Understanding Life-Threatening Risks

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Received December 6, 1994

Modern science and medicine, and increasing prosperity, have brought many benefits to our society, but not without costs. One cost is that some of the technological innovations and new activities bring with them different and perhaps greater risks that threaten our lives. Any problem involving life-threatening risks is complex, so it is difficult to think through all the implications of the alternatives proposed to address it. This paper presents a number of “facts” to guide constructive thinking about decisions concerning life-threatening risks. The intent is to help us appraise alternatives, design public policy and laws, and communicate about specific risk problems.

1. INTRODUCTION

As a society and as individuals, we Americans are preoccupied with risks, particularly risks to life. From AIDS to cancer to heart disease, from Alar to asbestos to benzene, from earthquakes to floods to tornadoes, from driving to flying to skiing, from eating to drinking to smoking, from living—we worry about all the risks. We allocate significant time, effort, and money to reducing risks, and yet most of us feel that our world is riskier now than it was a generation ago. This simply is not so. As a society, our expected longevity has increased despite the scourges of cancer, AIDS, and violent crime. We cannot banish life-threatening risks, but we can and should learn better ways to deal with them. Better dealing with these risks means worrying less and thinking more so that we make better-informed decisions concerning them.

Regulators, elected officials, managers, and the public all find it difficult to determine the best courses of action (i.e. alternatives) for addressing a particular risk. In certain cases, all may agree that “something needs to be done” but disagree on what that something should be. Furthermore, there is no common framework for appraising the implications of the alternatives in a systematic and rational manner. To help rectify this situation, this paper provides a foundation for systematically thinking about life-threatening risks (henceforth referred to simply as risks). To be specific, a risk from a particular cause refers to the possibility that one could die from that cause. As defined, you could measure the risk of cause A by the probability of dying from cause A in a lifetime.

2. FACTS ABOUT RISKS

Certain realities must be accepted as representing truth for any class of problems. With decisions involving risks, these realities are what might be considered facts of life, so I have chosen the term facts to describe them. For example, it is a fact that you cannot make life-risk-free, and claims that an alternative will do so are not true. Likewise, laws and regulations that mandate zero risk simply do not recognize reality.

Table 1 lists facts about the existence of risks, the analysis of risks, the evaluation of risks, and the choice of alternatives regarding risks. Taken together, these facts summarize my judgment about the current reality.
### Table I. Twenty Facts About Life-Threatening Risks

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<th>Fact</th>
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<td>1.</td>
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<td>2.</td>
<td>Total risk to an individual cannot be reduced; only the causes and timing can be transferred.</td>
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<td>Policies intended to reduce risks to some people often produce risks to other people.</td>
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<td>Alternatives intended to reduce risks often have indirect risks.</td>
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<td>Appropriate personal decisions can reduce personal risk more than all governmental actions.</td>
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Concerning risk problems. To think, communicate, or make decisions about risks while assuming that one of these facts is not true is to defy logic. Some of these facts will not change: there will never be zero risk. Others, for instance those concerning perceptions or current decisionmaking about risks, may not be true at some time in the future. In both cases, if we want to address risks logically today, we must take account of the facts on the list.

### 2.1. Fact 1. Life Is Not and Cannot Be Free of Risk

There are no risk-free alternatives pertaining to any activity, process, or product. Individuals going to the store or to work incur risks of mugging or accidents. Using electricity, drugs, food, and vehicles opens one to risks of product malfunction or misuse. And natural catastrophes, such as earthquakes, tornadoes, lightning, or floods, can strike anyone. Risks are clearly a part of life. Indeed, it is living that poses risks.

For society, too, there are no risk-free alternatives. The illusion of zero risk sometimes occurs when one thinks of eliminating an option. For example, some people believe that the elimination of nuclear power plants would result in zero risk. That may be true for the risks stemming from nuclear power plants themselves. However, the elimination of nuclear power plants would require either more power plants using other fuels such as coal, or more energy conservation. Both of these alternatives carry risks of loss of life as well as other adverse consequences. Steps taken to increase conservation, for example, include better insulation of homes and more burning of wood in fireplaces for warmth. As a result, indoor air pollution levels in some cases rise to well above outdoor air quality limits and more homes are destroyed by fire. The elimination of one alternative de facto means the selection of another, and any selected alternative will always have its risks.

In interpreting risks, people have a tendency to compare the active choice of an alternative to an unspecified alternative assumed to have zero risk. This occurred with the buildup of international forces in the Middle East before the Gulf War. The U.S. media naturally reported American fatalities throughout the time that our troops were involved. The Gulf War ended on February 28, 1991, and as of mid-March, Wallace (1991) reported 322 U.S. casualties and Cohen and Pas- ternak (1991) reported 184 U.S. troops killed. Whatever the number is, even one death is regrettable and irreplaceable. It is, however, instructive to ask how many of the U.S. personnel in the Gulf would have died in the same period had they remained at home. My calculations using data about the age, race, and sex of those sent to the Gulf suggest that some 340 to 450 would have died. Perhaps a more careful accounting of the expected at-home fatality rates for those who served in the Gulf would reduce these numbers somewhat, but it appears that fewer U.S. troops died in the Gulf than would have died had they stayed at home. The point is simple: there is no zero risk.

### 2.2. Fact 2. Total Risk to an Individual Cannot Be Reduced; Only the Causes and Timing Can Be Transferred

Everyone must eventually die. Hence, if one type of risk is reduced, other risks increase though the timing and cause of one’s eventual death are likely to change. For instance, seat belts have reduced the risk of dying...
in an automobile accident. As a result, for those who wear seat belts, individual risks of dying from cancer or heart disease have increased.

This fact in no way suggests that an individual or society should not manage life-threatening risks. Most of us would probably rather die of "natural causes" when we are ninety years old than of an automobile accident a year from now. The point is that our life is not saved, it is prolonged. Thus, when we speak of reducing risk, we mean reducing risks from particular causes, which in turn increases risks from other causes further in the future.

2.3. Fact 3. Policies Intended to Reduce Risks to Some People Often Produce Risks to Other People

Public problems also involve another kind of transfer of risks: transfer among individuals. Policies to exchange sterile needles for used needles from current drug users decreases risks from AIDS and other transmittable diseases for many users, but they may increase the risks for potential users who acquire a habit of using drugs. The selection of an alternative leads to a redistribution of risks (see Whipple, 1985) not to zero risk.

The transfer of risks from some individuals to others is often subtle. Using more resources for the treatment of cancer patients means that fewer resources are available for other patients, say those with heart problems. Consequently, risks to heart patients may increase. Another example involved a potential regulation to require expensive equipment to reduce air pollution from coal-fired power plants (see Keeney and von Winterfeldt, 1986). The regulation would have had a net benefit of one fewer fatal cancer per year. However, the equipment would have reduced power plant efficiency by about one percent, so an additional four large power plants nationally would have been needed. A simple analysis indicated that more workers would die in such a large-scale construction program and many more public fatalities would be associated with operating the four added power plants. The proposed regulation was not passed, perhaps in part because the risks produced in this case far outweighed the other risks it was intended to reduce. Even with the best of intentions, risks may be inadvertently transferred. Cutting curbs at crosswalks makes it safer for people in wheelchairs to cross streets, but it may make it more dangerous for blind people.

2.4. Fact 4. Alternatives Intended to Reduce Risks Often Have Indirect Risks

Alternatives implemented to reduce risks often indirectly induce other risks that fall on the same people whose risks were to be reduced. For example, one may purchase a heavier, "safer" car to reduce the risk of dying in a collision. However, individuals in a heavier car may feel safer and hence drive less carefully, increasing their risk of a serious accident (see Wasielewski and Evans, 1985). Medical decisions also involve indirect risks. Undergoing surgery for cancer may decrease cancer risk, but surgery itself carries risks. And inoculations to prevent life-threatening diseases such as diphtheria or swine flu can themselves cause loss of life.

Regulatory policies designed to reduce specific risks to the public also indirectly impose other risks. For instance, there was a proposal in 1983 to recall a class of cars for inspection and replacement of a potentially defective part on the axle. Lave (1983) analyzed the risks of recalling and not recalling the cars and concluded that the car owners would face greater risk from the extra travel involved in driving the car in for a recall and returning home than from driving the car for the rest of its projected lifetime without having the inspection. The indirect risk caused by the proposed "solution" was greater than the risk of the problem itself.

2.5. Fact 5. The Economic Costs of Risk Reduction Induce Risks

We all know that people in wealthier countries live longer. What is less generally known is that wealthier individuals within a country live longer on average than poorer individuals (see Kitagawa and Hauser, 1973; Sagan, 1987; Wilkens, Adams, and Brancker, 1989). On the national level, a wealthier nation has the economic resources to take preventive actions to reduce risks as well as intervening actions to address medical and national disasters. Wealthier nations have the infrastructure, knowledge, and funds to reduce risks significantly.

On an individual level, too, "richer is safer" (see Wildavsky, 1980, 1988), and, in fact, the economic costs of risk-reduction policies can induce significant risks. All the money to implement risk-reduction policies, including policies "paid for" by government, must come from individuals. This leaves them with less money to spend on all other needs, including personal activities to reduce risk. Graham, Chang, and Evans (1992), and Chapman and Hartharan (1994) present strong evidence that higher permanent income leads to lower individual
risks. A quantification of this principle (Keeney, 1990, 1994) suggests that a cost in the range of $5 to $12 million of 1990 dollars borne by many individuals may induce a fatality because those many individuals are slightly poorer and therefore they do not and cannot make many life-sustaining choices, such as buying better tires, eating more healthful foods, working fewer hours, living in safer communities, and in general leading a less stressful life.

2.6. Fact 6. Risk Problems Involve Conflicting Objectives

Those who make decisions about risk problems have objectives in addition to the reduction of a particular risk. These objectives may pertain to economic costs, environmental impacts, social concerns, or quality of life. By their nature, multiple objectives always conflict to some degree. This means that after one eliminates dominated alternatives (alternatives that are no better than some competing alternative in terms of any of the objectives), one can better achieve a given objective only if the achievement of another objective is reduced.

Consider the decision to set the speed limit for highways, and suppose that the single objective is to minimize risk. One could argue that a speed limit of 50 mph is preferable to 60 mph, because fewer accidents and consequently fewer fatalities occur with the lower speed limit. Using the same logic, 40 mph is preferable to 50 mph, and 30 mph is preferable to 40 mph. Clearly, risk in the context of highway speed limits would be reduced as much as possible if the speed limit were zero. But nobody argues that the speed limit should be zero or even 20 mph because automobile travel serves other objectives concerning convenience and economic costs and benefits. Risk problems are multiple-objective problems.

2.7. Fact 7. Identifiable Fatalities Are Not the Same as Statistical Fatalities

Suppose an accident in a coal mine traps one miner, Kirk Eastman. He has enough water and air to survive for a week. A quick appraisal indicates that it would cost $10 million to drill a shaft and rescue Kirk, an effort that is sure to be successful. The decision is made to proceed, and naturally almost everyone considers the decision appropriate: $10 million is certainly less significant than Kirk’s life. Just before the work begins, however, someone familiar with mine safety voices a dissenting opinion: “Coal mining is a risky occupation, and from time to time there are accidents in the mine. These accidents are often caused by weakened structural supports. If we spend the $10 million to strengthen support systems, we can expect fewer mining accidents over the next ten years, and statistics suggest that the lives of four miners will therefore be saved. Should we spend $10 million to save the life of one miner when we could use the same amount to save four miners?”

Perhaps $10 million should be spent for each purpose, but if only one of them can be pursued, many people will choose to rescue Kirk. There is, of course, no right or wrong answer to this. Rescuing Kirk Eastman would avert an identifiable fatality. Saving four miners who would have been in accidents that would not occur would avoid four statistical fatalities. In the former case, everyone would know who was saved, whereas in the latter case this could never be known. Because of this distinction, it may be appropriate to assign a different economic value (most people suggest a smaller one) to saving statistical lives than to saving identifiable lives.

Most public risk problems concern statistical fatalities, whereas personal risk problems naturally address identifiable fatalities. A program to upgrade road surfaces to make automobile travel safer would lower risks for millions of travelers and lives would be saved. These would be statistical lives. It might be possible to calculate the number of statistical lives saved, but it would never be known whose lives were saved. On the personal level, in contrast, you may take action to improve the safety of your driving by buying a car with anti-lock brakes. This may lower your risk of dying in an automobile accident. Here the risk concerns an identifiable fatality, namely you.

2.8. Fact 8. Attributing Lives Saved or Lost to Decisions Made Is Important

With identifiable fatalities, it is known before any decisions are made about a particular risk whose lives may be saved or lost. With statistical fatalities, it is not known even after the consequences of a decision whose lives have been saved or lost. Between these two extremes lies a third important category: attributable fatalities. In such cases, whose lives may be saved or lost is not known when the decision is made, but is known after the consequences of the decision.

Consider the context of automobile travel outlined above. Suppose the program to upgrade road surfaces would cost $100 million and save 100 statistical lives. But suppose an alternative plan, to install resilient bump-
ers on bridges to soften impact when a vehicle collides with the bridge, would also cost $100 million and save 100 statistical lives. Before the decision, we would not know whose lives would be saved with either alternative. But after installing the bridge bumpers, we could identify whose lives may have been saved in collisions with bumpers. These lives saved could be attributed to the bumper alternative. With the road surface upgrade, the 100 statistical lives saved could never be attributed to the decision. Policy decisions about risks are often evaluated in terms of lives saved, so decisionmakers consider attributable fatalities or lives saved more important than nonattributable ones.

Two related points are noteworthy. First, any identifiable life saved or lost is naturally an attributable life; if you know before a decision whose life may be affected, you certainly know after the consequences of the decision are felt. Second, the lives saved by programs focusing on cure are often attributable, whereas those saved by prevention programs are more often statistical (that is, nonattributable). Perhaps this partially explains the tendency to emphasize “cures” for various risks more than prevention.


Values are essential for evaluating risks. To some people, this is obvious. How could one evaluate anything without values? But others apparently would like to believe that values are not necessary. They wish to rely on facts and facts alone in evaluating alternatives and making choices. Yet when the facts are abundant and unambiguous, which is rarely the case, someone with a choice to make wishes to choose the best (or a good) alternative. The notions of best and good are based on values. These value judgments may be implicit and may not be recognized for what they are, but it is not possible to evaluate choices without them.

Suppose you have decided to buy a specific new car and the only question is whether to purchase the optional driver’s side air bag. The current data suggest that your risk of dying in a car accident over the next five years, the period you expect to own the car, is one chance in a thousand. Suppose an air bag would cut your risk in half, to one chance in two thousand. Finally, suppose the air bag costs $1,200. Do you buy the air bag? You have all the data. But to make this decision, you need to ask whether you value a reduction in your risk of one chance in two thousand over five years more than you value the $1,200. There is no way around it: this is a value judgment. Maybe the decision is easy to make or maybe you do not even want to think about it, but you cannot make it without involving your values.


The values necessary to evaluate risks deal with the characteristics of the risks themselves as well as their relative importance. Although everyone may have distinct values, professionals concerned with risk and laypeople characterize risk entirely differently. The professionals tend to characterize individual risks by the probability of death and public risks by the expected number of fatalities. Laypeople tend to consider many additional factors in evaluating risks. Starr (1969) was the first to note that the public considered voluntary risks, meaning those assumed as part of a conscious choice, less significant than involuntarily imposed risks. Many people evaluate the infliction of AIDS due to conscious sexual behavior differently from the same infliction due to a contaminated transfusion. Job-related risks and risks from chosen activities, such as smoking or skiing, are voluntary risks. Risks from airline accidents, pesticide use, and air pollution are involuntary risks. Studies of people’s perception of risks (see Slovic, Fischhoff, and Lichtenstein, 1980; Slovic, 1987) have expanded the list of characteristics considered relevant to the evaluation of risks to include whether the risks are known and understood by those exposed to them (automobile risks are known, bioengineering risks are not), whether they are controllable by those exposed, whether they are potentially catastrophic, and whether they are dreaded, meaning a terrible way to go. Voluntary, controllable risks that are not catastrophic or dreaded are considered least significant by most members of the public.


Over the past several years I have asked many people whether they think that the evaluation of public risk problems should include value judgments about the relative importance of the lives of different individuals. The response is almost always no. In a follow-up question, I ask the same people whether the lives of all citizens should be valued equally in public risk problems. Here, the answer is invariably yes. I then point out that this “equality” is definitely a value judgment.
Equality suggests that the death of any one individual is equally important to avoid. Then the death of a speeding drunk driver is as important as that of a passenger in a car rammed by that driver. Also, the lost life of a 90-year-old living in pain and mentally impaired is just as important as the lost life of a healthy 10-year-old. But the 10-year-old loses some 70 years of healthy life, whereas that 90-year-old loses only about 2 years. Should equality mean that we count the loss of each expected year of life the same, so that the death of the 10-year-old is 35 times as important as the death of the 90-year-old (see Graham, Raiffa, and Vaupel, 1986)? One way or another, value judgments about the relative importance of different lives are inescapable in public risk problems.


In essentially every public decision context, spending more money could reduce specific risks of loss of life. More safety features could be installed on automobiles, more testing could be done before licensing drugs, stricter controls could be required on pollution sources. All these steps presumably would reduce the risks involved, but they would also increase costs. Hence, it is necessary to make a value tradeoff between economic costs and loss of life—that is, to determine how much we are willing to spend to save a statistical life. Nevertheless, many people are uncomfortable with the idea of trading off economic costs against potential fatalities.

In personal decisions, individuals must make value tradeoffs between their own risks and their own funds. You can spend money in many ways to enhance your safety and health. You can buy a safer automobile, join a health club, obtain preventive health care, eat better food, and “safety-proof” your home. But because your funds are limited, purchases to lower one risk may preclude purchases to lower other risks. Knowing the economic costs of reducing various risks may provide some guidance for your individual value tradeoff between costs and risks.

There is a subtle interaction between the appropriate value tradeoffs for public risk problems and personal risk problems. With public risk problems, all economic costs of purchasing additional health and safety are eventually paid by individuals through a multitude of mechanisms such as taxes and higher product costs. These individuals then have less discretionary funds to promote other aspects of their own health and safety. In reviewing a regulation of toxic substances proposed by the Occupational Safety and Health Administration (OSHA), the Office of Management and Budget (OMB) used this logic to suggest that the proposal might claim more lives than it would save (MacRae, 1992). Consequently, OMB suspended its review until the risks induced by economic costs could be addressed along with the risks of exposure to toxic substances. The question is whether the public should pay for very expensive risk-reduction programs that would save a few statistical lives if significantly more lives would be lost due to being poorer.

2.13. Fact 13. It Is Not Unethical to Trade Off Economic Costs Against Risk of Loss of Life

Some people consider it immoral to trade off lives against economic costs. However, as stated in Fact 12, many risk problems require such a tradeoff. Moral theories clearly hold that an action is not immoral when there are no alternatives (Beauchamp, 1982), so making the value tradeoff between loss of lives and economic costs is not immoral.

In addition, many moral theories argue that refraining from actions to save lives is immoral. To the extent that analysis can lead to better decisions that will save more lives, it is perhaps immoral not to explicitly address the crucial value tradeoff between costs and statistical fatalities (see Keeney, 1984). The important issues are whether the value tradeoff is made explicitly or implicitly and what the tradeoff should be.


How should we responsibly compare public programs that save lives at different times? The answer is simple, but the reasoning (as described in detail in Raiffa, Schwartz, and Weinstein, 1978) is subtle. The answer is that lives saved in the future should be assigned a lower monetary value today than lives saved now. That is, future lives saved should be discounted relative to current lives saved. As shown below, this does not imply that future lives are less valuable than present lives.
Let us consider three alternatives: (1) spending dollars today to save lives this year, (2) spending dollars today to save lives 100 years from now, and (3) spending dollars in 100 years to save lives 100 years from now. To avoid two extraneous concerns, let us clarify that the dollars spent will be real dollars, meaning that the amounts have been adjusted for inflation, and that the lives saved will be individuals of the same age, say 30-year-olds, at the time they are saved.

Suppose we are just willing to spend $1 million today to save a statistical life this year. If we value lives in all time periods identically, this means that we should be just willing to spend $1 million (of inflation-adjusted dollars) in 100 years to save a statistical life in 100 years.

What does this imply about the relative value of saving lives this year and in 100 years with dollar investments today? A guiding principle for this evaluation is that dollars spent to save lives in 100 years should be spent to save the most lives possible. Consider a public decision to spend $1 million today to save one statistical life 100 years from now. Should the expenditure be made? A simplistic answer might be that since we value lives equally in all periods, we should be just as willing to spend the $1 million now to save the life in 100 years. But a logical alternative would be to invest the $1 million for financial return for 100 years and then spend the proceeds at that time to save lives. Suppose that the $1 million could be invested at a 3% real annual return. It would then grow to about $20 million in 100 years. Since we are just willing to spend $1 million in 100 years to save one life at that time, we should be just willing to spend the $20 million in 100 years to save 20 lives at that time. Therefore, we should be indifferent between saving one statistical life today and saving 20 statistical lives in 100 years. The same method can be used to calculate values for lives saved at other times in the future. Discounting future lives saved by present-day expenditures allows us to use resources more effectively and save more lives in the future.

A critical issue often raised is that discounting lives into the distant future implies counting one life saved this year as more important than saving billions of lives, perhaps even all of humanity, in a few thousand years. The simple response is that such catastrophic losses of life involve concerns for civilization and culture beyond the loss of individual lives. An appropriate evaluation of these concerns in addition to the individual lives lost would not suggest that catastrophic loss of life in the future is less significant than the loss of relatively few lives today.

2.15. Fact 15. Evaluating Risks Requires Both Science and Judgment

Some people desire completely scientific "answers" to problems involving risk. Others believe that science cannot be used to address risk—it is one's feelings that matter. Both extremes are inappropriate. Responsible evaluation of risks requires both good science and good judgment (see Committee on Risk and Decision Making, 1982).

How should we decide to spend time thinking about a specific risk problem and identify possible alternatives to address that risk? Judgment, perhaps based on scientific understanding, is essential for these activities. Scientific models and data are then useful, and perhaps indispensable, in the estimation of the risks and other consequences that might follow from a choice of each alternative. Atmospheric models of wind patterns may indicate where pollutants may be carried. Physiological models may indicate the consequences of exposure to specific pollutants. Epidemiological data may also help to estimate risks of pollutants. We need to combine such information as logically as we can to obtain estimates of risks. Because of the complexities inherent in such problems, there will be uncertainties about the risks, but good science can help us to understand and bound these uncertainties.

To appraise the estimated risks and reach an appropriate decision requires value judgments. These value judgments should be made systematically, consistently, and explicitly so that we can understand and appraise their significance. One can avoid thinking hard about these judgments or perhaps thinking about them at all, but one cannot avoid making them. If we do not think about them, they will be made implicitly without the benefit of review, appraisal, and reflection. As a result, the quality of decisionmaking will suffer.

2.16. Fact 16. Alternatives with Greater Risk May Be Preferred to Alternatives with Less Risk

The acceptable level of risk is not necessarily the level we are happy with, nor is it necessarily the lowest risk. Most of us would prefer less risk to more risk if all the other consequences were held fixed. However, all the other consequences are not fixed. Various pros and cons need to be weighted in selecting the best alternative for a specific risk problem. That best alternative has a level of risk associated with it. This level of risk is, by definition, the acceptable level.
Some individuals prefer to drive a car rather than fly a commercial airline between cities, even though the statistics tell us that driving is much riskier. The greater risk is preferred because the flying alternative also has significant fear associated with it. Similarly, as mentioned in Fact 12, it often becomes possible to lower risks further only at an economic cost. But it is clearly unreasonable to spend all one’s resources to reduce a specific risk. The acceptable risk is the level of risk associated with the best of the available alternatives, not the best level of risk associated with any of the alternatives.

2.17. Fact 17. There Is No Generally Acceptable Level of Risk

For public risks, the acceptable level of risk will depend on the prosperity in a country. A poor country may have few resources to address major public risks such as disease and famine. A richer country has the infrastructure that reduces many major risks and the resources to address many of the remaining risks. It follows that decisionmakers in, say, the United States and Bangladesh will consider widely different levels of risks to be acceptable. As a country becomes wealthier, the appropriate value tradeoff between costs and life-threatening risks will change. The risks to workers tolerated at the turn of the century would not be acceptable today.

For individuals, the acceptable level of risk from recreational boating need not be the same as that from a commercial ocean voyage, nor should the acceptable level of risk from drinking tap water necessarily be equal to that from smoking or skiing. Because risk problems have multiple objectives, the only responsible answer to “how safe is safe enough?” is “it depends.” If an alternative offers a small decrease in risk but has large negative effects in terms of other objectives, it is probably not worth pursuing. But if the negative effects are minimal and the reduction in risk is large, the alternative will likely seem desirable. Hence, the acceptable level of risk depends on the objectives and the alternatives proposed to address them and on the individual judging acceptability, and thus will vary significantly from problem to problem.

2.18. Fact 18. Conservatism Is Not Always Conservative

People working on risk problems often fall back on a guideline that is something like “when in doubt, be conservative.” In this case, being conservative is taken to mean lowering risk levels an extra amount “just to be on the safe side.” The intuition is that this kind of conservatism with respect to specific risks will lower total risks. But in fact, lowering one specific risk will often increase another risk.

Consider a proposed air pollution standard. Science may suggest that exposure to less than 10 parts per million (ppm) in air has no significant health effects. However, in the name of conservatism, suppose a legal standard of 8 ppm is established. Industries and businesses would have to install more expensive pollution control equipment to meet a standard of 8 ppm. Consequently, some additional firms would be forced to close. Employees would lose jobs and prices of other products would increase, both of which increase risks to the individuals involved. If the 8 ppm standard resulted in little or no extra benefit to health, it may cause greater immediate risk by inducing unemployment and higher prices. This is anything but conservative.

New drugs to treat serious diseases are constantly being developed. Suppose clinical trials indicate that a new drug reduces risks from its target disease but imposes smaller risks due to a detrimental side effect. And suppose the magnitude of this side effect is uncertain. A conservative approach would suggest not licensing the drug until the risk due to the side effect could be more thoroughly studied. This reduces the risk due to the side effect, but it maintains the risks due to the disease. In this case, the conservative approach avoids a small risk and maintains a larger one. Careful consideration of the problem may support the decision to delay licensing, because the disease risk and the side-effect risk may not be evaluated as equally important. However, without the drug the combined risk from the two sources to someone with the disease will be higher, and this consequence is not conservative.


Many governmental decisions seek to reduce public risks to save statistical lives. Since this typically requires an economic expenditure, it is appropriate to ask how much is being expended to save a statistical life with the respective decisions. Graham and Vaupel (1981) investigated this issue for 57 federal government programs and found a range in cost from a few tens of thousands of dollars to hundreds of millions of dollars per statistical life saved. Other government programs have been
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proposed that would avert a statistical fatality only at a cost of more than $1 billion per statistical life saved (see Morrall, 1986).

We may choose not to evaluate all statistical fatalities equally. We may consider statistical fatalities to children, for example, more important to avoid than those to adults. Similarly, statistical fatalities to workers from their work may seem less important than statistical fatalities to the general public from the workers' work, perhaps because the former risk is voluntarily assumed and the latter involuntarily imposed. In one evaluation of potential sites for a nuclear waste repository, statistical fatalities to workers and the general public due to transportation accidents and emitted radiation were evaluated at $1 million and $4 million respectively (Merkhofer and Keeney, 1987).

Whether or not we assign different economic values to different categories of statistical lives, it is important to note that some consistency in evaluating similar statistical fatalities averted due to different programs would potentially save thousands more lives—our lives. Suppose a program to reduce emissions of pollutant A would cost $200 million per statistical public life saved and a different program to reduce emissions of pollutant B would cost $1 million per statistical public life saved. If the government decided not to spend $200 million to reduce pollutant A, thereby not saving one statistical life, it could use the money to reduce pollutant B and save 200 statistical lives. There are numerous opportunities for such comparisons and changes in government investments in health and safety that would save thousands of American lives annually.

2.20. Fact 20. Appropriate Personal Decisions Can Reduce Personal Risk More than All Governmental Actions

Many of us feel that we have no control over the risks in our life. We read in newspapers and hear on television about new, previously unheard of risks; we learn that neither the scientists nor the bureaucrats understand their precise effects or how to control them; we hear from one group that these risks are under control and from others that they are completely out of hand; and yet we do not have the time or expertise to appraise each of the risks themselves. We feel powerless to make our lives safer.

In fact, we have control over a substantial amount of the risk that affects us (see Zeckhauser and Viscusi, 1990). The major health and safety risks faced by individuals are smoking, overuse of alcohol, being overweight, and vehicle accidents (see Ravenholt and Whelan, 1990; Cohen, 1991). If one does not smoke, stays in good physical shape, buckles one's seat belt, and avoids driving while inebriated or with the inebriated, a large part of one's own health and safety risk is eliminated. Smoking, being overweight, misusing alcohol and drugs, and automobile accidents account for greater loss of life than all the problem areas currently being regulated by federal and local governments.

3. SUGGESTIONS FOR STRUCTURED THINKING AND COMMUNICATING ABOUT RISKS

Citizens, regulators, legislators, and managers should be informed when making decisions about risk problems. To be informed, the problems must be well understood and the process of "solving" them must be open and consistent (see Ruckelshaus, 1984). The suggestions that follow are appropriate for thinking about any risk problem, whether the alternatives are appraised intuitively or with the aid of systematic analysis. The suggestions are equally appropriate for public and personal risk problems, although following them is less involved for personal risks.

3.1. Suggestion 1. Acknowledge the Issues Raised by Each Risk Problem

All those involved in making decisions about a given risk problem should explicitly acknowledge the complexity of the problem and the issues it raises. A good first step is to examine and discuss how the general facts about risks listed in Table I relate to that problem. The alternatives being considered, the interest groups concerned with the decision process, the citizens or groups of citizens affected by the decision, and the data pertaining to the problem should all be openly discussed.

Some of our laws explicitly prohibit following the common sense of Suggestion 1 for certain public risk problems. For instance, the Clean Air Act has as its stated purpose protecting the health of the public with an adequate margin of safety. However, legal interpretations of the Act prohibit consideration of the economic costs of the alternatives in setting national ambient air quality standards and emission standards. Likewise, the Delaney clause of the Food and Drug Act requires the banning of any food additive found to cause cancer in animals. This is essentially an attempt to mandate zero risk concerning foods and drugs. Furthermore, it pre-
cludes addressing issues inherent in the risk problems such as the value tradeoff between economic costs and statistical fatalities. Quite simply, such laws and interpretations indicate a lack of understanding of risk problems and prevent specific risk issues from being openly acknowledged, appropriately addressed, or honestly communicated.

3.2. Suggestion 2. Clarify the Objectives for Each Risk Problem

The reason to take action on any risk problem is to achieve certain objectives as completely as possible. These objectives should be clearly and explicitly stated, since they serve as a basis for both creating and appraising alternatives. One can select an appropriate level of risk only by understanding what must be given up in terms of the other objectives to achieve each different level of risk.

In specifying objectives for public risk problems, it is worthwhile considering the perspectives of different stakeholders who will be affected by a particular decision. For instance, with regard to regulating pollutants, one should consider the perspectives of the regulated, those who pay for the regulation, and those subject to risks from the pollutants. A reasonable and useful way to do this is to include public and stakeholder participation in the risk assessment process. Specifying the objectives with input from all the stakeholders should help to identify inadvertent impacts of proposed regulations or alternatives. Did the legislators who required street-level crossings to help those in wheelchairs recognize the unintended difficulties that they cause for the blind?

3.3. Suggestion 3. Identify the Role of Judgments About Facts and Values

Differences of opinion about what actions are appropriate to address risk problems can stem from different factual judgments or different value judgments. Experts, or so-called experts, may disagree about the relevance of data to a specific problem or about their interpretation. Stakeholders or policymakers may agree on the objectives for the decision problem but disagree on the value tradeoffs between different levels of achievement of those objectives. Individuals may even agree on the objectives to be achieved but disagree on the degree to which the various alternatives achieve those objectives. Such disagreements rest mainly on either different judgments about the facts and their interpretation or on different value judgments.

Since judgments about facts and about values are essential to making any decisions about risk problems, it is important to clarify their relevance in each situation. All of the judgments should be unambiguously stated along with any reasoning on which they are based. Furthermore, any analysis of alternatives should include sensitivity analyses of the value judgments and factual judgments to examine their significance.

3.4. Suggestion 4. Communicate Consistently with the Facts About Risks

People want to be informed about risks, so a good deal of communication is necessary. Whether the government communicates with the public, scientific experts with the government, interest groups with the news media, parent with child, or individual with individual, it is important that it be consistent with the facts about risks. Any claim that some alternative reduces risks to zero, or that value tradeoffs between economic costs and statistical lives are unnecessary, or that a certain course of action is based on a completely value-free or scientific analysis is inaccurate and misleading. This will result in a lack of respect for and trust in the communicator.

Risk problems are complex, and communications about such risks that do not recognize the complexity are irresponsible. Those charged with communicating about a specific risk problem should understand the problem from the viewpoints of their audiences. Results of risk analyses should be expressed both in terms of effects on individuals and in terms of impacts on society, with distinctions between the two made clear. Risk communicators should also avoid technical and bureaucratic language, putting information in terms that can be understood by the audience. Effective communication enables all of us to better understand general risk problems as well as specific risks that we face. With time, this should lead to better decision making regarding risks, which is our ultimate goal.

4. SUMMARY

The intent of this paper is to provide a basis for thinking about life-threatening risks. After detailing twenty facts about risks, it makes four suggestions for addressing risk problems. The paper clearly does not develop "answers" for solving such problems; that is the responsibility of legislators, regulators, and managers for
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public risk problems and of individuals for private risk problems. Instead, the paper seeks to provide insights to help those legislators, regulators, managers, and individuals to understand, evaluate, and communicate about risks.

ACKNOWLEDGMENTS

This paper was written with the support of the National Science Foundation with Grant SBR-9308660 and the Electric Power Research Institute with Project No. RP-2560-03.

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