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# WHERE NOW FOR SAVING LIVES?\*

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## INTRODUCTION

Many of the most pressing decisions of society directly or indirectly involve the saving or expenditure of lives. Energy planning, national health insurance, and occupational health and safety regulation, indeed national defense policy, represent major issues that invariably bring us back to the question: Which lives should be saved? Or, to reflect the process of lifesaving more accurately, the question might be rephrased: Where should we spend whose money to undertake what programs to save which lives with what probability?<sup>1</sup> Ten years ago, merely asking this question explicitly would have seemed unethical or at least repugnant to many, though its central issues, of course, were addressed implicitly in a whole range of individual and collective decisions. Today variants of this question are studied by theologians and sociologists, as well as economists and policy makers. The question of how lives should be valued is now an acceptable one for intellectual discourse, though it is true that for some the answer cannot come through academic discovery processes.

Why has it proved so difficult to frame a mere question of value: What is a life worth? Some factors can be speculatively identified. First, unlike traditional economic commodities, there is only the slightest degree of standardization for lives. Second, unlike most commodities we value, lives are not bartered on markets. Indeed, it is against the law to sell them. Third, and perhaps partially explaining the second, the question of whose life should be saved at what cost involves many of the most fundamental value issues in our society.<sup>2</sup> Fourth, there are many different producers of the commodity “in-

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2. Hence we may expect society to take a much stronger interventionist role in promoting its citizens' health than in promoting, say, their recreational enjoyment. Our transfer programs for the poor are particularly oriented towards medical resources. At times we are too self-congratulatory when we attempt to promote the health of the poor. In this context it is worthwhile to ask how much we are willing to hurt the poor in order to make a directed transfer for their health, rather than a general transfer.

creased probability of preserving a life." An individual can do it for himself; we can impose traffic laws and vaccination regulations to help protect him from other individuals; society can provide incentives to induce him to preserve his own life. Finally, through a variety of societal programs his life can be saved for him.<sup>3</sup> There are numerous other factors awaiting cataloguing in an eventual intellectual history of the lifesaving discussion.<sup>4</sup>

## I

### PROGRESS AND THE PRESENT SITUATION

For this history, a fundamental question should be: What have we accomplished by bringing lifesaving discussion out into the open? There are two possibilities: First, a rationalized policy choice process might have shifted outward the production possibility frontier specifying the available combinations of lives saved and dollars available for other purposes. With this shift, more of both can now be obtained.<sup>5</sup> Second, along any given frontier, we might have shifted the mix of lives and dollars to accord more closely with the valuations of the members of society. For example, if it turned out we had been substantially undervaluing lives, we could significantly improve well being by allocating more of our scarce resources to lifesaving.<sup>6</sup>

It would be difficult to document marked progress in either of these areas. A fully efficient or rational allocation of resources would be impossible, given the vast array of complicating institutional factors that affect resource allocation decisions, and it should be viewed more as a goal to be pursued than as a constraint to be satisfied. Still we might expect to be able to identify,

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3. We should perhaps admit at this point in the paper to a generally positive bias: We shall be talking about saving lives, when we could just as easily discuss expending them. Our choice of convention in this matter does not reflect any belief that more money should be spent on lifesaving in our society. It is just that it is more comfortable for us, as it has been for most analysts in the past, to speak of saving lives rather than expending them.

A set of fascinating and important questions revolves around the question: Where do the baselines lie for obligations with respect to the saving of lives? We seem to believe that there is a big difference between taking lives and not saving them, yet in many circumstances we do not have clear guidelines to distinguish, or benchmarks to divide, the two types of processes.

4. For useful literature surveys in this area, see J. LINNERTHOOTH, *THE EVALUATION OF LIFESAVING* (1975); Acton, *The Value of Life: An Overview and Critique of Alternative Measures and Measurement Techniques*, 40 *LAW & CONTEMP. PROB.* no. 4, at 46 (1976).

5. This innocuous sounding gain may not be innocuous at all. To make such an efficiency gain we may be sacrificing some probability in the life of one individual to secure a more than compensating gain for another individual. (This assumes the lives of all individuals are valued identically.) This need not be a situation of identified versus unidentified lives. It may be drivers as opposed to diabetics, or miners in contrast to overweight individuals.

6. The famous, perhaps notorious, Disease Control Memo was one of the first places where the costs of saving lives in various ways was tallied. U.S. DEP'T OF HEALTH, EDUCATION, AND WELFARE, *PROGRAM ANALYSIS—SELECTED DISEASE CONTROL PROGRAMS* (1966). Supposedly, following the dictates of cost-benefit analysis, we should merely start at the top of the list and push each project until its marginal lives saved per dollar equalled some target amount. This is discussed further in the section titled Marginal Versus Average Problems. See notes 55-56 *infra* and accompanying text.

say, half a dozen areas in which particular programs were discontinued because they were insufficiently productive in the saving of lives.<sup>7</sup> Conceivably we could generate anecdotal evidence in support of the contention that we had shifted along the feasibility frontier, saving lives at the expense of resources that would be devoted to other purposes. We now allocate a much greater percentage of our economic resources to medical care than we did a mere decade ago.<sup>8</sup> Related expenditures for health-promoting activities, for example to meet the standards imposed by environmental protection or occupational safety and health legislation, have increased dramatically as well.<sup>9</sup>

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7. Perhaps the examples that come closest to this paradigm involve renal dialysis. Many analysts have examined this issue and questioned whether the lives saved justified the resources expended. We suspect, though we can offer no evidence, that they may have been more impressed by the total dollars involved than they were shocked by the dollars per life year saved. There are at least two good additional reasons why renal dialysis might receive particular attention. First, the lives that are saved are substantially below average in quality. Most analysts are now agreed that such lives should in some sense be valued less highly. Second, renal dialysis may serve as the opening wedge for other, even more expensive, technologies for saving lives. It is noteworthy in this regard that the federal government now pays practically all costs of renal dialysis.

A number of individuals are now looking to a variety of new medical technologies to see whether the benefits they convey are worth the rather extraordinary costs they entail. (Both sets of quantities, of course, are difficult to tally.) For example, Dr. Lee Lusted of the University of Chicago is looking at the use of diagnostic X-rays to see how often they provide information that is useful or critical in diagnosis. Dr. Harvey Fineberg at Harvard is conducting an in-depth study of computer-assisted tomography, an expensive procedure for generating what is in effect a three-dimensional picture of the brain. The Lusted and Fineberg investigations start with the recognition that present incentives for medical practitioners do not encourage them to follow anything approximating traditional benefit-cost criteria when deciding whether to order some expensive test. The result, of course, is dramatically inflated costs.

The critical policy question in relation to these technologies, among others, is how we should regulate their use, recognizing explicitly the inevitable weaknesses of any administrative mechanisms we might develop to allocate them to specific classes of patients and tasks.

8. Many will say this merely reflects a change in technology. But advances in technology, from an efficiency standpoint, merely shift outward the frontier of lives saved versus dollars available for other purposes. It may not be a proportional shift, and we might wish to investigate what the substitution and income effects would be for various types of technological change.

Given our increased expenditures of dollars, we should be getting substantially more lives or we must have come to value lives more highly (perhaps they have a high income elasticity of demand) and "bought" expensive ones at the margin, or we may have pursued a disadvantageous reallocation, or there may be a secular trend at work making it more expensive to save lives at the margin.

We might identify a concern for distributional equity as a motivating factor for our policy choice. At least as far as inputs are concerned, the poorer members of society are receiving a great deal more to promote their health than they did only a decade ago. (Before drawing any firm conclusions, we should investigate what has happened over this period to other factors that work to enhance or destroy the health of this particular group.)

9. Here too, it is possible that merely informational changes could make a difference. If we merely knew that one of ten substances, each of which would cost us one million dollars to give up, was a carcinogen leading to ten deaths per year we might decide it was not worth it to give up all ten. But if scientific investigation could narrow the list to two, then we might decide to ban both substances. Some strong supporters of the environmental movement would claim its successes were achieved because large groups of people finally discovered what pollution was costing us, that is, they were able to prove that prior estimates used for policy purposes had been biased downward.

Table 1 shows our expenditures now (1973, the most recent year for which complete statistics are available) and then (1965) on various types of medical resources, and displays some key health indicators. Other health-promoting developments, such as the more than 30 per cent gain in real per capita disposable income, reduced smoking, particularly among adult males, and better nutrition and nutritional habits should share the credit for any health gains.<sup>10</sup> Any foregone pleasures associated with such developments should also be tallied when we assess the benefits and costs inherent in our intensified efforts to enhance health and prolong life.

Progress in the livesaving area then, where we can find it, is of two types: (1) a better intellectual understanding of the problem we confront and a greater willingness to discuss it; (2) policies that better accord with the values of the members of society. We are now experiencing a flurry of activity in these two areas. As this symposium and a number of others held recently attest, some quite sophisticated attention is now focused on the valuation of life. We would suggest that this intellectual activity reflects a logical process of summing up and drawing loose ends together. Much current work consists of bringing the general insights of the past to the point of application.

#### A. Where Should We Go From Here?

The decisions of a society must reflect the interests and values of its citizens. Where such a delicate issue as lifesaving is involved, those citizens may be as much concerned with the processes through which decisions are made as with the consequences of those decisions. The need to have equitable and widely accepted procedures for formulating policies in this area was the subject of a previous essay;<sup>11</sup> it will not be dealt with here. We divide the analytical aspect of the lifesaving decision process into four areas: (1) *Prediction and the provision of information*. What levels of outputs can we expect alternative policies to generate; what levels of inputs can we expect them to consume? (2) *Valuation*. What values do we attach to the inputs to and outputs from our

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A number of groups within our society, *e.g.*, the citizens of California who voted on (and defeated) Proposition 15 in June 1976, are making choices with regard to the pursuit of nuclear power. The choice for or against nuclear power, or rather whether to pursue it vigorously, modestly, or sluggishly, in effect reflects a tradeoff between lives and dollars. The debate is cast in rather different terms, with the proponents of nuclear power suggesting not that they have a different tradeoff rate, but rather that the process is safer than their opponents will admit, and that the appropriately computed dangers of competitive electricity generating processes are more significant than is usually recognized.

10. For further data, see Fuchs, *Some Economic Aspects of Mortality in Developed Countries*, in *THE ECONOMICS OF HEALTH AND MEDICAL CARE* 174-93 (M. Perlman ed. 1974); D. Shepard, *Disability and Medical Costs for Disease Associated with Hypertension* (1975) (unpublished paper on file at Center for the Analysis of Health Practices, Harvard School of Public Health). Fuchs provides a provocative case study, comparing Utah and Nevada, showing that lifestyle differences can account for significant mortality differences. Fuchs, *supra* at 189.

11. Zeckhauser, *Procedures for Valuing Lives*, 23 *PUB. POLICY* 419 (1975).

TABLE I  
SELECTED MEASURES OF RESOURCE USE AND PERFORMANCE IN THE  
HEALTH CARE SECTOR, 1965 AND 1973.

	1965	1973
<i>Resource use:</i>		
Expenditures per capita:		
in current dollars	188	432
in constant (1965) dollars (using implicit GNP deflator)	188	310
as percent of GNP per capita	5.9	7.7
Active physicians, engaged in patient care <sup>a</sup>	1.34	1.41
Persons employed in health occupations <sup>a</sup>	13.95	16.16 <sup>b</sup>
Short-term hospital beds <sup>a</sup>	3.83	4.30
<i>Outcome measures:</i>		
Life expectancy in years		
at birth	70.2	71.3
at age 1 year	70.9	71.6
Infant mortality rate (per 1,000 live births)	24.7	17.7
Days of disability per capita, age adjusted <sup>c, d</sup>		
restricted activity	16.3	16.2
bed disability	6.6	6.3
Number of acute conditions per year <sup>c, d</sup>	2.1	2.2
Annual days of work loss per person in the currently employed population <sup>d, e</sup>	5.8	5.3
Annual days of school loss per person of school age <sup>d, e</sup>	5.3	5.3

<sup>a</sup> Per 1,000 population.

<sup>b</sup> Interpolated from earlier projection for 1975.

<sup>c</sup> Age adjustment by two categories for which data reported, under age 65 and 65 and above.

<sup>d</sup> Averaged with two preceding years to reduce year-to-year and sampling variability.

<sup>e</sup> For civilian non-institutionalized population.

Source: Adapted from U.S. Bureau of the Census, STATISTICAL ABSTRACTS OF THE UNITED STATES, 52, 54, 66, 67, 76, 83 (1967); *id.* at 60, 63, 69-71, 74, 80, 85, 416 (1975).

policies? (3) *Accounting*. How should we tote up these values so that we neither misinterpret a quantity, miss anything of value, nor double count? (4) *Incentives and the assignment of decision making to the appropriate party*. Recognizing the interests of all affected parties and the likely differential access to information, who should be making the decisions, and what incentives will be required to induce them to make the appropriate decisions?

We do not attach any hierarchy of importance to these questions; like the four legs of a stool, each contributes to a common endeavor. The valuation question, the one that was the most difficult to confront ten years ago, has undoubtedly received the greatest attention in the interim from economists

and analysts, certainly when judged in relation to the definitiveness of the answers and the degree of refinement of methods that can be expected. It continues to offer an abundance of intriguing intellectual issues (a number of which are addressed in other papers in this volume). Here we shall attempt to promote interest in and demonstrate the potential for investigations relating to the other three classes of issues, for we believe that: Future progress in formulating effective policy regarding lifesaving activities will require significantly greater attention to questions of prediction, accounting and incentives.

In support of our statement we shall now outline some issues in and approaches to these three areas.

### B. Unresolved Differences in Predictions

Many of the important policy issues which affect lifesaving are the subject of spirited policy debate. What sort of health system should we have in the United States? How should we generate electricity? We suggest that the most significant disagreements involved in these debates could be resolved if we had the ability to make more accurate predictions about the health, dollar, and other consequences of alternative policies.<sup>12</sup> It is not differences in tradeoff rates that lead the proponents and opponents of nuclear power to their conflicting policy conclusions. Rather, those two parties provide quite different estimates of the potential costs of nuclear power, measured in terms of both dollars and the probabilities of loss of health and life.<sup>13</sup> Similarly, the advocates of some form of prepaid comprehensive coverage health insurance differ from those who support a fee-for-service system in their predictions about the ultimate consequences on medical care costs and the efficacy of the care ultimately delivered. The arguments of either camp would be refuted, if the predictions of the other could be shown to be accurate.

Milton Friedman, whose views on economic policy frequently diverge from the mainstream, made an equivalent point, "Differences about economic policy among disinterested citizens derive predominantly from different predictions about the economic consequences of taking action—differences that in principle can be eliminated by the progress of positive economics—rather

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12. At first glance, some of the valued consequences, say dependence on foreign oil, lie far afield from the primary subject of study in this article.

13. It is surely true that values correlate with probability estimates. (Causality probably runs in both directions.) In an ideally objective world they would not. However, to influence policymakers and the public, these individuals must present their probability estimates of outcomes, not their subjective valuations of these outcomes. Thus, improved predictive capability would help resolve policy debate.

The particular issues that are emphasized in debate may also reflect some degree of bias. Whereas the opponents of nuclear power may bemoan the loss of civil liberties entailed by efforts to safeguard fuel and facilities, its proponents may applaud the likelihood that with a lessened dependence on foreign oil, morality will be of greater concern in the formulation of our Middle Eastern policy.

than from fundamental differences in basic values, differences about which men can ultimately only fight.”<sup>14</sup>

Our interest in improved prediction reflects a desire to pursue issues that can be resolved in preference to those that can merely prolong debate. It is our belief that many policy issues, on both a macroscale and microscale, could be effectively resolved if our predictive capabilities were improved.

### C. Appropriate Measures for Outputs

One reason why we frequently observe conflicting predictions is that we have no commonly accepted measures for the outputs of alternative policies. The benefits of policy *A* may be measured in lives saved; those of *B* in years of life preserved. These are just not comparable or convertible units. Moreover, when we attempt to assess the two policies in comparable units, we may find that one policy is preferred if one unit is employed, and the other if another measure is the norm. In the analyses that follow, we provide a number of summary measures for each policy to illustrate that discrepancies of this sort are likely to arise.

A number of criteria could influence the choice among different output measures. The guiding principle should be to select the measure(s) that would predict the choices that an informed individual would make for himself. In effect, we are considering an individual standing at a node in a decision tree, choosing among alternative lotteries on quality and quantity of life. To choose a path, he would assign a utility to each possible outcome. The summary measure we are looking for, then, is in effect his utility function.

#### 1. *Quality Adjusted Life Years: QALYs*

We shall employ a hypothetical utility function in our analyses. The unit of output will be quality-adjusted life years, to be referred to by the acronym QALY.<sup>15</sup> It will be tallied on a year-by-year basis, with QALYs received in year *i* indicated  $q_i$  and the stream of QALYs as  $q_1, q_2, \dots$

QALYs could be computed on a variety of arbitrary scales. In order to gain a number of useful properties, we propose they be calibrated using von Neumann-Morgenstern utility, in the manner illustrated by the following example. Assign a year at full function a utility of 1, and a year without life a utility of 0. An individual has a choice between living the rest of his life with a specific impairment or having an operation. The operation has a probability  $x$  of restoring full function (this will not extend his lifespan, however), and a probability  $1-x$  of being immediately fatal. The value of  $x$  that would leave the patient indifferent between having and not having the operation is the QALY

14. M. FRIEDMAN, *ESSAYS IN POSITIVE ECONOMICS* 5 (1953).

15. Our term QALY is a variant of Robert Inman's suggestion to us of quality-adjusted citizen year (pronounced quacky), which we felt to be fowl usage.



level for his particular level of impairment. When an alternative will affect different years in different manners, the utility value for each year must be scaled separately.<sup>16</sup>

We shall assume that the utility function applied to the QALY stream can be written in the additive, separable form<sup>17</sup>

$$U(q_1, q_2, \dots) = v_1(q_1) + v_2(q_2) + \dots$$

If, as we have specified, the  $q_i$  values represent von Neumann-Morgenstern utilities, then this valuation function is appropriately written

$$v_1(q_1) + v_2(q_2) + \dots = k_1q_1 + k_2q_2 + \dots$$

That is, it must by definition be a linear function of the QALYs received in the individual periods. This form dictates that individuals will have constant rates of tradeoff between QALYs received in two different years: they will have straight line indifference curves. (The rate at which an individual will exchange QALYs received at age thirty for those received at age fifty will not depend on the QALYs already secured at those ages.) This is an important result. It implies that the structure of an individual's preferences will be the exclusive determinant of his tradeoff rates for QALYs received at different times; the opportunities available for exchanging QALYs in different periods will not matter.<sup>18</sup>

Let us look at a hypothetical, costless medical procedure using the QALY analysis. (Resource costs to the individual could be included in the calculations by including consumption levels as a determinant of the quality of life, hence the  $q$  value, within a period.) An individual has a maximum lifespan of two years. There is a .4 chance he will die at the end of the first year whether or not he undergoes the procedure. The QALY level for death is scaled to be 0.

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16. This formulation assumes that utility function within a year, both in terms of tradeoffs among attributes (if there are many) and in terms of preferences among lotteries, does not depend on the values of attributes in other years. Age may be a factor in quality of life, in which case the calibration of utilities would have to be done separately for each year.

Fanshel and Bush employ the closely related concept of dysfunction level as a health status index. Fanshel & Bush, *A Health Status Index and its Application to Health Services Outcomes*, 18 OPERATIONS RESEARCH 1021 (1970). Torrance reviews the use of a variety of health status indices. Torrance, *Health Status Index Models: A Unified Mathematical View*, 22 MANAGEMENT SCI. 990 (1976).

17. This form is implied by the assumption of marginality: multi-attribute lotteries can be valued based only on the marginal distributions of their attributes. See R. KEENEY & H. RAIFFA, DECISIONS WITH MULTIPLE OBJECTIVES: PREFERENCES AND VALUE TRADEOFFS 230-31 (1976).

18. With dollars, quite by contrast, productive opportunities may be the sole determinant of tradeoff rates between time periods. An individual who faces an interest rate that does not vary with the level of his transactions on the capital market, will have a straight-line opportunities locus. Barring corner solutions, he will adjust his claims in successive periods so that his marginal rate of tradeoff equals the absolute value of the slope of this locus, which is one plus the rate of interest. Moreover, if all individuals have the same market opportunities, they will all exchange dollar claims in different time periods at the same rate. This will substantially simplify social choice procedures.

The procedure, which may be conducted at the beginning of any year, entails a mortality rate of .2. If the procedure is a success it will restore the individual to full function, so that  $q_1 = 1$  and  $q_2 = 1$ . In the absence of the procedure, the individual will have a QALY level of .9 the first year and, should he survive, a QALY level of .7 in the second year. Consistent with von Neumann-Morgenstern utility, the QALY value in a period is computed as an expected value. That is, it is a weighted average of the  $q$  values for the different outcomes, with the probabilities that the respective outcomes are achieved employed as weights. The individual's alternative lotteries are shown in Table II. The procedure should be undertaken at the beginning of the second year. The QALY stream for that alternative dominates the other two streams.

TABLE II  
AN INDIVIDUAL'S QALY STREAM FOR THREE HYPOTHETICAL CHOICES

<i>Outcomes</i>	<i>No Procedure</i>		<i>Procedure First Year</i>		<i>Procedure Second Year</i>	
	<i>Prob-ability</i>	<i>QALY Stream</i>	<i>Prob-ability</i>	<i>QALY Stream</i>	<i>Prob-ability</i>	<i>QALY Stream</i>
Survive both years	.6	[.9, .7]	.48	[1, 1]	.48	[.9, 1]
Die at end of year	.4	[.9, 0]	.32	[1, 0]	.4	[.9, 0]
Die from procedure first year	—	—	.2	[0, 0]	—	—
Die from procedure second year	—	—	—	—	.12	[.9, 0]
Overall QALY stream		[.9, .42]		[.8, .48]		[.9, .48]

Source: Hypothetical illustration.

In many situations of policy choice there will not be a dominant alternative. The  $q$  values for different years will have to be weighted by the appropriate  $k_i$ 's to determine a preferred policy. What patterns these  $k_i$ 's should assume is difficult to state. Should quality of life be subject to time impatience? For example, if there were to be one year of pain and one of full function, would it be better to have the pain year come second? If so, the  $k_i$ 's must decline over time. (Strong anxiety considerations, which might lead to a reverse valuation pattern, would be at variance with the assumed independence of  $q$  values between time periods.) Some individuals may have preferences that would call for the discounting of period QALYs. Certain stationarity assumptions would be required to assure that  $k_i/k_{i+1}$  is invariant to time, in which case the implied discount rate could be computed by comparing various streams of QALYs.

A government policy maker choosing among alternative health-promoting policies should look to their consequences for individuals' QALY streams. Individuals will be affected differently because they differ with regard to their

situations and their preferences. Portions of many of the lotteries on life quantity and quality will have already been run at the time policy choices must be made. For example, the forty-year-old has already escaped infant mortality and the years of high auto fatalities in the teens and early twenties.<sup>19</sup> Dramatic, short-term gains in air quality as opposed to equally costly, more modest long-term improvements will yield the greatest relative QALY benefits to elderly individuals. Among individuals of the same age, smokers will benefit differently than non-smokers.

Preference differences among individuals may relate to scalings of QALYs, or to rates of time preference. If one individual takes much greater risks than another, say by riding a motorcycle for pleasure, we cannot infer whether he has a higher discount rate for QALYs, whether he assigns a lower QALY level to a life without the exhilaration of motorcycling, or whether both factors are at work. (A further possibility is that he takes greater present chances because he has lower probabilities of future survival.)

Consistent with the liberal dictum that social welfare should be solely the amalgam of individual welfares, we would argue that individuals' QALY streams should be aggregated using their personal weights. How should these aggregated individual QALY totals, indicators of individual welfares, be combined to give a total welfare indicator? Welfare economics provides us with a negative answer: no unambiguous procedure can be discovered. This suggests that if criteria are to be developed for policy choices affecting quantities and qualities of life, some simplifying assumptions will have to be invoked. In the analyses that follow, it is assumed that all individuals assign the same QALY

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19. Individuals' attitudes toward various risks may change dramatically over their lifetimes. Many a middle-aged person says not only that he wishes he had not smoked when he was young, but that knowing what he does now, the pleasures then were not worth the present health risks.

Individuals may even violate one of the fundamental principles of dynamic programming. If their preferences will change over their lifetimes, their plans at age forty may diverge from what they would have intended for themselves when they were age twenty. It is almost as though a new person comes in to control the decision nodes. Conceivably we could preserve the forward-looking optimality principle of dynamic programming if we assumed that the young man would say to himself: What should I do now, given my present preferences, knowing that at a future time I will change my preferences and take actions that I would presently not prescribe for myself. If this approach is followed we may have a peculiar anomaly. The individual may have a plan that always folds back in an optimal fashion, yet is inferior to another available plan for any of the utility functions the individual will ever possess.

The same type of problem may apply to decisions affecting intergenerational welfare. Consider a situation where each generation weights its welfare relative to the total discounted (at rate  $r$  per generation) welfares of all future generations in the ratio of  $A$  to 1. The nasty reality of generation selfishness is reflected by  $A$ 's value in excess of 1. This implies that generation 1 will tradeoff between generations 2 and 3 at a different rate,  $1:1+r$ , than will generation 2, whose rate is  $1:A(1+r)$ . Each generation will have an incentive to skimp on its bequests because it cannot bind future generations. (Among the more important bequests we might leave is an environment relatively free of contamination or a supply of non-replenishable natural resources.) A suboptimal bequest stream will be the result.

In this analysis we are not concerned with intergenerational weighting problems, nor with altruistic valuations of QALYs received by others.

values to equivalent circumstances of age and health condition; that their preferences are such that QALYs received in different years should be discounted at a constant rate; and that QALYs returning to different individuals should be weighted equally. Given these assumptions, the appropriate measure for the output of a health-promoting program is the total gain in discounted QALYs it provides to all members of the population.

#### D. Life Saving in the Context of Present Policy—A Model That Incorporates Prediction and Valuation

What should we do with our measure once we have it? A simple supply and demand diagram may prove useful in helping us keep our thinking straight on some of the issues to be considered below. The supply curve in Figure 1 represents alternative ways to secure one additional QALY. Following the cost-benefit approach, and leaving aside the possibly important question of who receives the years and who pays for them, we would wish to start by purchasing the lives that are cheapest. We would continue purchasing these quality-adjusted life years until the last unit purchased just cost us the amount we were willing to pay for it. If that socially optimal amount is  $V_1$ , then we would purchase up to but not beyond point  $A$ .

There has been a great deal of discussion, as we have mentioned, about the way  $V_1$  should be defined.<sup>20</sup> However fascinating the discussion, the diagram shows that it may not be of great operational importance. If the supply curve for lives available is quite inelastic in the range of values under consideration, neither the total number of life years nor the total amount spent on preserving life years will vary dramatically if the value placed on a QALY is, say, increased by 70 per cent to  $V_2$ . Therefore, even if we were to thrash out disagreements on which measures of life valuation are appropriate, or on how they should be estimated, we would not substantially improve performance on

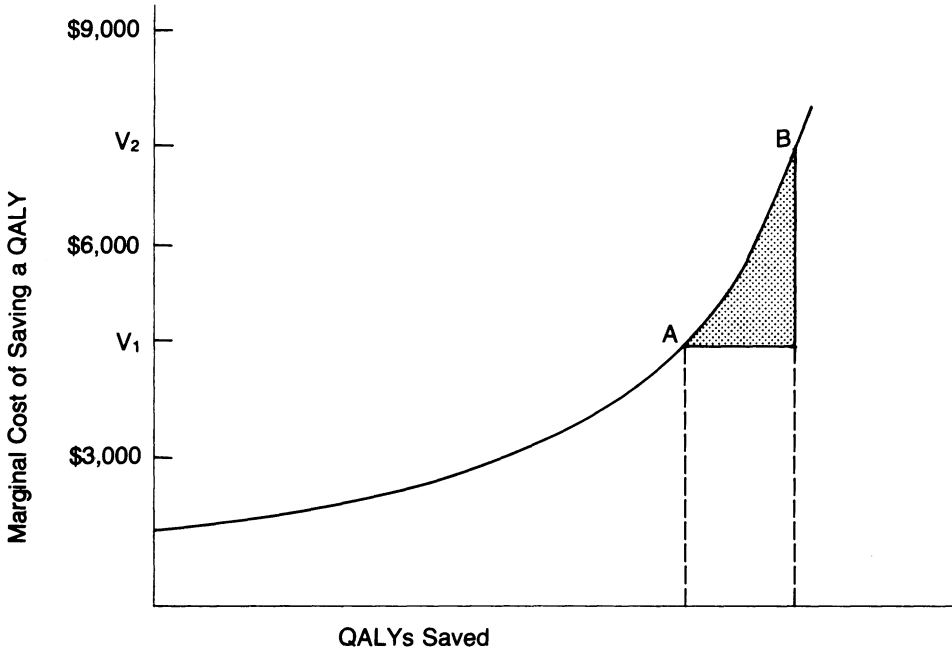
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20. Actually the discussion has been directed to a larger unit of aggregation, the remainders of a life. Many American discussions of the value of a life give numbers somewhere between \$140,000 and \$900,000. See J. LINNERTHOOTH, *supra* note 4, at 10. To convert lives to discounted QALYs we must divide through by the number of discounted quality-adjusted life years saved per life saved through a program. See Table III *infra*, for representative conversion calculations.

It is sometimes proposed that we should look at individuals' personal lifesaving decisions to infer the value they attach to quantities of life years. Actually, individuals have relatively few situations in which they can pay money to save their own lives. Most of the ways by which individuals can save their own life years involve giving up something directly pleasurable, not money. Thus, we might eat less, drive more slowly, or give up smoking. Clearly most of us have more significant experience with this type of tradeoff, and probably understand it better than, say, purchasing an electrocardiogram.

If we used survey questionnaires, we might inquire about an individual's life valuation indirectly: Assuming you were now overweight, how much would we have to pay you on a continuing basis to reduce your weight by some small amount? This might yield a more meaningful answer than inquiring how much one would pay for the availability of a particular device or medical treatment that might lower the probability of death by the same amount as the weight loss.

FIGURE 1  
SUPPLY CURVE FOR QALYS



Source: Based on authors' simulation.

our implicit objective function. (For example, if our true valuation were  $V_1$ , but we mistakenly employed  $V_2$ , the shaded area in the diagram would be the cost of our error.)

E. Saving Expensive Life Years Before Those That are Less Costly: Misordering

Even if the relevant portion of the supply curve is inelastic, we might still reap substantial gains through careful and thoughtful attention to decisions for saving lives. The primary difficulty with present decisions, we would argue, is that we are not proceeding smoothly up the supply curve; that is, we are not saving the expected life years that become available to us most cheaply.

The issue of "incorrect" ordering for lifesaving has been flagged and flogged in connection with the assertion that we spend much more to save "identified" rather than we do to save "statistical" lives. Whether this out-of-line ordering results in the sacrifice of a great number of life years, of course, depends on whether there are large numbers of identified lives that are saved

at high prices.<sup>21</sup> The most frequently cited example is renal dialysis, now estimated to cost approximately half a billion dollars a year.<sup>22</sup> (Though an impressive amount, it is less than one half of one per cent of our total health expenditures.) There is now speculation that the availability of an artificial heart could make it possible to save a number of identified, salvageable lives through a disastrously uneconomic process. If so, we would expect that a public sacrifice of the belief that we will spare no expense to save a life will be required.<sup>23</sup> At the present moment, it is our impression that there is not a monumental efficiency problem in what Howard Raiffa has called the murdering of expected life years due to the failure to get straight society's values and/or its valuations of life years.

### 1. *Misordering Due to Differential Accountability*

We would assert that, for at least two quite different sets of reasons, we are suffering grave losses in expected life years for the monies we are expending. The problem of differential accountability arises because the penalties and rewards that return to public decision makers are far from proportional to the benefits that those decision makers generate. This may be particularly true for lifesaving decisions, for these are likely to involve the rather distinctive reward of a free conscience for the decision maker. In some lifesaving circumstances, the chain of causality will be fuzzy and distended, and accountability minimal. In others, particularly where public consciousness has been heightened or identified lives are involved, the consequences of decisions may be highly visible, patterns of causality strongly sketched, and a decision maker subject to ready penalty for lost lives that can in some way be tied to his policy choices.

Accountability for expenditures will compete with accountability for lives in either circumstance, but we would expect that the variability in levels of dollar accountability would be somewhat less than that for lives. This suggests

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21. As a technical aside, it should be understood that even if there were a large number of such expensive lives being saved, the sacrifice in efficiency would not be great unless there were many statistical lives that were available on a much less expensive basis.

22. Some observers point out that we spend exorbitant amounts to add a few weeks or months to the life of many elderly individuals. We would argue that a different phenomenon is at play here. We have a health care reimbursement system that can not distinguish among values of outputs when deciding on reimbursement levels for hospitals and physicians. Our malpractice system reinforces our reimbursement practices for physicians and hospitals in discouraging the doctor decision maker from balancing health benefits against the resource costs incurred producing them.

23. Elsewhere in this essay we comment on the use of computer-assisted tomography, a diagnostic technology requiring a half-million dollar installation. The potential danger for efficient resource allocation with computer-assisted tomography relates to its widespread use in potentially low payoff situations. It introduces a new element into the identified-statistical debate. Its beneficiaries, patients undergoing tests, are identified, but most of the conditions that will be tested for may be low probability events. They are individuals identified as being at much higher risk than the general public, but still they are at low risk.

that the stronger the emphasis on accountability in lifesaving decisions, the greater will be the willingness of public decision makers to sacrifice dollars to save quality-adjusted life years. The result will be uneven tradeoff rates across lifesaving decisions and both fewer QALYs and fewer dollars than would be generated by consistent choice procedures.

The differential accountability problem, alas, does not yield to ready solution. Some progress might be made if we could decentralize decisions and let individuals make their own QALY-dollar tradeoffs, an approach we shall advocate later. For those decisions that are inevitably subject to centralized control, proposals for beneficial reform seem more pious than promising. Even recognizing this, we suggest that accountability for both dollar expenditures and lives should be strengthened in those areas of lifesaving activity where it is presently weak.

## 2. *Misordering Due to Poor Estimates of Benefits*

We may also be led to save expensive QALYs before cheap ones if our predictions of how many QALYs will be saved in different areas for the same level of expenditure are poor. Here, unlike the valuation area, sensitivity to improving estimates could be great. Estimates of benefits per dollar spent can vary by factors of ten or even one thousand. This particularly will be the case when there are many intervening causal steps, (What are the benefits of replacing three Boston teaching hospitals by a new \$130 million, 680-bed Affiliated Hospitals Center?) or where exceedingly low level probabilities are involved, (How likely is a core melt accident in a nuclear reactor?).

By changing estimates of these sorts, we can dramatically shift the location of a particular lifesaving technology along the supply curve. The problem, we would argue, lies deeper than the persistent difficulty of making informed predictions about how many lives will be saved with particular technologies. Most decision-making processes that affect the saving of lives never even attempt to estimate the end product, the expected number of QALYs that are added.<sup>24</sup>

## II

### PREDICTION

Predicting the benefits of health-promoting interventions is a complicated process. Most of the outputs are uncertain; many of them can not be ob-

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24. Despite political as well as technical difficulties, empirical assessment of the accomplishments of many controversial types of expenditures may be possible within a reasonable period of time. The real health benefits brought to the poor by Medicaid programs, for instance, are now being closely examined. It is discouraging, however, that a small amount of wastage through fraud (in welfare payments, for example) can excite much more attention more quickly than the massive wastage that will almost certainly result from a failure to quantify the benefits expected from a program.

served directly. Their level will depend significantly on the characteristics of the recipient population. Even among a cohort of the same age and sex, some members will benefit early, some late, some twice, and many not at all. Fortunately, simulations can be developed to trace over time the effects of interventions on individuals of varying health characteristics.

We developed a simulation for each of four health-promoting interventions. Two of these—mobile cardiac units and diet control of cholesterol—are designed to reduce deaths due to acute complications of atherosclerosis, most particularly heart attacks. The other two, air bags for cars and lower speed limits, are intended to reduce motor vehicle fatalities. The policy objective will be to identify the intervention or sets of interventions that maximize the amount of lifesaving benefit generated for alternative dollar levels of expenditure.

#### A. Prevention of Heart Attack Deaths

Mobile coronary care units represent a technological approach towards secondary prevention of heart attack deaths; they reduce the damage once a victim has already suffered a severe event. The mobile unit is a well-equipped emergency vehicle staffed with medically trained personnel. Our simulation, developed to fit results from the literature, showed that in the absence of a mobile unit, about 22 per cent of heart attack victims are dead on arrival at a hospital.<sup>25</sup> Some of these victims can be saved. If a person's heart has stopped pumping as a result of a heart attack, it can sometimes be restarted (defibrillated) if appropriate therapy is instituted within a few minutes. Mobile coronary care units provide this monitoring and therapeutic potential the moment the emergency vehicle arrives. With mobile units the risk of prehospital death is reduced to 14 per cent. (Recent unpublished estimates have been less optimistic about the benefits of mobile units).

The other intervention considered is a diet, low in cholesterol and satu-

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25. This simulation proceeded in three steps. (1) We estimated the number of members of the initial cohort who would suffer a first heart attack at each age, and those who would die without ever suffering a heart attack. (2) Relying heavily on slightly modified versions of models and computer programs generously supplied by Cretin, we generated the distribution of possible outcomes for individuals who suffer heart attacks. S. CRETIN, *A MODEL OF THE RISK OF DEATH FROM MYOCARDIAL INFARCTION* (MIT Operations Research Center, Technical Report No. 09-74, 1974); S. Cretin, *Comparing Strategies for the Treatment and Prevention of Myocardial Infarction* (Nov. 17-19, 1975) (unpublished paper presented at Joint National Meeting of the Operations Research Society of America and the Institute of Management Science, Las Vegas). Cretin's program deals with myocardial infarctions (MIs), a slightly less inclusive category than heart attacks. We assumed that individuals suffering MIs were representative of individuals suffering heart attacks in general. Cretin's semi-Markov model has six states: (a) first infarction; (b) second or subsequent infarction; (c) alive following infarction; (d) dead with history of infarction; but death due to other cause; (e) dead of MI, died prior to reaching hospital; (f) dead of MI, died in hospital. Transition times and probabilities depend on the availability of a mobile unit, age, and MI history. (3) We combined data from steps (1) and (2) to give overall survival, occurrences of subsequent heart attacks, and deaths due to heart attacks and other causes. The simulated data



rated fats (such as most animal fats) and high in polyunsaturated fats (as found, for example, in corn oil). Adherence to the diet is estimated to lower a person's serum cholesterol by about 10 per cent, a reduction which experimental studies have shown to be possible using commercially available foods.<sup>26</sup> Although conclusive evidence is not yet available, associations from observational studies suggest a beneficial effect. Using the risk function for males aged forty-five to seventy-four estimated from one of the most thorough prospective observational studies,<sup>27</sup> we estimated that this cholesterol reduction would lower the rate of first heart attacks at each age by nine per cent.<sup>28</sup>

The diet intervention is also expected to lower the rate of other cardiovascular events, such as stroke. To generate conservative estimates, it was assumed that this cholesterol reduction program had no further effect on the rate of recurrences after a person suffered a heart attack.<sup>29</sup> Since heart attack survivors tend to be highly motivated towards lifestyle changes, it was assumed that they were already achieving whatever cholesterol reductions were appropriate for them.

Each of these interventions was assumed to be applied to a cohort of ten thousand thirty-year-old males. Only males are considered; since their risk of heart attack is several times that of females of the same age, the effects of the interventions are more significant.

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agree well with vital statistics on life expectancy, and deaths and admissions due to heart attacks. NAT'L CENTER FOR HEALTH STATISTICS, U.S. DEP'T OF HEALTH, EDUCATION, AND WELFARE, PUB. LAW NO. 75-1767, INPATIENT UTILIZATION OF SHORT-STAY HOSPITALS BY DIAGNOSIS (1974).

26. Nat'l Diet-Heart Study, *The National Diet-Heart Study Final Report*, 37 CIRCULATION 184-87 (Supp. 1968); Christakis, Rintter, Archer, Winslow, Jampel, Stephenson, Friedman, Fein, Kraus, & James, *A Dietary Approach to the Prevention of Coronary Heart Disease—A Seven-year Report*, 56 AM. J. PUB. HEALTH 299 (1966).

27. SOME CHARACTERISTICS RELATED TO THE INCIDENCE OF CARDIOVASCULAR DISEASE AND DEATH: FRAMINGHAM STUDY, 18-YEAR FOLLOW-UP (W. Kannel & T. Gordon eds., DHEW Pub. No. 74-599, 1974).

28. Large scale intervention studies such as MR FIT are now underway to test whether risk declines with cholesterol reductions as predicted by observational studies. Kalata, *Prevention of Heart Disease: Clinical Trials at What Cost?*, 190 SCI. 764 (1975). The results of some earlier intervention studies have been inconclusive because of methodological problems and the small number of cases. Cornfield & Mitchell, *Selected Risk Factors in Coronary Disease*, 19 ARCHIVES ENV'T'L HEALTH 382 (1969).

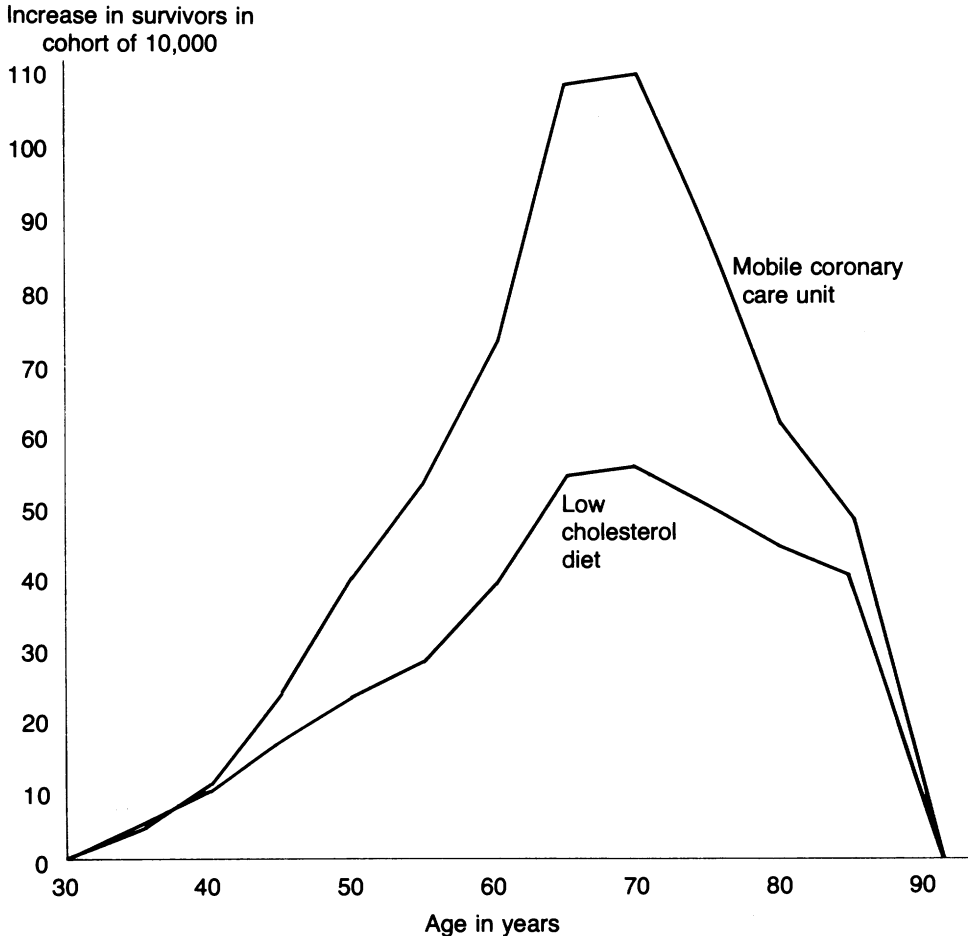
29. The effects of another risk factor, cigarette smoking, suggest our assumption is reasonable. The Framingham Study found that smokers had almost double the nonsmokers' risk of developing heart attacks. W. Kannel & T. Gordon, *supra* note 27. But Weinblatt found that smokers' subsequent prognosis was unrelated to smoking history. Weinblatt, Shapiro, Frank, & Sager, *Return to Work and Work Status Following First Myocardial Infarction*, 56 AM. J. PUB. HEALTH 169 (1966). Nevertheless, it is an open question, both conceptually and empirically, whether individuals who had been on low cholesterol diets previously will have higher or lower rates of heart attack recurrence than persons of the same age and sex who had not followed a special diet. A higher rate is plausible if the victims in the diet group, who had a heart attack despite their beneficial diet, were a higher risk group. For a discussion of population heterogeneity and risk levels, see D. Shepard & R. Zeckhauser, *The Assessment of Programs to Prolong Life, Recognizing Their Interaction with Risk Factors* (1975) (unpublished Public Policy Program discussion paper series No. 32D, on file at Kennedy School of Government, Harvard Univ.).

### 1. *Survival Generated by Two Interventions*

We think it most appropriate to measure benefits of interventions in terms of the quantity and quality of survival they generate, *i.e.*, in terms of incremental QALYs. Figure 2 shows the number of additional survivors to specified ages under each of the interventions. The biggest effect of either intervention is noticed at age seventy. In the absence of any intervention, the probability that a male survives from thirty to seventy is .54. The mobile unit raises this by slightly more than one per cent (109/10,000), while the diet raises the probability by slightly more than 0.5 per cent (54/10,000).

FIGURE 2

INCREASE IN THE NUMBER OF SURVIVORS AT  
EACH AGE DUE TO ALTERNATIVE INTERVENTIONS  
TO REDUCE HEART ATTACK DEATHS



Source: Hypothetical illustration.

Net increases in survival from an intervention are proportional to the net number of lives saved over a specified interval. After twenty years (age fifty), the net number of lives saved out of ten thousand participants is predicted to be thirty-nine for the mobile unit and twenty-three for the diet.<sup>30</sup>

Increases in life expectancy are easily calculated from Figure 2 as the areas under the incremental survival curves, .342 years for the mobile unit as compared to .239 years for the diet. It is interesting to balance these increases in life expectancy against the number of persons in the cohort whose lives are saved. For the mobile unit program, the number of beneficiaries was 412 out of ten thousand persons, so each life saved yielded 8.3 life years; *i.e.*,  $8.3 = .342/(412/10,000)$ . Each of the 153 lives saved by the diet gained 15.6 years; *i.e.*,  $15.6 = .239/(153/10,000)$ .

## 2. *Quality-Adjusted Life Years Saved*

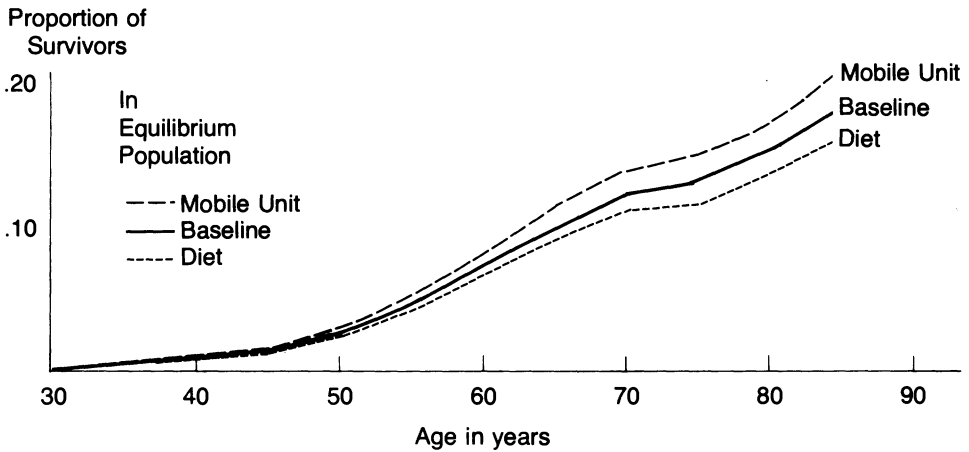
Policy planners, working on behalf of the consumers they represent, may not want to value all years equally. A heart attack, for example, may have a severe adverse effect on the quality of life. Although the survivor of a heart attack is presumably glad to be alive, his quality of life is likely to be below that of a cohort member who did not suffer a heart attack. The survivor typically spends several weeks in an acute care hospital. There is a delay in returning to work or resuming normal activities. One of the most careful studies<sup>31</sup> reported that eventually (at 4-1/2 years) the proportion of surviving male heart attack patients under age sixty-five who were employed is almost the same as non-heart attack controls (79 per cent versus 83 per cent). But in the first year after the heart attack the survivor is, on the average, unable to work for about four months. This study further reported that of men who did return to work, about 30 per cent were at different jobs after two years, presumably partly because of their physical limitations or their physicians' or employers' concerns. A heart attack may reduce quality of life in more personal ways. It may require restriction of sexual activity, cause chest pain (angina) or shortness of breath, and increase anxiety for the patient and his family. Taking these factors into account, we assigned a QALY value of .8 to the year in which the heart attack occurs, on the scale where a year of full function receives a QALY of 1, and dead in that year has a QALY of 0. A year of survival at least one year after the attack was scaled to have a QALY of .95.

30. As a measure of program effectiveness, the number of lives saved has the drawback that it is sensitive to the interval over which the measurement is made, and takes no account of the subsequent prognosis for those lives. If, for instance, we considered a seventy-year period, the number of lives saved would be nil because, with or without one of the special programs, virtually no one survives to age one hundred.

31. Shapiro, Weinblatt, & Frank, *Return to Work After First Myocardial Infarction*, 24 ARCHIVES ENV'T'L HEALTH 17 (1972).

These quality considerations require that we predict the age-specific incidence (rate of occurrence) of heart attacks, initial and recurrences, so that we can compute the expected number of years at each quality level under the alternative programs. Not only does the mobile unit intervention raise the proportion of the cohort who eventually (up to age eighty-five) suffer a heart attack, from .274 with no intervention to .304, but also it increases the number of subsequent attacks per victim from .58 to .68. For each intervention, we also need to know what proportion of survivors have had a heart attack, and are therefore judged to have a lower quality of life. Figure 3 shows these proportions at each age, and in the stationary population of all men age thirty and over. Since the diet postpones or prevents heart attacks, it lowers the proportion of survivors who have had heart attacks. The mobile unit has the opposite effect—an observation that points simultaneously to both the efficacy and limitations of a mobile unit.<sup>32</sup>

FIGURE 3  
 PROPORTION OF SURVIVORS WITH A PREVIOUS  
 HEART ATTACK AT EACH AGE UNDER  
 ALTERNATIVE INTERVENTIONS



Source: Based on authors' simulation.

32. Figure 3 illustrates an important lesson in comparing the short- and long-run benefits of lifesaving programs. If persons saved by a program remain at very high risk, then the short-run benefits of a program are partially offset by future increases in the death rate. The mobile unit intervention does just this, increasing the proportion of persons alive with a heart attack history. The diet intervention, on the other hand, differentially reduces the risk to the low-risk group (individuals without heart attacks). It thus increases the low-risk proportion in the population.

Many interventions provide greater absolute benefits (in terms of reduction of the force of mortality) to high-risk than to low-risk individuals; in such cases, naive extrapolation of short-run mortality benefits will give an overestimate of long-run benefits. For a discussion of methods of

Our simulation estimated that without the mobile unit intervention the cohort would experience 5,394 heart attacks, of which 22 per cent would result in pre-hospital death. Taking into account the mixture of first and subsequent attacks, the mobile coronary care unit was predicted to lower this rate to 14.2 per cent. In this manner, 421 separate lives would be prolonged by the presence of the mobile unit. The diet program exerts two separate effects, delaying as well as reducing the number of first heart attacks. The program reduces the number of fatalities from 1,709 out of 3,417 first heart attacks for the cohort to 1,556 out of 3,085. The fatality rate per attack rises slightly because the age of attacks is being delayed.

Quite apart from a dramatic health event such as a heart attack, life quality may diminish (or improve) over time. A year at a relatively early age when one's health is likely to be good may be valued more highly than one in the years of decline. Vaupel's provocative analysis<sup>33</sup> suggests that society should shift some emphasis towards lifesaving of "prime years" (ages fifteen to sixty-four), in which productivity and social responsibilities are likely to be great. The principle is clear: Our policy analyses should weight highly the years and quality gains that our citizens would weight heavily. We invoked this assumption earlier when we argued that individuals' personal weights should be assigned to the QALYs they receive in different time periods. For purposes of illustration, our analyses apply the constant discount factor of  $r = .05$  per annum to both dollars and QALYs. A QALY received  $n$  years into the future receives only  $1/(1.05)^n$  times as much weight as one received immediately.

Table III compares the outputs of the two different interventions. The mobile unit yields .0655 discounted quality-adjusted life years; the diet program yields .0483. Quality adjustments somewhat diminish the appeal of the mobile unit, which extends life at the expense of average quality. The diet intervention, on the other hand, has a major effect in postponing heart attacks. It increases to full function years that would otherwise be post-cardiac years of diminished quality. (For this preliminary analysis, we ignore the effects of the diet on the quality of life of one who is following it.) It is important to understand these factors; they reflect the way our estimates of discounted QALYs were computed. But for policy prescriptions, the only information we need carry forward on the benefit side is the summary statistic computed to reflect our preferences: discounted QALYs saved.

### 3. *Resource Costs*

Computing benefits is the first step. Now we must turn to the resource costs of the alternative policies we might pursue. To reiterate, our objective

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estimating the benefits from interventions applied to populations that are heterogeneous with respect to risk, see D. Shepard & R. Zeckhauser, *supra* note 29.

33. Vaupel, *Early Death: An American Tragedy*, 40 LAW & CONTEMP. PROB. no. 4, at 73 (1976).

TABLE III  
CHANGES IN NUMBER OF YEARS AT VARIOUS QUALITY LEVELS  
FOR THE MOBILE UNIT AND DIET INTERVENTIONS

Quality Description	Utility Per Year	Mobile Unit		Diet	
		Years	Quality- Adjusted	Years	Quality- Adjusted
<i>Not Discounted</i>					
Alive, highest quality	1	0	0	.3964	.3964
Alive, at least one year since last MI	0.95	.2720	.2584	-.1166	-.1108
Alive, MI occurs during year	0.80	.0704	.0563	-.0413	-.0330
Total		.3424	.3147	.2385	.2526
<i>Discounted at <math>r = .05</math></i>					
Alive, highest quality	1	0	0	.0917	.0917
Alive, at least one year since last MI	0.95	.0564	.0536	-.0375	-.0356
Alive, MI occurs during year	0.80	.0149	.0119	-.0097	-.0078
Total		.0713	.0655	.0445	.0483

Source: Results of simulation by authors.

will be to identify the program or mix of programs that yields the greatest level of benefit for any given level of expenditure. This is the traditional approach to cost/effectiveness analysis. Its primary virtue, in comparison to cost/benefit analysis, is that it does not require that costs and benefits be measured in comparable units. Its liability is that it cannot tell how much should be spent, only how to spend any particular amount.

Preliminary cost estimates for the two interventions were made using the procedures summarized in Table IV. It was essential, of course, to employ our simulations in order to determine when and how frequently various types of expenditures would be made.

The discounted present cost of the mobile unit per enrolling thirty-year-old male is \$130. The comparable figure for the diet program is \$291. If we had \$291,000 to spend, we could make the diet program available to one thousand men or the mobile unit available to  $1,000 \times (291/130) = 2,238$  men.<sup>34</sup> Table V provides the appropriate comparisons between the two programs. The mobile unit costs \$1985 discounted dollars to yield a discounted QALY. The diet program yields a discounted QALY at a discounted cost of \$6,025.<sup>35</sup> Following the cost/effectiveness prescription, assuming that these

34. There need be no question of equity here deriving from the concentration of benefits in groups of different size. In choosing between these two programs, the members of our initial cohort would be choosing between 1,000 chances in 10,000 of benefiting from the diet program or 2,238 chances in 10,000 of benefiting from the mobile unit program.

35. These calculations, though amply tedious, necessarily made numerous simplifying assump-

calculations accurately represent benefits and costs,<sup>36</sup> dollars made available for one of these two interventions should first be spent on mobile units.

TABLE IV  
ESTIMATED INCREMENTAL RESOURCE USE OF PROGRAMS TO REDUCE  
HEART ATTACK DEATHS, PER MAN IN COHORT

Component	Unit Cost <sup>b</sup> (\$)	Mobile Coronary Care Unit			Low Cholesterol Diet		
		Undisc. Units	Discounted <sup>a</sup> Units	Cost (\$)	Undisc. Units	Discounted <sup>a</sup> Units	Cost (\$)
MCCU vehicle & staff, per confirmed MI	400 <sup>c</sup>	.5348	.1235	49	—	—	—
Dietary Counseling & Media							
—For first year	150 <sup>d</sup>	—	—	—	.997	.997	150
—For each subsequent year	10 <sup>e</sup>	—	—	—	39.20	15.68	157
Treatment of additional MI's per hospitalization	3500 <sup>f</sup>	.0704	.0149	52	-.0413	-.0097	-34
Other medical treatment, per year of additional life	400 <sup>g</sup>	.3420	.0713	29	.2390	.0445	18
Total				130			291

<sup>a</sup> Discounted to beginning of program at five per cent per year.

<sup>b</sup> Based on 1974 costs.

<sup>c</sup> From S. Cretin *infra* Table IV. Determined by dividing annual costs of operating mobile unit system by number of heart attacks (MI's and other coronary events). This computation assumes that the community is quite large and densely populated so that discontinuities in mobile unit capacity can be ignored.

<sup>d</sup> Subjective estimate based on one interview with physician and ten sessions with diet therapist.

<sup>e</sup> Subjective estimate based on follow-up by physician in the course of other medical visits, plus continuing media information.

<sup>f</sup> Derived from SOCIAL SECURITY ADMINISTRATION, *infra* Table IV, and related sources. Details of computation procedure available in an unpublished paper by Shepard.

<sup>g</sup> For persons age 65 and over, since most additional life years occur in this age group. Obtained by adjusting average expenditures for this age for 1970 reported by Anderson for the increase in medical care prices to 1974. See R. Andersen, J. Kravits, O. Anderson, and J. Daley, *infra* Table IV. From the result, \$495, the expected cost of heart attack hospitalization (\$87, derived from the simulated rate of .025 MI hospitalizations per year) was subtracted to avoid double counting.

Source: Results from authors' simulation using model from S. Cretin, Comparing Strategies for the Treatment and Prevention of Myocardial Infarction (Nov. 17-19, 1975) (unpublished paper presented at Joint National Meeting of Operations Research Society of America and the Institute at Management Science, Las Vegas); SOCIAL SECURITY ADMINISTRATION, MEDICARE, 1970, LENGTH OF STAY BY DIAGNOSIS (DHEW Pub. No. (SSA) 74-11704, 1973); D. Shepard, Disability and Medical Costs for Disease Associated with Hypertension: A Preliminary Note (1975) (unpublished paper on file at Center for Analysis of Health Practices, Harvard School of Public Health); R. ANDERSEN, J. KRAVITS, O. ANDERSON, AND J. DALEY, EXPENDITURES FOR PERSONAL HEALTH SERVICES: NATIONAL TRENDS AND VARIATIONS 1953-1970 45 (DHEW Pub. No. (HRA) 74-3105, 1973).

tions. Alternative assumptions could readily produce results at variance with ours by a factor of two.

36. Our cost estimates included only resource costs within the health sector. All costs should be included when policy is being formulated. The diet program, for example, exhorts individuals

TABLE V  
DOLLAR COST PER ADDITIONAL LIFE YEAR OF PROGRAMS  
TO REDUCE HEART ATTACK DEATHS

<i>Method of Aggregation</i>	<i>Mobile Unit</i>	<i>Diet</i>
<i>Undiscounted</i>		
Not Quality Adjusted	380	1220
Quality Adjusted	413	1152
<i>Discounted</i>		
Not Quality Adjusted	1823	6569
Quality Adjusted	1985	6025

Source: Calculated from results of simulation by authors.

If there are sufficient dollars, of course, it might be appropriate to pursue the diet program as well as the mobile unit program. We computed the effect of the diet program assuming that the mobile units were already in place. Consideration of small interdependencies in both cost and effectiveness between the two programs would lead to a slight modification in our previous figures. The discounted cost of the diet program per person falls to \$279. It would now offer .0410 discounted QALYs, making the unit cost \$6,805. As a supplement, the diet program has slightly lower cost/effectiveness than it did as a primary intervention.<sup>37</sup>

Before turning to two motor vehicle interventions, it is interesting to observe that both the mobile unit and diet interventions compare favorably to existing and contemplated health sector programs. Weinstein and Stason have estimated the cost per discounted QALY achieved through the treatment of

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to eat fewer eggs and rich desserts; they may feel this is a loss. Those who do not give up these high cholesterol foods may feel worse for not having done so. Atkinson has made an equivalent point about the adverse effect of smoking campaigns on those who continue to smoke. Atkinson, *Smoking and the Economics of Government Intervention*, in M. Perlman, *supra* note 10, at 428.

The diet program may also have untalied benefits. A pilot study of the effects of a low-cholesterol diet found that patients enrolled in a fat-controlled diet program changed their behavior with respect to other risk factors, particularly smoking. Nat'l Diet-Heart Study, *supra* note 26. Indeed, 54 per cent of smokers curtailed their consumption; 22 per cent quit smoking altogether.

It might be suggested that the cost-effectiveness of these programs might rise if they were delayed to older ages. The effect turns out to be rather minor for the mobile unit, since both benefits and costs are discounted, and both would be delayed. (We need to provide fewer mobile units to cover the cohort when it is age thirty as opposed to age fifty.) For the diet intervention, the irreversible nature of severe atherosclerosis prevents delay from improving cost-effectiveness.

37. If there were more than two programs under consideration, and if there were strong interdependencies among them, it would be necessary to compare all combinations of programs to determine the most cost-effective mixes. The package which begins with the program that is most cost-effective in isolation then adds the next most cost-effective, and then the next, till the funds run out may not end up being cost-effective.



hypertension to be in the range \$3,000 to \$20,000, with \$10,000 being common for mild hypertensives.<sup>38</sup> Their quality adjustments were somewhat different from ours.) Cole and Berlin have estimated the cost of prolonging life by elective hysterectomy at \$8,000 per undiscounted year;<sup>39</sup> discounting would approximately quadruple this number. Estimates of the value of "life saved" have ranged from \$140,000 to \$900,000,<sup>40</sup> a range that translates roughly to \$10,000 to \$65,000 per QALY. This suggests that, if our assumptions and calculations are reasonable, either of these programs would yield more QALYs than present programs making equivalent expenditures.

### B. Prevention of Motor Vehicle Deaths

Speed limits provide their lifesaving benefits by reducing the incidence of serious accidents. Air bags that inflate instantaneously upon impact reduce the consequences once an accident has happened. As with our heart attack programs, we are comparing a primary and a secondary prevention program.

As a secondary program, air bags do nothing to reduce the frequency of accidents. Indeed, for each of three reasons, they may increase it slightly. First, they work against a very weak force of natural selection which would tend to eliminate drivers at high risk (whether because of individual traits, greater exposure, or merely age). Second, they increase the number of drivers who survive accidents; hence they obviously increase the pool at risk. Third, they may encourage more accident-prone driving, if individuals are influenced by the knowledge that they have air bags that may save their lives.<sup>41</sup>

Experience since the Organization of Petroleum Exporting Countries oil embargo has provided us with a splendid natural experiment which reveals that lowered speed limits significantly reduce the rate of accidents per vehicle mile. Fatal accidents are eliminated more than proportionally, since the accidents avoided are differentially those at high speeds. Differential adherence

38. M. WEINSTEIN & W. STASON, *HYPERTENSION: A POLICY PERSPECTIVE* (1976).

39. Cole & Berlin, *Elective Hysterectomy* — AM. J. OBSTETRICS & GYNECOLOGY — (forthcoming).

40. J. LINNERTHOOTH, *supra* note 4.

41. Our statistical analyses assume that air bags do not affect the habits of individual drivers. If they actually do induce changes, then leaving aside externalities to other drivers, passengers, and pedestrians, our no-change analysis would generate estimates that were biased against air bags. The minimum estimate of the benefits they yield is what the driver would gain if he continued in his same old driving patterns. Since he changes, by a revealed-preference argument, he must be doing better.

A situation where more lives were ultimately lost because individuals chose to drive much faster than before might represent a truly dramatic benefit from an air bag program. R. Zeckhauser & A. Fisher, *Averting Behavior and External Diseconomies* (1976) (Public Policy Program discussion paper series No. 41D, Kennedy School of Government, Harvard Univ.). Peltzman presents an artful statistical analysis of the lifesaving effects of various life-promoting interventions relating to highway safety. Peltzman, *The Effects of Automobile Safety Regulation*, 83 POLITICAL ECON. 677 (1975). He shows that increased driving speeds have partially offset safety gains from improvements in vehicle and road design.

may produce further interesting, though not particularly powerful, selection effects for speed limits.<sup>42</sup>

Our calculations once again are based on the male population, because they are at substantially higher risk. This time, however, we begin at birth rather than age thirty. The pool of males was assumed to consist of two groups: the regular group (96.5 per cent of the pool) and a high risk group of regular alcohol users (the remaining 3.5 per cent).<sup>43</sup> We assumed that at every age the high risk males had ten times the fatal accident rate of the regular group. The rate for regular males was calibrated so that the average rate at any age, based on the proportion of high and low risk men surviving to that age, would equal the rate reported by the National Center for Health Statistics.<sup>44</sup> We estimated that air bags would reduce the fatality rate of accidents by 23 per cent compared to baseline characteristics (*i.e.*, low usage of seat and shoulder belts). Universal adherence to reduced speed limits was predicted to reduce the rate of fatal accidents by 15 per cent.<sup>45</sup>

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42. The magnitude of selection effects depends positively on: (1) the absolute magnitude of risk, and (2) the differential in risk levels among different members of the population. In contrast to heart attack programs, motor vehicle programs deal with low absolute risks. Both types of programs encounter considerable variability (measured by ratios of risk levels) among individuals.

43. Our calculations assumed that members of the high-risk pool were at high risk at all ages, and that the elevation in risk applies to fatalities of passengers and pedestrians, as well as drivers. This undoubtedly overstates the risks that high-risk drivers undergo in their youth. Distortions due to this simplification would not be significant, since relatively few nondriving children are killed in auto accidents.

The prevalence and risk ratio for high-risk drivers were derived from three findings and one assumption. (1) In tests of drivers randomly selected at times and places where fatalities had occurred, about 1.7 per cent of subjects had blood levels of alcohol above the legal limit (100 mg per 100 ml blood). (2) Legally intoxicated drivers have about twenty times the risk of sober drivers of being in a fatal accident, and passengers and pedestrians killed in accidents also show above average alcohol concentrations. HOUSE COMM. ON PUBLIC WORKS, 90TH CONG., 2D SESS., 1968 ALCOHOL AND HIGHWAY SAFETY REPORT (Comm. Print 1968). (3) Reports on repeated violations suggest that a group of problem drinkers could be identified by prior records. Waller, *Identification of Problem Drinking Among Drunken Drivers*, 200 J.A.M.A. 114 (1967). (4) We assumed that a heavy user of alcohol is intoxicated half the time while driving in places where fatal accidents occur.

44. 2 NAT'L CENTER FOR HEALTH STATISTICS, VITAL STATISTICS OF THE UNITED STATES, 1969, pt. A (DHEW Pub. No. (HRA) 74-1101, 1971).

45. The National Highway Traffic Safety Administration estimated that in 1975 cars, with a brief warning buzzer to remind occupants to fasten seat belts, 15 per cent of occupants were estimated to use lap and shoulder belts, and an additional five per cent lap belts only; the remaining occupants used no belts. With these utilization rates, the estimated effectiveness of these belts in saving lives is 7.4 per cent. Based on an estimated readiness of 98 per cent, air bags, together with lap belts, were estimated to be 42.1 per cent effective. The estimated effectiveness of air bags among motorists unprotected by shoulder belts with present utilization is  $(42.1 - 7.4)/(100 - 7.4) = 37.5\%$ . This effectiveness applies only to the 73.7 per cent fatalities of motor vehicle accidents. NAT'L HIGHWAY TRAFFIC SAFETY ADMINISTRATION, U.S. DEP'T OF TRANSPORTATION, THE EFFECTS OF THE FUEL SHORTAGE ON TRAVEL AND HIGHWAY SAFETY 34-35 (Rep. No. (DOT) HS-801-715, 1975). Motorcyclists, bicyclists, and pedestrians derive no protection from air bags. The effectiveness against all accidents is thus  $.737 \times 37.5\% = 27.6\%$ .

The OPEC oil embargo provided evidence which reinforced earlier studies on the safety consequences of reduced speed limits. The motor vehicle death rate per one hundred million vehicle

Table VI reports the results of our calculations. As was to be expected, air bags, the secondary intervention, increase the proportion of high risk drivers. Speed limits will increase it somewhat less, significantly less if high risk drivers are much less likely to adhere. For each of the programs, the increase in life expectancy is greater for the high risk group, ranging from 9:1 for air bags to 2:1 for speed limits with partial adherence. We calculated the discounted QALYs returning to the alternative interventions as .0263 for the air bags, .0132 for speed limits with full adherence, and .0085 for speed limits with partial adherence. Distinctions of quality levels, seemingly unimportant, were not introduced into these calculations.

TABLE VI  
PREDICTED EQUILIBRIUM BENEFITS AND COSTS OF  
AIR BAGS AND SPEED LIMIT PROGRAMS<sup>a</sup>

	<i>Air Bags<sup>b</sup></i>	<i>55 mph Speed Limit<sup>c</sup> Universal Adherence</i>	<i>55 mph Speed Limit<sup>c</sup> 80% Low Risk, 20% High Risk Adherence</i>
<i>Undiscounted</i>			
Expected gain in life at Birth, Years	.263	.142	.093
High Risk Cohort	1.814	.979	.193
Regular Drivers	.208	.113	.087
Lives Saved in Cohort <sup>d</sup>	107	58	40
Reduction in Fatal Accident Rate (%)	26.9	14.6	10.1
Change in Rate of all Accidents <sup>e</sup> (%)	.11	-2.62	- .60
Increase in Proportion of High Risk Persons (%)	2.6	1.6	0.3
<i>Discounted to Birth at <math>r = .05</math></i>			
Expected gain in life years per person, discounted QALYs	.0240	.0132	.0085
Gross Costs per person (\$)	139 <sup>f</sup>	340 <sup>g</sup>	255 <sup>h</sup>
Change in number of accidents per cohort	.77	6.62	.74
Savings per person (\$) <sup>i</sup>	0	0.9	0.1
Net costs per person (\$)	139	339	255
Cost per Discounted QALY (\$)	5,792	25,700	30,000

<sup>a</sup> Cohort consists of 10,000 live male births. Some 3.5 per cent of these births are destined to be high risk drivers with an accident fatality rate per ten times that of regular risk drivers of the same age.

<sup>b</sup> Air bags with lap belts reduce the fatality rate per accident by 27.6 per cent.

<sup>c</sup> Adherence cuts probability of suffering fatal accident by 15 per cent.

miles fell 15 per cent from 4.27 in 1973 to 3.65 in 1974. NAT'L HIGHWAY TRAFFIC SAFETY ADMINISTRATION, *supra* at A-10. We assume that with full adherence to reduced speed limits, this 15 per cent reduction in fatalities would be maintained. Full adherence can not be expected. Even with the scarce gas and moral fervor of 1974, nine per cent of travel on main rural roads was at speeds at or above 70 mph. NAT'L HIGHWAY TRAFFIC SAFETY ADMINISTRATION, *supra* at 30.

- <sup>d</sup> Reduction in number of men eventually dying from motor vehicle accidents in cohort of ten thousand live male births.
- <sup>e</sup> Accidents were derived from fatalities. The baseline fatality rate was that reported for 1972, 2.3 fatalities per thousand reported accidents. Air bags were assumed to lower this rate by 27.6 per cent. Speed limits under full adherence were assumed to lower the fatality rate per accident by 15 per cent, as observed in North Carolina and other states for which data were available for 1973 and 1974. A. SEILA AND D. REINFURT, *infra* Table VI, H. SCHECHTER & J. PFEFFER, *infra* Table VI Source.
- <sup>f</sup> The incremental cost of air bags with lap belts over lap and shoulder belts was estimated by the National Highway Traffic Safety Administration *infra* Table VI, to be \$133. This estimate includes initial costs, expected replacement of deployed air bags, and additional discounted operating costs of the vehicle because of the estimated 48 pounds increase in weight. It was assumed that each car lasts ten years, and that costs for equipping and maintaining one half a vehicle are borne by every member of the cohort. (The current ratio of cars registered to population is one to two.) There is a complicated problem of allocating joint costs among passengers and drivers, and between men and women. To the extent that men are a higher risk from fatal auto accidents than women, our procedures understate the portion of costs that should be assigned to men. This may counterbalance the assignment of the same cost to male children as to male adults, although children have lower motoring exposure.
- <sup>g</sup> Based on subjective estimate of cost of driver education, enforcement, and additional travel time of \$20 per capita per year.
- <sup>h</sup> Based on subjective estimate of cost of driver education, enforcement, and additional travel time of \$5 per capita per year.
- <sup>i</sup> Savings based on "economic loss" per accident of \$1,300 in 1972. U.S. BUREAU OF THE CENSUS, *infra* Table VI. This loss may be an upper-bound for this analysis, since it includes lost wages due to fatalities. For air bags it was assumed that reduction in medical costs of some accidents would be counterbalanced by increased number of accidents and increased medical costs for severely injured persons who would have died (at lower cost) otherwise.

Source: Calculated from results of simulation by authors, using data above. A. SEILA & D. REINFURT, THE EFFECTS OF THE LOWERED MAXIMUM SPEED LIMIT AND FUEL SHORTAGE ON HIGHWAY SAFETY IN NORTH CAROLINA (U.S. Dep't of Trans., Pub. No. DOT-HS801-428, 1975); H. SCHECHTER & J. PFEFFER, POLICY ASSESSMENT OF THE 55 MPH SPEED LIMIT (National Science Foundation Rep. PB243481, 1975); U.S. BUREAU OF THE CENSUS, STATISTICAL ABSTRACT OF THE UNITED STATES (1973).

There are good cost data on air bags. We estimated a discounted lifetime cost per man protected of \$139. Speed limits present a more sophisticated estimation problem. The cost of additional enforcement procedures must be added to the value of the increased expenditure on travel time. Rather arbitrarily we calculated an annual cost of \$20, giving a discounted lifetime total of \$339 for full adherence; the comparable numbers are \$15 and \$255 for partial adherence.

Turning once again to cost/effectiveness calculations, air bags entail a discounted cost of \$5,792 per discounted QALY saved. The comparable figure for full adherence speed limits is \$25,200; for partial adherence it is \$30,000. If more rigorous calculations yield the same result, the policy conclusion is unmistakable. If we wish to spend money on motor vehicle safety we should start with air bags.<sup>46</sup>

46. As with heart attack interventions, it might also be worthwhile to check the performance of the second-place program as a supplement to the more cost-effective program.

Full efficiency, of course, would require that we are able to allocate funds across areas. Air bags must compete with mobile coronary care units and diet programs, not only with speed limits.<sup>47</sup> Given such unfettered competition, our calculations show that mobile units would be highly desirable, and that the less attractive air bag and diet programs would be approximately equivalent in cost-effectiveness.

It should be evident that the policy prescriptions we have formulated in the areas of motor vehicle safety and the reduction of heart attack fatalities depend critically on both valuation procedures and mechanisms for prediction.

Policy interventions that save lives work in complex fashion; we should not expect to be able to make precise predictions of their performance based on unassailable assumptions. Our brief analyses were intended to demonstrate that these predictive difficulties need not force us to abandon our responsibilities as analysts and policy makers. Appropriately qualified predictions can be made, and even those that suggest only broad distributions of outcomes can help to guide policy choices. It is true that improved predictive capabilities are vital to the better formulation of policies for lifesaving, but while awaiting perfection in that sphere, we must do the best we can with the capabilities at hand. Relying on the best-informed judgments we can now summon, we should steel our nerves and make the necessary choices knowing that these choices may later be shown to have been in error. Policy makers must not stand immobilized by uncertainty, waiting for predictions that will meet academia's rigorous standards of precision.

### III

#### ACCOUNTING

Our discussion of prediction has already provided a limited introduction to one problem of accounting where lives are involved. We have to define appropriate units of measurement. The next step, quite simply, is to add them and subtract them appropriately to compute an accurate total of the benefits and costs a program will impose. We have not had the opportunity to

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47. We have weighted equally all dollars of resource expenditures. If resources are constrained to areas of expenditure, then dollars spent in particular areas may be contributing much more (or much less) than a dollar of benefits. Assume, for purposes of illustration, that municipal budget dollars available for motor vehicle safety were inefficiently constrained so that at the margin they were generating five dollars of benefits. Then when considering the speed limits, program dollars for signs or police salaries should be weighted on a five to one basis with the (unconstrained) dollars an individual would pay to avoid wasted travel time when adhering to a speed limit.

The general principle is that when not all expenditures come from the same budget, each expenditure must be weighted with its own shadow price. Recognizing that budgets are constrained, and that shadow prices should vary for different types of expenditures, can substantially shift the choice among competing programs. (With efficient budgeting, of course, all these shadow prices would be equal.)

pursue the important task of developing a complete accounting system. However, we have been able to identify some significant and frequently recurring errors that would be eliminated if such a system were developed. We shall address four of them.

#### A. Appropriate Tallying of Willingness-to-Pay

Summing the willingness-to-pay of all affected parties is probably the most widely, though by no means universally, conceptually accepted procedure for valuing the benefits generated by programs to preserve lives and promote health. However, carrying through the assessment may be horrendously difficult. Merely adding up the benefits may be hard. Besides the individual saved, the major group of primary beneficiaries would seem in most cases to be his or her family.<sup>48</sup>

We shall be talking about small changes in both probabilities and expenditure levels. If we offer Mr. Jones some lifesaving options, and inquire at what sum he implicitly values his life, must we separately add the valuation of Mrs. Jones? The answer would be yes if the Joneses had separate allocations to purchase their individual lifesaving and provide for their own consumptive pleasures. Then assuming that Mrs. Jones valued positively the continued existence of her spouse, she would be willing to sacrifice some of her allocation to increase his survival probability.<sup>49</sup> More likely, the Jones's expenditures are taken from a common fund that promotes the welfares of both of them. Their lifesaving expenditures should already reflect the benefits that both derive. This need not imply they have identical preferences or an agreed upon family welfare function. Assume that they don't. The Mrs. Jones's valuation might add to or subtract from that of her husband depending on whether her implicit valuation of her husband's life is greater or lower than his own evaluation of his life. If her evaluation is lower, then given that they are spending out of common funds, an additional dollar spent on saving his life (and reducing their resources for other consumption) actually reduces her welfare. A not wholly uplifting analogy makes the point clear. Let us ask not what we would pay to save Mr. Jones, but rather Rover, the Jones's dog. The spouse who is more greatly enamored of the dog would probably quote a greater valuation. For efficiency, assuming no other affected parties, some in-between evaluation should be employed.

Which of the couple will place a greater value on Mr. Jones's life will depend on his tradeoffs between current consumption and probability of

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48. For reviews of the merits and liabilities of the willingness-to-pay and alternative approaches, see Acton, *supra* note 4; Zeckhauser, *supra* note 11. They review the associated question: How should we measure the benefits returning to society at large when a particular life is preserved?

49. This would be a traditional public good problem, presenting free-rider problems, and yielding the Samuelsonian efficiency condition.

death, and her attitudes towards a life without her husband, which will surely be influenced by the loss of income that would accompany widowhood. The results of a simple model, as well as anecdotal evidence from Class B movies, suggest that the better her expected financial situation in widowhood, the lower her valuation of her husband's life.<sup>50</sup> The upshot of all this is that securing the valuations of other family members can lower, as well as raise, willingness-to-pay amounts.<sup>51</sup> A simple point of accounting explains why this possibility arises with families, but is not likely with other uninvolved parties: with families, lifesaving expenditures come out of a fund that is used for common purposes.

A critical question, of course, is how the preferences of different members of the society in general, not of a single family, should be added together. This question gets us into many thorny issues relating to the structure of a social welfare function.<sup>52</sup> We shall avoid them, and stick to our narrow accounting perspective, a perspective that enables us to make a simple point: If efficiency is our goal, then we should employ the same incremental tradeoff rate between benefits to different individuals across social decisions in all areas. Consistency in tradeoff rates does not require that we simply sum willingness-to-pay across beneficiaries when evaluating a life-promoting program. This procedure would be appropriate only if a straight dollar sum of benefits were called for.

We have an entire array of programs that achieve some measure of redistribution, invariably at some loss of efficiency. Such a program will take a dollar from citizen *A* to provide, say, ninety cents of benefits to citizen *B*. If there are some programs where our tradeoff rate is 10 for 9, and others where it is 10 for 5, we could expand the former programs and shrink the latter and have more benefits for both *A* and *B*. The implication for programs that provide health and life-preservation benefits is straightforward: the implicit tradeoff rates they employ should be consistent with the redistributive objectives and accomplishments of other programs in society. A look to these other programs should provide us guidance on how benefits to different classes of individuals should be weighted.<sup>53</sup>

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50. In a two-period model, the magnitude to be examined is the tradeoff rate between first period consumption for the couple and an additional one per cent probability of survival for the husband.

51. This is not to imply that all family members would not benefit if the resources of the society were devoted to preserving one of them. They would, just as they would benefit if society spent one hundred dollars, say on housing services, to give a total benefit to the family of eighty dollars.

52. Equally thorny is the question of adding expenditures by different members of society to benefit some target group. The expenditures are commonly indirect, in the form of higher prices or taxes.

53. Altruistic benefits should be assigned to the altruist. If *B* gains when *A*'s health is improved, that is a benefit to *B* and should be weighted as such.

### B. Marginal Versus Average Problems

Most policy interventions are proposed as a unit. Thus, we may propose an  $X$  million dollar nutrition program, designed to bring all expectant mothers up to the levels of American middle class nutrition. An alternative expenditure of the same resources may provide  $Y$  home health visits per infant after birth. Sometimes we undertake programs that are defined by a particular level of output, not input. Thus, we may decide to undertake an auto fatalities reduction program to cut traffic fatalities by 10 per cent.

A famous early effort of this sort was the Department of Health, Education and Welfare's Disease Control Memorandum.<sup>54</sup> It outlined a dozen or so interventions, and ranked them in order of the lives saved per dollar expenditure. An advertising program encouraging motorcyclists to wear helmets came out on top.

Unfortunately, the calculations presented in the memorandum do not reveal the information we would like to have. What have we gotten for the last dollars expended on each program?<sup>55</sup> In most cases, though with exceptions, we would expect diminishing returns within each of these alternative programs. That is, the first lives that are saved come cheapest. Maximum efficiency, as is well known, is not achieved by ranking the projects in order of average output per dollar input, but rather by expanding all projects until the output per marginal dollar input is the same. For example, if 98 per cent of the benefits of the motorcycle advertising program could be achieved with only half of the proposed expenditure, then it might be undesirable to "waste" the second half of the proposed expenditure. Better to start on a lower average payoff project that may be offering high marginal benefits in

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The argument that we should look to other areas of society for guidance relies on two assumptions: (1) These other areas must reflect appropriately the tradeoff rates of the society as a whole. (2) Lifesaving programs are not of sufficient magnitude to affect appropriate tradeoff rates, *i.e.*, we will not have to resolve a new social welfare maximization problem to get new shadow prices for individual welfares. Casual observation suggests that tradeoff rates for benefits to different individuals are not constant across programs; significant gains for both poor and rich must be achieved by bringing the tradeoff rates across programs closer together.

54. See note 6 *supra*.

55. There is a natural trap here. Analysts sometimes assume that we can order expenditures in a totally rational fashion starting with those that offer the highest payoffs. Frequently, such pinpoint control of the process is not possible. For example, computer-assisted tomography is an expensive diagnostic procedure now coming into use. It would be inappropriate to value the use of the device on the premise that it would be employed in optimal fashion, starting in those situations where the expected value of the information it would provide would be greatest. Rather, we should choose among alternative allocational schemes, recognizing that some inappropriate usage of the device will accompany each. A few analysts, taking explicit account of the difficulty of preventing excessive use of this diagnostic device, are conducting studies to see whether it is worth having at all. If we could control its use, and if we were in a large hospital referral setting so indivisibility would not be a problem, there would be no difficulty: we should have the device.



the initial range.<sup>56</sup> The principle is a simple one: equate marginal returns across projects.

### C. Worst Case and Best Guess Analyses

Many policy analysts have been indoctrinated in the academic tradition of arguing conservatively. If one is trying to prove a point irrefutably, consideration of the least favorable situation makes sense. This is not, however, an appropriate approach for rational policy analysis. Where policies are being chosen, each possibility should be assigned a probability and an expected performance score should be computed, assuming that we wish to be consistent.

Many variants of worst case analysis are employed frequently in the life valuation area. Two of the most common types are: (a) assume that everything goes wrong and see what the performance will be,<sup>57</sup> and (b) concentrate on the most dangerous aspect of a process. The second variant, being more subtle, is more likely to lead to a misinterpretation. For example, when nuclear-based electricity generation technologies are compared with others, analysis frequently concentrates on the relatively most dangerous aspects of the process: the possibility of reactor accidents, diversion of fissionable material, and disposal of radioactive wastes. Such analyses seldom consider the significant advantage of nuclear over competitive technologies in air pollution (with coal), or danger of military confrontations (with oil).

Worst case analyses generate a variety of biases. First, they lead to distortions in estimates of expected tradeoff rates between lives saved and dollars expended. Second, where alternative approaches are being compared, they favor conventional technologies, whose outputs can be estimated with some precision, as opposed to those that are less well understood. Third, they tend to discourage the use of sequential strategies that would enable society to capitalize on learning.

A more purely logical problem, easily overlooked, is associated with using best guesses as the basic parameter estimates in complicated systems. The problems that arise are of two sorts. First, if there are substantial nonlinearities in the system, the use of means, say, rather than entire distributions may lead to misestimates. Second, it is possible that in some situations there will be a correlation of errors, and all parameters will be under- or overestimated.<sup>58</sup>

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56. The required output per unit would be the tradeoff rate of the decision maker if there were an unconstrained budget. If a certain amount had to be spent, no more and no less, then the shadow price would be defined implicitly by the budget level.

57. Sometimes, following in the tradition of classical statistics, there is only the assumption that things go relatively wrong. We may inquire, for example, what is our 95 per cent confidence limit on the maximum number of lives lost due to a particular process. If only a single estimate is required, the bias is not extraordinary. We are using the 95 per cent to give some indication of an entire distribution. But if estimates are being combined, the extent of the overestimation can be extraordinary.

58. Suppose there was a one-third chance the analytic approach taken would lead to 50 per

#### D. Double Counting

An ideal accounting procedure for life valuation would make sure that every valued commodity was included and that no valued commodity was counted twice. In reality, the double counting of compensated risks is a common error.

Consider a hypothetical cost analysis of a coal-based electricity-generator technology. First the dollar costs of producing a unit of electricity are computed to be \$100. One input to this calculation is the miner's wage, which reflects his valuation of the risks he runs. Let us assume that in deciding what wage to accept he values his life implicitly at \$300,000, at least where small probabilities are involved. If one miner's life is lost for each hundred thousand units of electricity produced, then \$3 of the \$100 unit cost of electricity is attributable to risks of miners' lives.

Next we tote up other costs, one of which is expected lives lost. What value should society attach to those miners' lives that are lost in the production process? The first step in arriving at an answer is recognition that those lives have already been counted in the \$100. That amount is \$97 for inputs other than lives, and \$3 as a valuation of the lives lost. To attach an additional value because a particular type of input is used would be double counting, no less inappropriate conceptually than listing wear and tear on mine railroad cars separately, then adding the cost (which is also already included in the \$100) on to the initial dollar total.

Though we should surely wish to avoid double counting, there are some circumstances in which we might want to attach an explicit cost to lives lost. First and foremost, the miners may not take all the costs associated with their loss of life into account. Other members of society may feel uncomfortable about allowing them to sacrifice their lives; these others might be willing to pay something so that this would not happen. This is a traditional form of uncompensated externality; the miner cannot charge those concerned others if they indirectly (by pursuing alternative technologies) or directly (say, through legislation) prevent him from working.

It is worth noting that society presently has rather extensive directed transfer programs whose primary function is the promotion of health, sug-

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cent underestimates on each parameter, a one-third chance that each parameter would be estimated accurately, and a one-third chance that there would be a 50 per cent overestimate on each parameter. Consider a process where the output, perhaps lives lost, is the product of five parameters. The expected value of the output would then be

$$(1/3) [(0.5)^5 + (1)^5 + (1.5)^5] = 2.88$$

times the appropriate means value. Though the expected value of each individual parameter is equal to its true value, the fact that the directions of bias on any particular trial are correlated will lead to an overall bias in assessment. When these interdependencies are recognized by the assessors, as many were in the intensely debated Rasmussen study on the safety of nuclear energy, they can be correctly treated analytically with such conceptual devices as "common mode failures." U.S. ATOMIC ENERGY COMM'N, REACTOR SAFETY STUDY: AN ASSESSMENT OF ACCIDENT RISKS IN THE U.S. COMMERCIAL NUCLEAR POWER PLANTS (1974).

gesting that bodily well-being is a good perceived to differ significantly from beer and television enjoyment.<sup>59</sup> If we are more concerned about our fellow citizens' health than about other aspects of their consumption, our societal choices should reflect that fact. But given the rather complex nature of societal decision procedures, and the inherent difficulty of calculating levels of health benefits from various programs, we should not assume too quickly that our "revealed preference" as to the magnitude of this externality is an accurate indicator.<sup>60</sup>

The other members of society may also have a self-interested dollars and cents concern for a miner's health. Because there are social welfare programs which provide dependency benefits, health coverage and the like, a miner may not take account of the full resource costs of any health risks. The other members of society will share in some of the costs of his losses. We shall explore this matter in greater detail in our subsequent discussion of appropriate incentives.<sup>61</sup>

#### IV

#### INCENTIVES AND THE LOCUS OF DECISION MAKING

Two principles are critical if we are to make appropriate decisions about saving lives. First, we must place decision-making authority in the appropriate hands. Second, we must also provide decision makers with the incentives and information that will enable them to make appropriate decisions. In the past, most policy discussion on the lifesaving issue has taken the locus of decision making as given. It has focused for the most part on the decision problem of the government or other collective organizations. The key question that has been examined, as we stressed earlier, is how lives should be valued for such decisions.

It is now widely asserted that future progress in lifesaving will depend largely on the actions of individuals. They will have to drive more safely, eat less extensively, follow medical regimens more closely than they have to date. Assuming that this is so, we still might inquire why this whole area is suitable

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59. It may be that these health programs are supported because they supplement or replace highly imperfect contingent claims markets.

60. Indeed, the argument might be made the other way. Rather than infer preferences from decisions in this area, we might wish to calculate and publicize the implied tradeoff rates in the hopes of changing the direction of future decisions. The health area offers some particularly intriguing issues in this respect. It is now commonly averred that though poor people's health has not benefited much from the increased doctors' visits Medicaid has made possible, they value these visits highly. (This is the "caring" output of the system.) Is it not possible they would have a substantially different valuation of this caring output if they knew that it offered rather insufficient medical benefits?

61. A further factor may be at play because some nonmarginal changes in resource allocation may be involved. Inframarginal miners, those who would have worked at a lower wage, may have much lower valuations on their health risks; they may be securing substantial rents on either their low valuations or the fact that they can work more safely than the marginal miner.

for policy investigation? Our government, after all, is content to stand by while a citizen becomes a daring golfer, overindulgent television viewer, or sloppy homemaker.

Let us assume that careful investigations, of the type outlined in Section II of this paper, reveal that the major health gains available per dollar of expenditure could be achieved by changing the actions that individuals take on their own behalf. An assumption that individuals had the appropriate incentives to care for themselves, and that they should be the sole parties concerned with their own health, might lead to a rather negative evaluation of present governmental programs for promoting health. These programs are clearly overextended; they do not reflect the interests of the citizenry.

We might come to a quite different conclusion if we started instead from the premise that perhaps the competitive market model does not perfectly mirror the type of decision situation that confronts an individual when he makes choices that affect his health. If so, optimally tailored government policies for saving lives would implicitly place valuations on those lives different from individuals' decisions. If the society would, on the whole, benefit when individuals sacrificed other goods for survival probability or improved health, then the social valuation would appropriately be higher. The desirable direction for policy, of course, would be to make decisions that implicitly placed higher values on these individuals' lives than they themselves had done. This could be accomplished through government regulation. For example, we can make it hard for an individual to drive a car if he does not wear seatbelts. Alternatively, we might try to provide specific incentives to get individuals to pay more attention to their physical well-being, leaving the final decision to the individual himself.<sup>62</sup>

#### A. Why Individuals Might Choose Lifestyles Other Than the Most Healthy

Before we encourage individuals to pursue more health-promoting lifestyles, we must understand why they might not. We identify four classes of reasons. First, and most important, there are many benefits from following unhealthy lifestyles. Most of us eat for recreation as well as for nutrition; we like to drink at parties and then drive home; at times we are in a hurry to get some place, and take liberties with the speed limit. Indeed, we argued earlier that there are relatively few areas where individuals can use money to save their own lives. Most of the tradeoffs they make affecting their lifespan relate

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62. Clinical trials are now being conducted to test whether tangible incentives, in the form of cash, green stamps, or chances at a raffle can improve adherence to a medical regimen by patients with high blood pressure. For a discussion of a trial at the Peter Bent Brigham Hospital, on which he is a coinvestigator, see D. Shepard, *Prediction and Incentives in Health Care Policy* (1976) (doctoral dissertation on file at Harvard University).

more to lifestyle than patterns of resource allocation.<sup>63</sup>

Second, there may be externalities among the behaviors of different individuals. Systems of compensation to secure a healthier environment for all may be difficult to secure. It is difficult to protect oneself against the drunk driver, the air contaminator, or the man who spreads infection. Moreover, we ourselves may impose some unhealthy externalities on others. The most significant externality is likely to be that between the individual and his future self. If he smokes now, his health is likely to suffer many years later. There is an interesting question, which merits both empirical and philosophical investigation, whether individuals give appropriate weight to their future well-being. To what extent is John Jones at age twenty the same person as John Jones at age forty?

Third, fellow citizens share in the cost of one's illness. This is probably the most significant externality contributing to the divergence between individuals' choices of lifestyles and the pattern of lifestyles that would prove most beneficial for society. Some of this cost sharing arises through private contractual arrangements, whether disability, life, or health insurance plans. Other aspects work indirectly through the market. For example, overall productivity, hence ultimately wages, declines as the absentee rate rises.

Fourth, lack of knowledge can lead individuals concerned with balancing health against consumptive pleasure to suboptimal choices of lifestyle. Frequently, the sign of a causal relation is known, but not its magnitude. It is bad to smoke, bad to eat fattening desserts, bad to speed, and bad to eat eggs. For the individual who is willing to give up two of these practices but not all four, it would be nice to know just how bad each is. The tradeoffs become much more difficult to estimate when we choose across the spectrum of individual and collective choice. An individual concerned with the risks of nuclear power might be reassured or dismayed to understand that *X* pounds overweight is equivalent to residence half a mile from such a power plant. This information may help him when he votes on public issues, as well as when he sits down at the table. Our earlier argument is underscored: substantial gains in lifesaving per dollar expended will perhaps be the most readily achieved if we improve our predictions of the benefits from alternative life-promoting interventions.

### B. The Role of Government

There is conceivably a role for government in each of these four areas where private behavior may diverge from the optimal behavior for social efficiency. Too many policy analyses, however, leap automatically from diagnosis

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63. Some of these lifestyle choices are dictated in part by habits, such as smoking. With habits, consumptive choices no longer represent optimal allocations chosen in response to predetermined tastes. Once the possibility of changes in tastes is recognized, the efficiency arguments supporting a laissez-faire approach to consumption lose some potency.

of an externality or other aspect of market imperfection to a prescription of government intervention. Here too, empirical estimation would help. Some of these externalities may be relatively minor. Even if the imperfection is significant, whether the government should intervene or not depends on whether it has effective tools which would enable it to help rather than hurt the matter.

The potential roles for government in encouraging individuals to choose more healthful lifestyles are: establishing incentives to deal with externalities on fellow citizens' health, providing information, and attempting to compensate for the inappropriate incentives created for the most part by private and public compensation programs.<sup>64</sup> To the extent that government programs have created these problems, we encounter the problem of pyramiding intervention. Once the government provides compensation for a particular misfortune, it will have an incentive to try to step in to regulate individuals' behaviors so the misfortune is not more likely to occur.

### C. Means to Change Lifestyles

Understanding the government might wish to intervene to encourage individuals to choose more healthful lifestyles, we must next ask what forms of intervention are available.

At the most modest level, the government can merely engage in the provision of information. Information of this type, except for the costs of dissemination, is a public good. If the government can discover, for example, the effects of various diets on health, then it should distribute this information to the general public. No private entrepreneur would have an incentive to provide this information efficiently, *i.e.*, at a price of zero, the marginal cost of making it available. (We distinguish availability costs from dissemination costs.)

Information on the likely consequences of different lifestyles is certainly important; yet we should not overrate its impact. Public education campaigns are rarely evaluated; when they are, often no change in behaviors is observed. A controlled study of television advertisements for wearing seat belts found no increase in the proportion of viewers using them.<sup>65</sup> Mandatory warning labels on cigarette packages and ads have had little effect on consumption.<sup>66</sup>

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64. There would be no inefficiencies generated by these programs if they could be run as traditional contingent claims markets. The problems are two: (1) many lotteries have already been run so useful risk spreading would be lost, or as it is usually put, we would be overlooking distributional considerations, and (2) the information required to conduct such markets is not available without cost.

65. Robertson, Lelley, O'Neill, Wixom, Eiswirth, & Haddon, *A Controlled Study of the Effect of Television Messages on Safety Belt Use*, 64 AM. J. PUB. HEALTH 1071 (1974).

66. U.S. BUREAU OF THE CENSUS, DEP'T OF COMMERCE, STATISTICAL ABSTRACT OF THE UNITED STATES 1975, at 751 (1975).

Often a second type of information is needed: how to change lifestyles if one wants, or has been convinced, to try. In a recent national survey on cigarette smoking,<sup>67</sup> 71 per cent of male smokers indicated that they had made some effort to stop, yet other data show that only a small proportion had been successful. Data on efforts by individuals to lose excessive poundage (outside an institutional context) show similar failures.<sup>68</sup> Only a quarter shed as much as twenty pounds; most of these "successes" eventually return to their former weight. The forces that encourage unhealthy habits in smoking and eating are sturdy; interventions that could empower individuals to control them would be a boon to the national health.

The government can attempt to develop schemes for dealing with externalities among individuals, as there might be with smoking or with driving at excessive speeds. As we have detailed above, the existence of compensatory programs is likely to provide a strong incentive for individuals to allocate less than sufficient resources to the promotion of their own health.

Understanding the possible justifications for government intervention, we should next estimate the magnitudes of the imperfections in any particular circumstances. Finally, we should examine alternative forms of government participation, to see which among them, including the possibility of doing nothing, would prove most desirable.<sup>69</sup>

Basically, the government can choose between active and passive roles.<sup>70</sup> With active roles, the government in effect changes the locus of decision mak-

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67. Horn, *Determinants of Change*, in SECOND WORLD CONFERENCE ON SMOKING AND HEALTH 58, 60-64 (R. Richardson ed. 1972).

68. Stunkard, *Presidential Address—1974: From Education to Action in Psychosomatic Medicine: The Case of Obesity*, 37 PSYCHOSOMATIC MED. 195 (1975).

69. Adam Smith was perhaps the first to point to the merits of a competitive market system in providing individuals with the mixtures of product characteristics they desire. He pointed out, for example, that if the citizenry desires good nutrition, then their best interests will be served if the butcher and baker maximize profits, and take heed of their customers' nutritional needs only to the extent that profits are promoted.

In a *New York Times* column, George Wald made a quite opposite point relating to nuclear safety. "The real question we face is whether nuclear power can be produced safely *while maximizing profit*. The answer to that question is *no*." Wald, *The Nuclear-Power-Truth Maze*, N.Y. Times, Feb. 29, 1976, at 15, col. 5. Assuming for purposes of argument that Wald is correct, then something has gone wrong with our incentive system. (Perhaps the liability system for nuclear accidents is poorly constructed.) Rather than ban nuclear power, we should try to get our incentives in order, for the pursuit of profits is probably generating mischief in many places.

70. Our analysis is pitched to a well-intentioned government attempting to take actions that will enhance the well-being of its citizens. Not all governments are so benevolently inclined. They may act as if they had interests of their own (one of which may be catering to special interests), and take actions that are at variance with the preferences of their citizens.

Most of our discussion is focused on government actions to save or prolong lives. We should not forget that governments engage in life-taking policies, most particularly wars. Moreover, depending on where the benchmark of responsibility is set, as Sissela Bok reminded us, many noninterventions by the government, *e.g.*, permitting health-endangering production processes to continue, may be thought of as explicit actions not to save lives.

ing from the individual to the government. With an active role intervention, all individuals will in effect have the same decision made for them. Passive role intervention leaves the decision in the hands of the individual, though the government may change the terms of the decision he will be making.

Active intervention in the health-promotion area is primarily of two types: direct government provision and government regulation. Thus, the government might make available hospitals, nutrition programs, genetic screening programs, and the like. Regulation includes such measures as making air bags mandatory in new cars, and establishing standards that must be met, such as strictures imposed by EPA and OSHA, or minimum requirements for the deliverers of different types of medical care.

Passive modes of government intervention relate primarily to the provision of information and incentives. In some areas, the provision of information could be an alternative to regulation. The government might publicize the benefits of air bags, or establish certification procedures for medical personnel, allowing the customer to decide whether a physician assistant is sufficient to deliver certain types of care.

#### D. The Provision of Incentives

Where externalities are present, the conceptually appropriate means of government intervention is to provide an incentive for efficient behavior. The magnitude of the incentive should be equal to the total social benefits if an individual takes one action as opposed to another. Where health and lifesaving are concerned, outcomes will be uncertain; estimates of the externality benefit will have to include some probabilistic modeling. If we know what different outcomes are worth, then we should pay differentially for actions according to the probabilities that they lead to the different outcomes.

Let us say Jones can smoke or not. If he smokes he has a .20 chance of contracting the less favorable condition. If he does not smoke, that probability falls to .10. The only externality is that it costs society one thousand dollars if he contracts the less favorable condition. It would be worthwhile for society to charge the individual

$$.2(\$1,000) - .1(\$1,000) = \$100 \text{ for smoking.}^{71}$$

A few methodological points may suggest that a more spirited investigation of the possibility of providing appropriate incentives might prove profitable. First, the actual payments that are made as part of an incentive scheme are lump sum transfers.<sup>72</sup> Unlike the use of X-rays or personnel, they do not

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71. One could argue that there would be a risk-spreading loss if this were done. Propensities to take certain actions that may result in the loss of health may derive from risk factors not under one's control.

72. Any achieved changes in behavior reflect the real cost of diminished enjoyment.



involve the use of scarce resources. Second, when individuals are allowed to respond to incentives, rather than forced to follow particular regimens, we tend to influence the individuals who attach the least cost to the change in their action. For example, if we were trying to encourage individuals to stop their smoking and thereby promote their own health, we would want to get only those individuals whose loss of pleasure from smoking was balanced by health gains. Individuals for whom this pleasure loss is intense, perhaps more accurately individuals who will incur substantial pains if they cease smoking, should not be required to do so. Third, incentives can be targeted where they do the most good. We can pay fat men to lose weight or change their diets.<sup>73</sup> We do not need to prohibit everyone, thin or chubby, from enjoying fattening foods. Fourth, incentives can convey information. In particular, financial incentives can convey information that otherwise fades into the general background noise of centrally provided advice. An individual who is told he will get five dollars a month for maintaining his weight below a particular level may find that a much more compelling communication of the value of the weight loss than a simple reminder that it is dangerous to be overweight, even if that danger is quantified.<sup>74</sup> Fifth, in addition to their efficiency effects, incentives programs can redistribute the costs of unhealthy behaviors and unfortunate outcomes. Taxing cigarettes, for instance, hurts those who are already disadvantaged, in that they are smokers. If such redistributive consequences are unwelcome, they must be balanced against any efficiency gains an incentives program can expect to achieve.

At present, we have a vast array of public and private programs that reduce individuals' incentives to provide for their own health. Probably the best way to generate countervailing incentives to induce individuals to behave properly would be to restructure some of our "offending" present programs. How this can best be done is a challenging subject for research study.

#### CONCLUSION

Most analysts would probably agree that we are far from achieving maximum benefit from the resources we are devoting to lifesaving activities. With the continued expansion of our expenditures for lifesaving, the efficiency loss grows with each passing year.

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73. Targeting can be tricky. Once fat people are paid to lose weight, some people will become fat to get paid to lose weight.

74. The most effective documented efforts to fight obesity involve the use of incentives to change small elements of behavior: climbing a flight of stairs, recording eating situations, tabulating food consumption, practicing stress-reducing behaviors that substitute for eating, etc., can be tallied on a point scale, and rewarded with measured praise and/or more tangible incentives.

Incentives related only to larger scale measures of behavior change, such as praise for weight loss or reduced life insurance premiums for nonsmokers, have not been shown to be as effective in altering behavior patterns. See Stunkard, *supra* note 68; D. Shepard, *supra* note 10.

To curb these losses will require insightful policy reforms. To aid such reforms, we have argued, useful studies might be made: (1) to improve benefit and cost accounting; (2) to refine techniques for predicting the consequences of interventions; and (3) to suggest how incentives should be structured to secure well-considered and efficient lifesaving decisions.