are given in Table 2 as an illustrative example.

We now can ask, how will willingness to pay for life saving vary with \( I \)? Note that as \( I \) is increased, if the average risk to the group, \( \bar{p} \), is unchanged, the \( p_i \) of some individuals will rise, while that of

<table>
<thead>
<tr>
<th>Distributional information</th>
<th>( I )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No information; ( p_i = \bar{p} = 0.9 ) for all ( i )</td>
<td>0</td>
</tr>
<tr>
<td>2. ( p_i = 1 ) for 50 persons&lt;br&gt;0.8 for 50 persons</td>
<td>0.01389</td>
</tr>
<tr>
<td>3. ( p_i = 1 ) for 80 persons&lt;br&gt;0.5 for 20 persons</td>
<td>0.08889</td>
</tr>
<tr>
<td>4. ( p_i = 1 ) for 89 persons&lt;br&gt;0.0909 for 11 persons</td>
<td>0.9889</td>
</tr>
</tbody>
</table>
Public Policy Toward Life Saving

others will decline. Proposition 1 cannot be applied directly; some individuals will be willing to pay more for treatment while others will be willing to pay less. The net effect is described in proposition 3.

**Proposition 3**: For any group of individuals the aggregate willingness to pay for saving a life increases as the amount of individual information \((I)\) increases.

(For the derivation, see the Appendix.)

**Program Information**

Information regarding life-saving measures can be increased, however, not only for individuals in a given group, but also for a program that applies indistinguishably to all members of such a group. Again, we are concerned with how such information affects aggregate willingness to pay for life saving.

The first thing to recognize is that variations in program information will have no effect if information regarding individuals is zero; if every individual is perceived as having the same \(p_i\), then identifying who receives the benefits of a proposed program has no effect.

Given some positive level of individual information, then proposition 1 tells us that variations in the distribution of benefits will matter. The general result is given as proposition 4.

**Proposition 4**: Whenever individual information \(I\) is positive, the more the benefits are concentrated on those individuals with the lowest survival probabilities, the greater is the aggregate willingness of the group to pay.

(Again, the Appendix provides the derivation.)

An example of the application of proposition 4 is the contrast between two alleged life-saving programs: seat belts and laetrile. Seat belts are inexpensive to use (they only require a few seconds of buckling time plus perhaps some minor discomfort while wearing them) and have a well-documented life-saving capability. Nonetheless, at least in the United States, most people fail to use them. In other words, willingness to pay for seat belts is low. In contrast, laetrile is widely believed to be useless, yet willingness to pay for laetrile seems quite high. Treatment is not covered by insurance and often requires the expense of travel to a foreign country in addition to the direct treatment costs. At least some of the observed differences in willingness to pay can be explained by proposition 4. Seat belts help everyone to about the same degree (though they are of greater use to drunk drivers) while laetrile is a treatment for those with very low survival probabilities. Of course, poor information or simple irrationality may also be important explanatory factors.
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TREATMENT VERSUS PREVENTION

It is commonly believed that today's health industry shows an inordinate preference for treatment over prevention. In this section we demonstrate that this result could be generated by rational behavior on the part of individuals. In particular, the availability of a relatively ineffective treatment may discourage individuals from purchasing a relatively effective preventative. In the process of demonstrating this proposition, we will also show that, contrary to an analysis by Theodore Bergstrom, individuals facing the prospect of becoming very sick, with a resulting high demand for treatment, may not be disposed thereby to purchase insurance.5

We begin with Bergstrom's example. A man faces a probability that he will contract a specific fatal disease. If he does contract the disease, he may purchase a painless treatment at cost $c$, but its probability of success is only $\theta$. If the treatment is not purchased he will die quickly and painlessly. Health insurance is available that will pay for the treatment if the disease is contracted; it is priced at the actuarially fair price of $\lambda c$. Before the man knows whether he has the disease, he must decide whether to buy the insurance. Three options are available: (1) buy insurance to pay for the treatment; (2) buy no insurance; if he gets the disease, buy no treatment and die; (3) buy no insurance; if he gets the disease, buy treatment and possibly die.

Bergstrom assumes as we do that the man has no bequest motive, hence is not interested in saving money to benefit his heirs. Furthermore, the cost of treatment is assumed to be less than the man's wealth, so he can afford to pay for the treatment if he chooses to do so.

Bergstrom compares the options pairwise. First consider options 1 and 2. Purchase of the insurance adds $\lambda \theta$ to his probability of life at a cost $\lambda c$. If $\lambda \theta$ is "small" then the insurance will be purchased as long as the ratio of the cost to the gain in probability is less than $V$. Now assume the contrary: $c/\theta$ is more than $V$, so that the insurance is rejected; so option 2 is preferred to option 1.

Now consider options 2 and 3. If he selects option 2, he will die for sure if he gets the disease and thus his expected utility is $E_2 = (1 - \lambda) U(x)$. On the other hand, if he buys the treatment upon discovery of the disease, he will get an extra survival chance $\lambda \theta$, although with reduced wealth. Thus, his expected utility will be $E_3 = (1 - \lambda) U(x) + \lambda \theta U(x - c)$. Option 3 clearly dominates option 2, inasmuch as $E_3 = E_2 + \lambda \theta U(x - c)$ and the extra term must be positive.

Now compare 1 and 3. Bergstrom argues that 1 should be preferred to 3:

... he realizes that he would go ahead and try the cure even if he bought no insurance. Knowing that this is the case he realizes that whether or not he buys insurance he will attempt a cure if he has the disease. Whether or not he buys the insurance, his probability of dying from the disease is $\lambda (1 - \theta)$. In either case his expected cost is $\lambda c$, but if he buys insurance he pays $\lambda c$ with
certainty and if he buys no insurance he pays $c$ with probability $\lambda$ and 0 with probability $1 - \lambda$. If he is a risk averter he will prefer to buy insurance. . .

This analysis, while it seemed sensible at each step, has led us to the conclusion that option 2 is preferred to option 1 which is preferred to option 3; yet we know for sure that option 3 dominates option 2. What led to this intransitivity? The slip occurs in the quoted paragraph in the assertion that fair insurance will be preferred to option 1 (which amounts to self-insurance). Such insurance may not, in fact, be purchased. The reason is that the insurance pays off only in the event that the person has a life-threatening disease; assuming that the victim has no interest in the size of his estate after death, the value of money in such circumstances is attenuated.

Consider an analogous example. The probability of an earthquake strong enough to destroy a man's house is $\lambda$. Given such an earthquake, the probability the man will survive is $\theta$. Will he purchase actuarially fair earthquake insurance for his house? Not if $\theta$ is small, since then he would be buying insurance that would pay off after he was dead. This result is stated as proposition 5.

Proposition 5: Assume that an individual has a probability $\lambda$ of contracting a disease that is fatal when untreated. The cost of treatment is $c$, a sum that is less than his current assets, and the probability of cure is $\theta$. In such circumstances, the individual may refuse to buy the insurance for the treatment at the actuarially fair price $\lambda c$, even though he plans to purchase the treatment if he gets the disease.

(Once again, see the Appendix for derivation.)

Proposition 5 has implications that go beyond the question of financing health expenditures. The results for insurance apply with equal force to prevention activities. Consider a disease that has two strains, $A$ and $B$. The probability of getting the disease is $\lambda$. Given that the disease has been contracted, the probability that it is strain $A$ is $\theta$, while the probability it is strain $B$ is $1 - \theta$. A cure exists at a cost $c$ which is 100 percent successful for strain $A$, but completely unsuccessful for strain $B$. Similarly, an inoculation is available at a price $\pi$ which prevents the individual from getting strain $A$ but not strain $B$. Straightforward application of proposition 5 implies that people may purchase the cure for $c$ dollars rather than the inoculation, even if the price of the inoculation is less than the expected cost of a cure ($\pi < \lambda c$). This implies that individuals' purchases of cures will yield smaller increases in life saving than will equivalent purchases of prevention activity.

The above example was constructed so that the cure would never be purchased if the prevention had already been purchased, since purchasing the cure would be redundant. This was necessary to apply proposition 5 directly. However, proposition 5 can be generalized to the case in which both the prevention and the cure may be purchased.
**Proposition 6:** Given the choice of buying prevention in advance or treatment once the disease is discovered, or both (or nothing), an individual may choose to purchase only the treatment, even though the prevention is more cost effective.

An interesting implication of proposition 6 is that the introduction of an ineffective treatment can induce people to cease prevention activities even though their expected outlays will go up and their expected survival chances go down. An extreme case of such behavior can be illustrated with another numerical example.

**Example 2**

Consider an individual with utility function $p \ln(x + 1)$, with $x = 10$. Assume he faces a probability $\lambda = 0.01$ of contracting a fatal disease. An inoculation exists that reduces this probability by 35 percent and costs $.09. A treatment is available at $9, which is effective only 5 percent of the time.

Even at these odds (with expenditure on the prevention seven times more effective than on the cure) the individual will choose to buy only the treatment, to be applied if he contracts the disease, thus yielding a survival probability of 0.9905. Yet if the treatment were not available, he would choose the prevention and have a survival chance of 0.9935. This demonstrates that some of the observed preference for treatment over prevention may be rational.
Public Policy Toward Life Saving

Example 3

Assume that the 25 individuals learn today of the risks described in example 1, but will not learn of the composition of the groups until the following week. Which program will they choose?

In example 3 each individual faces identical risks. The chance they will end up in group S is 0.4; otherwise they will be in group H. It can be shown that each such person would pay $1.79 for program S or $2.99 for program H.*

Thus, aggregate willingness to pay is $44.75 for program S and $62.31 for program H. This contrasts with the values of $60.50 and $42.75, respectively, once the composition of the groups is made known. Program H is preferred ex ante whereas program S is preferred ex post.

This change in preferences creates a dilemma. Even if one is committed to basing societal decisions on willingness to pay, there remains the question of which measure of willingness to pay should be used.

A profit-maximizing firm would solve this problem by selling the program at the time at which it could collect the most revenues, ex ante in this example. But in other cases it would wait and sell the program once all the information was available.

Which choice should society prefer? The ex ante choices are made in circumstances comparable to Rawls' "original position" in which decisions are made behind a "veil of ignorance"? Such choices have normative appeal since they amount to choosing the nature of the society in which the individual would rather live. Nonetheless, the choices made ex ante in our particular case have one peculiar feature. They lead to the decision to help the relatively healthy members of group H even though the members of group S are clearly worse off. If, instead, society should wish to maximize the welfare of the individuals that are worst off, as Rawls proposes, it might prefer program S. Yet consider the next example.

Example 4

A society yet to be formed will consist of two groups of equal size, each with the same initial survival probabilities, but with different wealth levels. Assume group R will be rich while group P will be poor. A program can be adopted to save one life from either group, but it must be selected before the assignment of individuals to groups is known.

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*To derive these willingness-to-pay figures, \( W_S \) and \( W_H \), we proceed as follows. Expected utility without any program is

\[
E_0 = (0.4)(0.2) \ln(11) + (0.6)(0.7) \ln(11).
\]

If they must pay \( W \) for program H, expected utility becomes

\[
E_H = (0.4)(0.2) \ln(11 - W) + (0.6)(0.8) \ln(11 - W).
\]

The maximum willingness to pay, \( W_H \), is found by setting \( E_0 = E_H \) and solving for \( W \). The value for \( W_S \) is found using the same procedure.
In this example individuals will prefer the program that saves one member of group R. Society chooses to save the rich! This is not due to the greater ability of the rich to pay, since the choice is made before the rich are rich. Rather, the decision is based strictly on individual calculations. Each individual faces 50-50 odds of being rich or poor. Nothing, according to our assumption, can be done to alter these odds. So the choice comes down to whether the individual wants high survival chances to coincide with higher wealth. According to our assumptions, that is the choice the individual will elect. This choice is even more inegalitarian than the choice made in example 3.

What can be said about the normative significance of life-saving choices on an *ex ante* basis; that is, without knowledge regarding the outcome for individuals. A logical case can be made both for and against the *ex ante* choice. First consider the arguments against.

(1) The choices have “bad” distributional outcomes.
(2) They ignore the ultimate willingness to pay of the most affected group after its members acquire the information regarding the distribution of risk.
(3) Later decisions are based on more information and thus should be “better.”

But the arguments in favor are:

(1) All choices made in the original position are in some sense egalitarian—in the sense that all individuals are equally ignorant of their ultimate fates. In this case, the individuals know that their risks will be distinguished by later developments, but they prefer to act in a way that may appear inegalitarian.
(2) The willingness to pay of the groups with low survival probabilities should be discounted, because their willingness is based in part on their slim chances of survival. Since they are likely to die, the dollars they are offering are in some sense worth less to them. It is only their inability to trade with the lower-risk groups that allows them to outbid those groups.
(3) The “information” that people will eventually acquire relates purely to the distribution of the risk; it says who will lose rather than how much will be lost. When choosing a course of action before they have that information, individuals are deliberately deciding to ignore the information. Knowledge in this case cannot improve the decisions.

How to Maximize Lives Saved While we do not necessarily advocate that the goal of public policy should be to maximize the number of lives saved, it is interesting to consider how it could be accomplished. It appears that if reasonable assumptions are made regarding the insurance and annuity markets, such maximization could only be accomplished through extensive government intervention. We have shown that a pure market system will lead those who are fatally ill to spend large amounts on ineffective, expensive treatments. Yet, before it is
known who will get sick, everyone would prefer to allocate health care expenditures on a very different pattern.

To avoid expenditures on life-saving activities with lower productivity, society would have to impose its decisions on the individuals concerned. One way to do so would be to enforce prohibitions against ineffective treatments. To be sure, lesser measures could be taken. Private health insurance companies or prepaid health care plans, for example, could exclude such treatments from their coverage. Such measures, however, would not prevent those enrollees who got sick from spending their own funds on ineffective treatments when they chose. Furthermore, such restrictive contracts would be complex and expensive. In fact, the existence of health insurance contracts as currently written probably exaggerates the effects described here since they provide the very sick with the means to satisfy their nearly unlimited desire for treatment.

It is interesting to note that one way insurance companies have limited expenditures on ineffective treatments is by placing an upper limit on total claims. This type of "shallow" coverage has been severely criticized. Yet our analysis suggests that a case could be made for imposing such limits if in fact they reduce the use of ineffective treatments. As a corollary, if the government provides insurance for health care in "catastrophic" situations, there may well be a sizable increase in expenditures on ineffective treatments.

Nevertheless, banning ineffective treatments is a policy of dubious value. Practically, it may be unenforceable (as the recent laetrile experience has suggested) and politically it appears to be both cold-blooded and meddlesome—a combination likely to anger liberals and conservatives alike.

Instead, costly ineffective treatments must be discouraged before they exist. One way to accomplish this seemingly impossible goal would be through policies regarding medical research and development. To that end, the expected cost per life saved could be used as one criterion by which research priorities are set.

CONCLUSION It seems appropriate to end this article with two warnings. The first, the basic theme of this article, is that seemingly irrational allocations of life-saving resources may be nonetheless consistent with the preferences of perfectly rational individuals. Thus, critiques of such allocation should be evaluated carefully. The second warning is to be cautious in deciding how much of the observed behavior is attributable to the factors analyzed here. The individuals we have modeled are mechanical expected-utility maximizers, more like robots than humans. More empirical research will be needed before we will be able to say whether the factors analyzed here are more or less important than those that are omitted, such as fear, anxiety, and concern for one's heirs.
APPENDIX We assume throughout that individuals are expected-utility maximizers with no bequest motive so they maximize $pU(x)$, where $p$ is the probability of survival, $U$ is the utility function with $U' > 0$ and $U'' < 0$, and $x$ is wealth. Willingness to pay for life saving, $V$, is defined as

$$
\frac{dx}{dp} = \frac{U(x)}{pU'(x)}
$$

that is, the rate at which the individual is willing to trade money for $p$, holding utility constant. Proposition 1 states that $V$ is inversely related to $p$. To show this we just differentiate $V$ with respect to $p$.

$$
\frac{dV}{dp} = -\frac{U(x)}{|p^2U'(x)|}
$$

This is negative as long as $p$ is a normal good (that is, the individual chooses higher $p$ as wealth increases).

Proposition 2 states that the amount of money necessary to compensate an individual for taking some risk $\phi_2$ does not depend on the level of other independent risks he faces, $\phi_1$. To show this, note that $(1 - \Phi_1)U(x)$ is the expected utility if discretionary risk is zero. Let $c$ be the amount of money necessary to compensate him (leave him just as well off) for accepting some discretionary risk $\phi_2$. Then

$$(1 - \phi_1)U(x) = (1 - \phi)U(x + c) = (1 - \phi_1)(1 - \phi_2)U(x + c)
$$

Hence $U(x) = (1 - \phi_2)U(x + c)$ which is independent of $\phi_1$, proving the proposition.

For propositions 3 and 4 we need some additional notation. Let there be $K$ health status cells which we will denote by $k$, $k = 1, \ldots, K$. Each health status cell has an associated survival probability $p_k$. In addition, let there be $N$ individuals denoted by $i$, $i = 1, \ldots, N$. The "aggregate information" available to individuals is denoted by $\{f_i\}$, where $f_i$ is the probability that a randomly drawn individual will be assigned to cell $k$. Clearly, $f_k$ is nothing more than the population rate.
If the only information available to individuals is the population rate, then each individual will view his probability of survival as being the same, given by

$$\bar{p} = \sum_k f_k p_k$$

We will refer to this case as the no-individual-identification case, $I = 0$. In this case the aggregate value of a life is given by

$$V_A(I = 0) = \frac{U(x)}{pU'(x)}$$

In this particular case, individual and aggregate concepts of $V$ are identical.

But now consider any other state of information denoted by $\{f_{ik}\}$, where $f_{ik}$ is the probability individual $i$ attributes to his assignment to cell $k$. We require a special form of coherence: If some individual believes that he is more likely than average to be assigned to cell $k$, then other individuals taken as a group must believe that they are less likely than average to be assigned to the cell; i.e.,

$$\sum_i f_{ik}/N = f_k$$

Thus, we consider changes in distributional information holding aggregate information constant. Individual $i$ attributes probability

$$p_i = \sum_k f_k p_k$$

to his survival, and $\bar{p}$ may be interpreted as the average survival rate.

The aggregate value of a life given this information is given by

$$V_A = \frac{1}{N} \sum \frac{U(x)}{p_i U'(x)}$$

$$= V_A(0) + \frac{U(x)}{U'(x)} \left[ \frac{1}{N} \sum_i \left( \frac{1}{p_i} - \frac{1}{p} \right) \right]$$

If we define individual identification $I$ as the bracketed term, the previous equation may be rewritten

$$V_A(I) = V_A(0) + \frac{U(x)}{U'(x)} I$$

Thus, $I$ is a sufficient statistic for this problem. Information that increases $I$ increases the value of a life.

It is quite simple to show that, given coherence, $I$ is bounded from below by zero and that any divergence from no distributional
information must increase \( I \). Furthermore, \( I \) is additive in the sense that moving from any state of information \( I_1 \) to \( I_2 \), the value of a life may be rewritten as

\[
V_A(I_2) = V_A(I_1) + \frac{U(x)}{U'(x)} \Delta I
\]

where

\[
\Delta I = I_2 - I_1 = \frac{1}{N} \sum_i \left( \frac{1}{P_{II}} - \frac{1}{P_{II}} \right)
\]

Other properties of \( I \) are most easily shown by example, which was done in Table 2. The preceding results are summarized by proposition 3.

In proposition 3 the aggregate value of a life was determined by taking a very specific weighted average of individuals’ values of a life. Namely, we assumed individuals gain an increase in the probability of survival of \( 1/N \) so that one life is expected to be saved. One way this could be accomplished operationally would be to increase the probability of survival by \( 1/N \) in each health status cell. Thus, the aggregate value of a life in this special case really refers to the value of a specific project, that we will refer to as the unidentified project \( I_p = 0 \). We adopt the notation

\[
\tilde{V}_A(I, I_p = 0) = V_A(I)
\]

We now consider the value of any project expected to save one life.

Let \( \{\delta_k\} \) represent the distribution of a project’s benefits across health status cells, defined so that \( \delta_k/N \) is the absolute increment in cell \( k \)'s associated survival probability. The unidentified project corresponds to \( \delta_k = 1 \) for all \( k \). All other projects can be summarized \( \{\delta_k\} \) subject to the constraint

\[
\sum_k \delta_k = 1
\]

which arbitrarily scales all projects so that one life is expected to be saved.

It is apparent that as long as there is no individual information then the value of all projects must be the same. No matter how various projects distribute their benefits across health status cells, there can be no distributional effect across individuals. All individuals have identical cell assignment probabilities and therefore must expect a gain of \( 1/N \).

If there is individual information, however, then there may be distributional effects. The value of the program, \( \tilde{V}_A' \), is given by the summation of individuals’ value of a life multiplied by the expected benefits attributed to the program by the individual, or
Algebraic manipulation yields

\[ \tilde{V}_A = \sum_i \frac{U(x)}{P_i U'(x)} \sum_k f_{ik} \frac{\delta_k}{N} \]

or defining the bracketed terms as \( I_p \) and expanding \( \tilde{V}(I, 0) \) back to \( V \),

\[ \tilde{V}_A(I, I_p) = V_A(0) + \frac{U(x)}{U'(x)}(I + I_p) \]

\( I_p \) in this equation is the covariance between the (reciprocal of) initial survival probability and the distribution of the expected gain. \( I_p \) may be interpreted as the extent to which those with the lowest initial survival probabilities expect to gain relatively the most. These results were summarized as proposition 4.
The proof of proposition 5 was sketched in the text and so needs only be formalized here.

Labeling the three options as in the text, the expected utility of each is

\[ E_1 = (1 - \lambda)U(x - \lambda c) + \lambda \theta U(x - \lambda c) \]
\[ E_2 = (1 - \lambda)U(x) \]
\[ E_3 = (1 - \lambda)U(x) + \lambda \theta U(x - c) \]

Note that these expected utilities are just numbers so an intransitivity is impossible. As we pointed out in the text, \( E_3 \) must be preferred to \( E_2 \) since \( E_3 = E_2 + \lambda \theta U(x - c) \) and the second term is positive as long as \( c < x \), which has been assumed. Now compare \( E_1 \) and \( E_2 \). Note that if \( \theta = 0 \) then \( E_1 = (1 - \lambda)U(x - \lambda c) < (1 - \lambda) < (1 - \lambda)U(x) = E_2 \). If the cure is completely ineffective, then the purchase of insurance lowers the individual's wealth without raising the chances of survival. Clearly, there will be some \( \theta^* \) such that \( E_1 = E_2 \), but for any \( \theta < \theta^* \), \( E_1 < E_2 \). In this case we shall have \( E_3 > E_2 > E_1 \). Q.E.D.

The key role of \( \theta \) is illustrated in Figure 1. If \( \theta < \theta^* \) insurance is actually worse than the "die if sick" option 2. Not until \( \theta > \theta^* \) will the individual prefer to pay for insurance rather than for the cure.

The proof of proposition 6 is similar to that for proposition 5 but is too long to be included here. It is available from the authors upon request.

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NOTES

1. Cited in Rhodes, Steven E., "How much should we spend to save a life?" The Public Interest, Spring 1978.
2. For an analysis of these issues see Zeckhauser, Richard, and Shephard, Donald, "Where now for saving lives?" Law and Contemporary Problems, 40 (Autumn 1976): 5–45.
Bergstrom, and Edward Rappaport (School of Engineering and Applied Science, University of California, Los Angeles, 1974).


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Announcement and Invitations for Nominations

The David N. Kershaw award has been established to honor persons who, at under the age of 40, have made a distinguished contribution to the field of public policy analysis and management. The award will be given every other year starting in October 1982 through the Association for Public Policy Analysis and Management. The award consists of a medal and a $5,000 prize.

Nominations will be considered by a committee appointed by APPAM, and must consist of a nominating essay, the vita of the nominee, and written evidence of the nominee's contribution in the form of an article, book, report or other appropriate evidence of the nominee's contribution. The latter requirement is to provide convincing evidence of the nominee's responsibility for the contribution identified. Joint awards for a single contribution will be considered where the jointness of the contribution can be clearly identified.

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