Introduction

Wars often involve major health consequences for thousands of individuals. Those affected include the combatants from the countries engaged in the conflict, armed forces from other nations, and citizenry. These groups also could include individuals far removed from the conflict if, for example, chemical exposures from the combat situation led to genetic damage that harmed the offspring of a combatant.

This chapter addresses how adverse consequences resulting from war should be valued from the standpoint of compensation. In undertaking this analysis, I will make the assumption that compensation is appropriate. In some instances involving war, providing compensation may strike one as being quite odd. For example, one would not think that a nation that launched an aggression would seek financial compensation for the injuries to the soldiers who were killed in such a conflict. What I will assume, then, is that there has been a determination that compensation is warranted, and the remaining issue is how such compensation should be set.

This subject in a generic sense has been the focus of a considerable literature in economics. How one should set compensation will depend in large part on the purpose one is trying to achieve through such compensation. In particular, is the intent to insure the losses of the accident victim or to provide deterrence? The principal message of this chapter is that the standard objective in compensatory legal contexts should be an insurance function so that compensation for economic loss should be the guiding principle determining the value of the adverse health consequences of wars.
Valuing the health consequences of war

The valuation of health outcomes is not a straightforward proposition. We are generally dealing with issues much more complex and of a different dimension than financial costs alone. Risks to individual health often are unpleasant to confront. To some, valuing losses to individual health may appear to be outside the realm of usual economic analysis. However, over the past several decades, a considerable literature in economics has developed in an effort to enable analysts to think sensibly about these issues and to place meaningful empirical estimates on health outcomes.

This chapter will consider how one should approach the valuation of the health-related effects of wars. The nature of the inquiry will necessarily be limited by current knowledge, much of which is associated with the valuation of health outcomes in contexts in which these values already play a prominent role in government policy. The chief example is, of course, the extensive literature on the value of life. The fact that these examples will not encompass all health outcomes that are possibly influenced by wars does not imply that the economic methodology is restrictive. Rather, this literature indicates how one can successfully address these questions and what methodological mechanisms are available for people to resolve the often difficult valuation problems for health effects.

The first section will introduce the principal methodological concerns, primarily focusing on what should be the guiding principle for setting damages: should it be society’s willingness to pay for risk reduction or the present value of the financial losses? This section will also address practical techniques that are frequently used in the medical decisionmaking context, such as the focus on quality-adjusted life years. The second section explores how market-based evidence often has been used to assess the implicit value of life and job-related injuries. Since explicit or implicit market trades do not always exist for every health outcome of interest, it is often necessary to utilize surveys to elicit the appropriate willingness to pay values, and these are the subject of the third section. The fourth section indicates how such survey results can be used to assess the underlying utility functions pertaining to different health states. One potential difficulty for health loss assessments is that these risks do not arise from choices and may be tainted by irrational behavior. Some of the more salient irrationalities are the subject of the final section.
Economic principles for valuing health risks from war

COMPENSATION PRINCIPLES

Determining the appropriate value of compensation for the adverse health effects of war depends in large part on the purpose of such compensation. In the US legal system, the basic principle for accident compensation is that of insurance.\(^1\) In particular, the intent of such compensation is to restore the economic loss associated with the accident.

As a practical matter, this approach leads to the following kinds of compensation. In the case of a wrongful death, the value of compensation is the present value of the decedent’s lost earnings net of the share of these earnings that would have been devoted to the decedent’s consumption. In the case of non-fatal injuries, the value of the compensation is the present value of the lost earnings plus the present value of the medical costs. Courts often supplement these amounts by some value for pain and suffering compensation, but these levels on average are around the same magnitude as the value of the attorneys’ fees, thus enabling the injured person to be made whole financially, after attorneys’ fees are deducted.

In this chapter, I adopt the point of view that these same economic principles for damages applied in US tort law should also be applicable for determining the value of appropriate compensation for injuries due to wars. To the extent that the objective is insurance and compensation of accident victims, the standard economic methodology of determining financial losses is appropriate.

One alternative approach is to ask how much an individual would need to be compensated to be made whole after the adverse health effect. In the case of a person killed or catastrophically injured in war, no amount of money may suffice to make that individual as well off as they would have been had they remained healthy. This concept consequently leads to a potentially unbounded level of compensation even for an individual person.

The more general concept adopted by economists is the value of society’s willingness to pay for risk reduction. Much of this chapter will focus on this concept, which is widely employed throughout the US government

Valuing the health consequences of war

to value the health benefits of reducing risk. It is important to note, however, that this concept pertains to the optimal deterrence value for preventing injuries, not the appropriate compensation value for transferring income to people after they are injured. If, for example, one were to use this willingness-to-pay measure to compensate people injured in wars, the result would be excessive compensation from the standpoint of insurance. The reasons for this difficulty will be apparent upon further exploration of the source of these willingness-to-pay figures.

Within the US court system, there have been attempts to use these willingness-to-pay measures to set a value for human life and health. This effort has come under the general heading of "hedonic" damages. This approach to setting damages is generally viewed with disrepute and has been widely rejected in jurisdictions throughout the country.²

THE WILLINGNESS-TO-PAY MEASURE

The deterrence value of the health outcomes associated with wars is no different in character from valuing any other public policy outcome. What matters is society's willingness to pay for the benefit generated by this effort. In the case of wars, the typical outcome will be an increase in societal risk levels due to the conflict. As a result, the value of society's willingness to pay to avoid the marginal increases in risk that will occur is the appropriate deterrence measure.

In making this deterrence tally, one consequently should not equate the economic costs of war with financial costs alone. The effects on hospital fees, out-of-pocket medical expenses, and earnings of those affected by wars are, of course, among the potential consequences that should be valued. However, these items reflect only a partial tally of the overall effects. Many of the most severe impacts will be the ramifications for individual well-being. Even though individual health is generally not treated explicitly in markets, changes in risk to health can be valued and should be an explicit component of any deterrence value assessment of wars.

The valuation amounts that are pertinent are those associated with the preferences of those at risk. Thus, the matter of interest is society's willingness to avoid the risks from wars. We are not concerned with the assessments

of politicians, generals, physicians, or other experts, but rather with the preferences of the people who will be directly affected by the outcomes. To obtain these assessments, it is necessary to acquire information with respect to individual preferences in the target population, rather than to rely upon expert panels or government officials to make these judgments.

In situations in which economists assess valuations of small risks, the phraseology “value of life” often appears. The genesis of this terminology is as follows. Consider the case where the good being valued is a reduction in mortality risk, such as one in 10,000. Let there be some associated willingness to pay for this risk reduction, such as $500. In such an instance, a group of 10,000 individuals would be collectively willing to pay $5 million to avert one statistical death. As a result, the “value of life” in this instance would be $5 million. What is being valued here is a statistical life rather than a certain death.

Society’s valuation of a certain health outcome, whether it be death or some other health effect, may be quite different. Few of us would knowingly face a certain probability of death for a fixed reward such as $5 million. However, such certain adverse outcomes are not the matter in question. The consequences of wars are also lotteries, given that the effects are probabilistic. We do not know in advance who will be affected adversely or favorably by these efforts. What is needed is the value of the statistical lives, statistical illnesses, and other expected health effects that will result from these efforts. In this regard, utilization of value-of-life estimates as well as similar valuations for other health outcomes is appropriate.

These estimates generalize lives of different length and quality, health outcomes of different severity, and other potential health conditions. The appropriate value is the pertinent willingness to pay for the associated risk reduction. Formulating this issue, however, is much more straightforward than placing an explicit dollar value on the answer. Subsequent sections of this chapter will detail how evidence from the market and from surveys can be utilized to resolve issues such as this.

QUALITY-ADJUSTED LIVES

The length of life that is at risk may vary depending on the particular ailment involved, whom it affects, and the lag time before the health impacts become apparent. Research by Viscusi, Hakes, and Carlin provides estimates of the quantity-adjusted values of these different health risks, as well
Valuing the health consequences of war

as the cost per quantity-adjusted health risk prevented for a variety of government regulations. For example, efforts that address acute accident risks tend to have a greater health effect than those that reduce health hazards, such as cancer.

Within the medical economics field, a variation of this methodology has also been employed. Zeckhauser and Shepard, for example, proposed that a quality-adjusted life year (QALY) measure be used. In particular, when one values life, one values heterogeneous commodities. One cares about the length of life that is at stake as well as the quality of that life. The concept that the quality and duration of life is of consequence is certainly a legitimate concern. Often, however, the degree of information available does not permit full refinement of values to reflect all of these differences.

The use of some kind of QALY approach is not necessarily inconsistent with the traditional value-of-life literature. For example, the same kinds of job risk studies that have been used to estimate the implicit value of life also have been employed to estimate the quantity-adjusted value of life, where the life years at risk reflect the quality of life likely to be experienced by a typical worker.

In practice, the quality-adjusted life year approach has been associated with various pragmatic techniques for obtaining an assessment of the QALY value associated with different health outcomes. As a result, generating the QALY value often requires imposing strong assumptions. The typical approach is to ask what proportion of the individual's future lifetime when healthy would the person be willing to sacrifice in return for obtaining a particular specified health improvement. This approach may provide a health index, but it is not a direct valuation of the willingness to pay associated with a small risk reduction. Moreover, as shown by Johannesson et al., such an approach does impose severe restrictions.

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Adopting their notation, the risk-neutral QALY equates the utility $U(Q,T)$ of some health state $Q$ with associated number of life years available $T$ as being equal to some function that reflects the quality of the health state $V(Q)$ multiplied by the number of years of life remaining, or

$$U(Q,T) = V(Q)T.$$  

This approach embodies three principal assumptions. First, the various life years $Q$ are assumed to be utility-independent. This is a very strong assumption in that it implies that the shape of the utility function for life years is the same for all health states. Moreover, the degree of risk aversion is assumed to be the same for all health states. Since the effect of many adverse health effects, such as paraplegia, cancer, and other severe illnesses, is to alter the structure of individual preferences greatly, this assumption is unlikely to be borne out in practice for many health outcomes of interest. This independence assumption also implies that the standard gamble quality weighting term $V(Q)$ does not vary with the number of years that will be spent in the health state, whereas in practice there may be an important variation of this type.

The second major assumption associated with this approach is that a constant proportional tradeoff is assumed by the model. In particular, the proportion of remaining life that one would be willing to sacrifice in return for some specified quality improvement is assumed to be independent of the amount of remaining life. In practice, one would not expect this assumption to hold. One implication of this formulation is that individual utility functions for life years will display constant proportional risk aversion, which constitutes another restrictive assumption.

The third principal assumption embodied in the standard formulation is that individuals are risk-neutral over life years. Thus, having four life years for sure is viewed as being equivalent to a 50–50 chance of eight life years remaining or zero life years. Such a linear utility function is unlikely to be a plausible shape, although the formulation can be generalized to incorporate the potential for risk aversion.

Discounting is also a potential concern. Years of life far into the distant future are likely to receive a lower weight than more immediate life years at risk. The QALY format can be generalized to incorporate discounting by eliciting the percentage amount of the discounted number of life years that the individual views as being equivalent to a particular health consequence. Although one can reformulate the QALY model in this
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discounted manner, most implementations of the analysis do not incorporate such flexibility.

There has also been an increasingly substantial literature with other approaches to assessing QALY values. This includes literature on health-year equivalents as well as a variety of techniques for assessing QALY amounts. All such techniques should be viewed as approximations to the more fundamental objective of eliciting the willingness to pay for the associated risk reduction explicitly.

Risk–money tradeoffs

The most prevalent approach to valuing health risks in the literature has been an examination of wage–risk tradeoffs. These are values for prevention, not compensation after the fact. Using data on worker wages and linking these data to worker characteristics and job characteristics, including job risks, economists have estimated the wage premiums that workers receive for risk.

The underlying theoretical basis is indicated in Figure 21.1. Firms have offer curves FF and GG, where these represent the different isoprofit lines for the firm. At a high risk level in each case, the firm can offer a higher wage rate and still maintain the same level of profitability. The outer envelope of these offer curves is the market opportunities frontier facing workers in terms of their best available wage–risk combinations. On the supply side of the market, workers have a constant expected utility locus, such as is illustrated by EU₁ and EU₂ for two different workers. The worker’s objective is to be on the highest constant expected utility locus possible, or as far in the upper left direction, where this expected utility locus will be tangent to the available market opportunities. In the case illustrated, worker 1 will select job risk p₁ and an associated wage rate of w₁(p₁).

The wage equation estimates will ascertain the wage–risk tradeoff locus given by XX in Figure 21.1. In the case in which a linear relationship between wages and risks is estimated, economists in effect estimate the average local rate of tradeoff for the set of workers in the sample. These tradeoffs, which are based on the tangency of the expected utility locus with the market opportunity set, consequently represent both the

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8 The pivotal contribution to this literature is Zeckhauser and Shepard, “Where Now for Saving Lives?”
willingness-to-pay and the willingness-to-accept amount for very small risks. It is not appropriate to extrapolate these amounts to larger risk changes. For example, a risk increase from $p_1$ to $p_2$ would require that the worker be compensated at a level of $w_i(p_2)$ rather than the lower amount of $w_i(p_1)$ that would be pertinent based on the estimated market risk tradeoff. Thus, the estimated market curve XX will lie below the constant expected utility locus and will be tangent only at a single point.

The market tradeoff locus consequently provides very limited information regarding risk–money tradeoffs, as it only pertains to a local neighborhood. Through the use of various interaction terms, such as those involving age, union status, and other personal characteristics, it is possible to estimate differences in tradeoff rates. However, since these tradeoffs reflect the simultaneous interaction of labor supply and labor demand, each of which may depend on these characteristics, market-based evidence is not ideal for making refined judgments regarding the heterogeneity of tradeoff values.

The overall implication of these studies is that, on average, the estimated rates of tradeoff based on labor market studies tend to cluster in the
range of $3 million to $7 million per statistical life (in 1990 prices).\textsuperscript{9} Overall, labor market evidence alone is not sufficient to resolve all the pertinent issues with respect to the valuation of risks. Although it offers the advantage of being based on actual choices being made involving real threats to individual well-being, it has important limitations as well. Perhaps most salient is that the job risks involved, which include acute accidents and in some cases non-fatal on-the-job injuries, do not span all of the risk outcomes of interest. Within the domain of health outcomes, government policymakers often have to value illnesses, such as chronic bronchitis, and other causes of death, such as cancer, which may be viewed quite differently from immediate deaths.

Moreover, there are many risks, such as environmental risks, that may not be reflected accurately even in terms of implicit market prices. Although one could undertake property value studies to investigate environmental amenities in much the same manner as labor economists have done for job risks, these market experiments are not perfectly controlled. It is often impossible to disentangle the wide variety of influences at work. These difficulties pertain to the labor market studies as well and may have contributed at least in part to the disparity in the value-of-life estimates across different studies.

Use of market data also presupposes that individuals understand the risks they face. Thus, the analyses are typically based on an assumption that the objective measures of the risk and the subjective risk assessments that drive behavior are identical. To the extent that one wishes to move beyond this assumption and incorporate a measure of the subjective risk assessment, then a more extensive survey is needed.\textsuperscript{10}

Perhaps the most fundamental limitation of the labor market studies is that even if one elicits the subjective risk perception value and perfectly controls for all the individual and job characteristics driving wages, the scope of the questions that can be answered is very limited. Only a narrow range of health outcomes can be addressed – far fewer than are needed to


assess the health consequences of war. The only tradeoffs that can be examined are the local tradeoff rates pertaining to averages across some broad population group. Finally, any attempt to refine these tradeoff levels for different population subgroups is impeded by the aforementioned difficulty of disentangling the interaction of labor demand and labor supply factors, given that the econometric analysis estimates only the locus of market equilibrium, and does not consider either labor demand or labor supply separately. (Structural estimation techniques potentially could be of some assistance in this regard, but to date they have not been.)

The first attempt to go beyond the hedonic labor market studies of risk was a study by Viscusi and O’Connor, which utilized a survey approach to value changes in job risk.¹¹ The survey structure can best be discussed with reference to Figure 21.2. The sample of workers consisted of 335 workers at four different chemical plants. The first piece of pertinent information elicited from the respondents was their baseline job risk $p_2$ at their current job, where this was indicated using a linear risk scale in which there was a single job risk anchor, the average worker injury rate. (A 1990 study by Hersch and Viscusi modifies this approach by using a series of discrete boxes to indicate the risk level and by including multiple risk reference points. In each case, the risk reference point pertains only to job hazards.)

¹¹ Viscusi and O’Connor, "Adaptive Responses to Chemical Labeling."
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Table 21.1. Summary of value of life estimates based on survey evidence

<table>
<thead>
<tr>
<th>Author (year)</th>
<th>Nature of risk</th>
<th>Implicit value of life ($ millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acton (1973)</td>
<td>Improved ambulance service, post-heart attack lives</td>
<td>0.1</td>
</tr>
<tr>
<td>Jones-Lee (1976)</td>
<td>Airline safety and locational life-expectancy risks</td>
<td>15.6</td>
</tr>
<tr>
<td>Gerking, deHaan, and Schulze (1988)</td>
<td>Job fatality risk</td>
<td>3.4 willingness to pay</td>
</tr>
<tr>
<td>Jones-Lee (1989)</td>
<td>Motor vehicle accidents</td>
<td>8.8 willingness to accept</td>
</tr>
<tr>
<td>Miller and Guria (1991)</td>
<td>Traffic safety</td>
<td>1.2</td>
</tr>
<tr>
<td>Viscusi, Magat, and Huber (1991)</td>
<td>Automobile accident risks</td>
<td>2.7 (median)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.7 (mean)</td>
</tr>
</tbody>
</table>

Note: All values in December 1990 US dollars.

The survey also elicits the baseline wage or salary amount Y so that the starting point B can be observed. After acquiring this information, subjects received one of four different hazard warning labels and were told that this chemical would replace the chemicals with which they were then working on the job. They were then asked to assess their new risk level ($p_2$) and were asked what percentage wage increase they required to work with this new chemical.

Thus, the survey establishes two points along a constant expected utility locus, B and D, which provides different information than does market-based evidence. For small increases in risk, this tradeoff will be identical to the marginal tradeoff at point B. However, for larger risk increments, the average risk tradeoff for BD will exceed that at the point of tangency with EU at point B. Moreover, once one has knowledge of two or more points along a constant expected utility locus, it will be possible to estimate the structure of individual utility functions, as will be indicated below.

Surveys have been used to value not only job-related outcomes but other health consequences as well. Table 21.1 summarizes the survey results pertaining to estimates of the value of life. The first two studies appearing in Table 21.1 are based on relatively small samples and should be regarded as
being very exploratory in nature. The latter four studies are more extensive and yield implicit value of life estimates of the same order of magnitude as those found by the labor market studies. The main exception is the lowest mean value of life in the Miller and Guria study, but since this sample pertains to New Zealand, for which the average income level is lower, one would expect to obtain lower value of life estimates. In addition, it is noteworthy that the classes of health outcomes, including motor vehicle accidents and death due to heart attack, also can be broadened to analyze differences in the value of life depending on how one dies as opposed to simply death itself.

For the most part, the studies in Table 21.1 utilize either an interview approach similar to the one used by Viscusi and O’Connor or a relatively straightforward contingent valuation approach in which respondents indicate how much they would be willing to pay for different kinds of improvements in public safety efforts that will lead to improved safety. The main exception is that Viscusi, Magat, and Huber utilize an interactive computer program in which respondents are presented with pairwise comparisons of different areas in which they could live, where these areas differ in terms of their automobile accident fatality risk and their cost of living. Respondents indicate which of the two areas they prefer, and the program revises these options until indifference is achieved. The observed rates of tradeoff at this point of indifference are then used to determine the implicit value of life.

Table 21.2 indicates how this methodology can be extended to analyze non-fatal health risks. The methodology can address a broad range of classes of injuries, including illnesses, a wide variety of health consequences from different household chemicals, and health outcomes from broader environmental exposures including nerve disease, lymphoma, and chronic bronchitis. Thus, these studies can greatly expand the scope of the outcomes that can be addressed.

The 1987 study by Berger et al. is perhaps the main exception in that this study does not focus on probabilistic outcomes but rather willingness

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13 Viscusi and O’Connor, "Adaptive Responses to Chemical Labeling."
Table 21.2. Summary of valuations of non-fatal health risks

<table>
<thead>
<tr>
<th>Author (year)</th>
<th>Nature of risk</th>
<th>Value of health outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mark Berger et al. (1987)</td>
<td>Certain outcome of one day of various illnesses</td>
<td>$98 (coughing spells), $35 (stuffed up sinuses), $57 (throat congestion), $63 (itching eyes), $183 (heavy drowsiness), $140 (headaches), $62 (nausea)</td>
</tr>
<tr>
<td>Viscusi and Magat (1987)</td>
<td>Bleach: chloramine gassings, child poisonings; Drain opener: hand burns, child poisonings</td>
<td>$1.78 million (bleach gassing), $0.65 million (bleach poisoning), $1.60 million (drain opener hand burns), $1.06 million (drain opener and child poisoning)</td>
</tr>
<tr>
<td>Viscusi, Magat, and Huber (1987)</td>
<td>Morbidity risks of pesticide and toilet bowl cleaner; valuations for 15/10,000 risk decrease to zero</td>
<td>Insecticide: $1,504 (skin poisoning), $1,742 (inhalation), $3,489 (child poisoning); Toilet bowl cleaner: $1,113 (gassing), $744 (eye burn), $1,232 (child poisoning)</td>
</tr>
<tr>
<td>Viscusi, Magat, and Forrest (1988)</td>
<td>Insecticide inhalation–skin poisoning, inhalation–child poisoning</td>
<td>Inhalation–skin poisoning: $2,538 (private), $9,662 (NC altruism), $3,745 (US altruism); Inhalation–child poisoning: $4,709 (private), $17,592 (NC altruism), $5,197 (US altruism)</td>
</tr>
<tr>
<td>Evans and Viscusi</td>
<td>Morbidity risks of pesticides and toilet bowl cleaner; utility function estimates of risk values. T values pertain to marginal risk–dollar tradeoffs, and L values pertain to monetary loss equivalents.</td>
<td>Insecticide: $761 (T), $755 (L) (skin poisoning); $1,047 (T), $1,036 (L) (inhalation–no kids); $2,575 (T) (inhalation–children) $1,748 (L); $3,207 (T), $2,877 (L) (child poisoning); Toilet bowl cleaner: $633 (T), $628 (L) (eye burn); $598 (T), $593 (L) (gassing–no kids); $717 (T), $709 (L) (gassing–children); $1,146 (T), $1,126 (L) (child poisoning)</td>
</tr>
<tr>
<td>Magat, Viscusi, and Huber (1991)</td>
<td>Environmental risk of non-fatal nerve disease, fatal lymphoma, non-fatal lymphoma</td>
<td>$1.6 million (nerve disease), $2.6 million (non-fatal lymphoma), $4.1 million (fatal lymphoma)</td>
</tr>
<tr>
<td>Viscusi, Magat, and Huber (1991)</td>
<td>Environmental risk of severe chronic bronchitis morbidity risk</td>
<td>0.32 fatality risk of $904,000 risk–risk; $561,000 risk–dollar</td>
</tr>
<tr>
<td>Krupnick and Cropper (1992)</td>
<td>Environmental risk of severe chronic bronchitis morbidity risk</td>
<td>$496,800–$691,200 (median)</td>
</tr>
</tbody>
</table>

Source: W. K. Viscusi, “The Value of Risks to Life and Health,” J. Econ. Literature 31(4) (1993), Table 7, with additions by the author.
W. KIP VISCUSI

to pay to alleviate certain outcomes in which particular days are going to be spent with health symptoms, such as a sore throat. Otherwise, the studies focus on risk–money tradeoffs of various kinds. Further, all six studies in which I collaborated involve different kinds of pairwise comparisons, where the attributes of the options are manipulated until indifference is achieved. The 1992 Krupnick and Cropper study\textsuperscript{16} administered the Viscusi, Magat, and Huber survey to a different sample and consequently adopts an identical methodology. In almost all cases, the pairwise comparisons involve a choice of two different products or a decision to move to one of two different regions, where the two attributes of each option include risk and monetary components.

Some of these studies also use what can be termed risk–risk tradeoffs in that instead of trading off combinations of health risks and money, the pair of attributes for each of the options pertains to risk. For example, a region may be characterized by an automobile accident fatality rate and a cancer death rate due to environmental air pollution exposures. Respondents then consider different options and continue to do so until achieving indifference, where the ultimate objective is to establish an automobile death risk equivalent to the health outcome such as cancer. Use of this risk–risk approach avoids the utilization of a monetary metric in the survey, and some of the advantages of this method will be discussed below. In conjunction with existing estimates of the implicit value of life, it is possible to convert these risk–risk estimates into risk–money tradeoffs. Alternatively, one can incorporate such a risk–money tradeoff into the survey, as was the case in these studies.

The death risk metric

A major class of concerns pertains to the metric used to assess the valuation of the risk reduction. Although it is convenient to use the familiar monetary metric, this metric often offends the sensitivities of non-economists and may seem a bit inappropriate to respondents who are less comfortable with the idea of making such tradeoffs. Another approach that can be utilized is to use a risk metric in which two different classes of risk are traded off.

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Although the risk–money tradeoff approach is the most common, it is also possible to use other metrics to value risk. For example, an approach used to value cancer, nerve disease, and chronic bronchitis has utilized reference lotteries involving automobile accident risks. Thus, instead of giving respondents pairwise choices involving money and health outcomes, the outcome pairs involve automobile accident deaths and the risk in question. Should one then choose to convert an automobile accident death risk metric to a monetary metric, one can either use automobile accident–money tradeoffs elicited within the survey or else use implicit value-of-life estimates based on the literature.

Moreover, in some contexts, it is not necessary to make such a conversion. Policy analyses in which the critical concern is the cost per life saved do not require the establishment of a benefit value, as one can simply compare the cost-per-life saved amount with various reference points for policy acceptability. In the standard benefit–cost case, this reference point would be the implicit value of life, but few government agencies in the United States other than the US Department of Transportation appear to be constrained in this manner.\textsuperscript{17} Wars also involve a range of health effects that can be converted to death risk equivalents.

The use of the death lottery metric has a variety of practical advantages. Most important is that it avoids the explicit presentation of money–risk tradeoffs to respondents. Many policymakers and, indeed, many respondents may be averse to making tradeoffs between cost of living and lives saved or similar kinds of choices. Use of two different risk attributes can alleviate these specialized sensitivities. Wholly apart from the special problems posed by outcomes such as life and health, this approach presents subjects with commodities that may be more comparable. As a result, it may be easier for respondents to conceptualize tradeoffs since the nature of the commodities is much more similar.

A particularly important benefit of utilizing risk–risk tradeoffs is that this approach may be less prone to criticisms that respondents are dealing with hypothetical interview currency. In situations in which respondents are asked their willingness-to-pay amounts for risk reduction, there may

\textsuperscript{17} The low value of life for regulations issued by the US Department of Transportation relative to other agencies is exemplified in the cost-per-life-saved statistics reported in Viscusi et al., “Measures of Mortality Risks.” See also the data presented in S. Breyer, \textit{Breaking the Vicious Circle: Toward Effective Risk Regulation} (Cambridge, Mass.: Harvard Univ. Press, 1993).
be a tendency to exhibit substantial willingness to pay that may not in fact be evidenced once confronted with real choices.

Hypothetical expenditures are not bound by the same rigid budget constraints as actual expenditures. Use of two different risk attributes makes both of the consequences involved pertinent to the respondents' well-being, and they are likely to elicit more honest and meaningful answers than would be yielded through hypothetical contingent valuation currencies.

The final studies listed in Table 21.2 indicate the implications of these risk–risk tradeoffs for several different environmental risks. Nerve disease, fatal lymphoma, and non-fatal lymphoma are all associated with implicit values of more than $1 million per statistical health outcome.\textsuperscript{18} Severe cases of chronic bronchitis are less highly valued, as they are tantamount to roughly one chance in three of death.\textsuperscript{19} In contrast, cancer is viewed as being tantamount to death by the respondents.

By utilizing two different risk tradeoffs, it is also possible to normalize the denominators associated with the risks being faced. It may be that the risks in question are truly rare events, of the order of one in a million. Respondents can then be asked what the equivalent automobile accident risk per 1 million would be, thus enabling them to focus on the relative severity of the two different health outcomes involved as opposed to attempting to comprehend the subtleties of the small probabilities being presented to them.

Although there has been much less experience with the risk–risk approach than with the various risk–money contingent valuation methodologies, the technique does offer substantial potential advantages, particularly in contexts in which respondents will be better able to deal with the risk tradeoffs in a more meaningful manner.

**Estimation of utility functions**

Knowing the shape of individual utility functions for the particular attributes of interest would put one in a good position to assess the deterrence values for a wide variety of health risks associated with war. It would be


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possible to analyze local rates of tradeoff, substantial changes in risk, and a
wide variety of other questions regarding how people value risk and how
these valuations differ across the population.

Perhaps the greatest benefit of utilizing surveys rather than market data
is that one is not restricted to addressing the narrow set of questions that
can be answered using available market evidence. Hedonic wage and price
studies focus on the market equilibria represented by the set of tangencies
between individual offer curves and the available opportunity sets. In the
job market case, one observes average rates of tradeoff between risk and
wages. For property values, one can estimate average rates of tradeoff
between property values and environmental amenities. However, the use
of surveys enables one to trace out the entire character of the constant
expected utility locus sketched in Figure 21.2. Indeed, by asking the indi-
vidual multiple questions, one can identify more than two points on a con-
stant expected utility locus and thus ascertain the character of individual
preferences.

A series of studies with William Evans20 examines many survey situ-
ations involving consumers and workers. Using a survey on more than
one price–risk combination or wage–risk combination along a constant
expected utility locus, the studies estimate the character of individual
utility functions pertinent to the problem.

In the case of job accidents, for which the risk is likely to alter the char-
acter of individual utility functions, we have estimated state-dependent
utility functions. These have included functions for which no specific
functional form has been assumed, as we have taken first-order and
second-order Taylor’s series approximations to general utility func-
tions. In addition, we have also obtained estimates assuming a specific
logarithmic functional form for the utility functions. In each case, it is
possible not only to estimate average shapes of utility functions across
a population, but also to let the parameters of the utility function vary
with the individual characteristics. The key parameters can be made
dependent on demographic attributes such as individual age, education,

20 See W. K. Viscusi and W. Evans, “Utility Functions that Depend on Health Status: Estim-
ates and Economic Implications,” *Am. Econ. Rev.* 80(3) (1990), 353–74; W. Evans and
sex, and similar attributes. Thus, not only does this formulation enable one to estimate the character of utility functions, but it also enables one to distinguish the heterogeneity in preferences, whereas market evidence on heterogeneity compounds the influence of heterogeneity in supply and heterogeneity in demand.

In the case of consumer risks, the consequences have often been so minor that it is unlikely that the adverse outcomes alter the structure of utility functions. Using this approach, it is impossible to test formally whether utility functions alter in character or whether the adverse outcome can be treated as a monetary loss equivalent. Thus, this technique enables one to explore the implications of different outcomes for the structure of individual preferences, which is often of substantial interest in its own right.

In the case of risks that entail losses that might be potential objects of government insurance, as in the case of workers’ compensation or court-provided product liability awards, the structure of utility functions is clearly of paramount interest. If the marginal utility of income substantially decreases as a result of an accident, then it will not be optimal to replace the income loss. Individuals who suffer brain damage, for example, experience a very low level of utility, but transfers to them may do little to enhance their welfare once the basic medical care has been provided.

In the case of job market risks, we have found that because of the adverse effects of job injuries on individuals’ ability to derive welfare from expenditures, the optimal replacement rate for job-related income losses is 0.85. In contrast, for minor consumer product injuries that individuals view as being tantamount to a drop in income, the optimal replacement rate is equal to the monetary equivalent value of the loss. 21

This same kind of issue would be pertinent to other damages, including health losses from wars, if the objective were to provide optimal social insurance. Moreover, if the objective is to restore individual levels of utility, adverse effects on the structure of utility functions and the marginal utility derived from income also should be taken into account. The procedure that we have developed enables one to distinguish the particular factors that are at work and the extent of their influence.

Knowledge of individual utility functions enables one to address all of the fundamental issues pertaining to valuation, and we have done so in our consumer- and job-related examples. Thus, it is possible to analyze local

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21 Viscusi and Evans, "Utility Functions that Depend on Health Status."
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rates of tradeoff, not only at the current level of risk, but also if the base risk level is altered. Higher base risk levels increase the implicit value of injury, but the extent of the variation is an empirical question that must be resolved through exploration of the character of individual preferences.

Similarly, one can analyze marginal rates of willingness to pay and willingness to accept based on the character of individual utility functions, thus avoiding the distortion of these responses through the explicit use of a willingness-to-accept survey methodology. Along the same lines, one can assess the valuation of non-marginal risk changes and explore risk valuations for risk changes other than those specifically addressed in the survey instrument. The effect of individual income and other personal attributes on the heterogeneity of risk valuation can also be resolved through explicit estimation, thus making it possible specifically to link findings to the populations of interest. For example, the estimated income elasticity of the implicit value of job injuries is approximately 1.0.\textsuperscript{22}

In short, the use of survey data to estimate utility functions makes it possible to assess individual utility functions and to answer all the risk valuation questions that may be on our evaluation agenda. As a consequence, surveys should not be viewed as simply a mechanism to replicate or augment market-based data, but rather as a much more powerful approach for expanding the scope of inquiry.

Sources of potential irrationality

Although there should be little difference between small changes in risk that represent risk increases rather than risk decreases, in practice there is often substantial asymmetry in the way these risks are treated. It is important to isolate the pertinent tradeoff values free of possible irrational responses that may taint them. In the case of pharmaceutical regulation by the Food and Drug Administration, for example, researchers have suggested that the agency behaves as if its objective is to minimize type II errors, which are the risks arising from approving a defective new drug, while at the same time accepting very substantial type I errors, which are the risks that could have been averted if the drugs had been approved earlier.\textsuperscript{23} The

\textsuperscript{22} Ibid.

drug lag in the United States that accounts for prescription drugs being approved more rapidly in Europe has averted potential disasters, such as the effects of the drug Thalidomide, which led to birth defects in Europe. The FDA, however, never approved this drug for use by pregnant women in the United States. The usual case is that prescription drugs are approved more quickly in Europe, making it possible for these citizens to benefit from drugs such as beta blockers before US patients can take them. These instances are not isolated examples. Among the many drugs ultimately approved in the United States and which were approved earlier in the United Kingdom are Somatotropin, Danazol, and Propranolol. Similarly, drugs that led to major adverse reactions in Europe before being withdrawn include the following drugs that were never approved in the United States: Practolol (severe conjunctivitis), Aminorex (pulmonary hypertension), and Benziodarone (jaundice).

Similarly, events that reduce mortality rates by 1/100,000 are likely to be viewed as less consequential than those that generate an increased mortality risk of 1/100,000. Although the risks involved are very small, there may be an asymmetry in society’s value of the two risk changes, even though there should not be.

From an economic standpoint, there should be very little difference between the willingness-to-pay and the willingness-to-accept values for small changes in risk. There may be some small discrepancy. One source of differences is the role of income effects, since an individual’s willingness to pay for risk reductions will be a decreasing function of one’s income level. Willingness-to-accept values will also be higher than willingness-to-pay values because this change is associated with the increasing risk, where this change involves an increase in the probability that a state of the world in which there is a lower marginal utility of income will occur. Consequently, the opportunity cost of the resources has diminished. These influences are unlikely to be substantial, however, for very small risks.

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24 For further discussion of these and other drugs that were approved earlier for use in Europe, see the US General Accounting Office, “FDA Drug Approval – A Lengthy Process that Delayed the Availability of Important New Drugs,” HRD–80–64 (May 28, 1980), p. 68.

25 For further discussion of drugs that led to adverse reactions in other countries but were never approved in the United States, see the US Congress House Subcommittee on Science, Research, and Technology, “The Committee on Science and Technology, Report on the Food & Drug Administration’s Process for Approving New Drugs,” 96th Congress, First Session, 1980.
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Table 21.3. Valuation of incremental risk reductions for household chemicals

<table>
<thead>
<tr>
<th>Starting risk (injuries/10,000 bottles)</th>
<th>Insecticide</th>
<th>Toilet bowl cleaner</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inhalation–skin poisoning</td>
<td>Inhalation–child poisoning</td>
</tr>
<tr>
<td>15</td>
<td>1.04</td>
<td>1.84</td>
</tr>
<tr>
<td>10</td>
<td>0.34</td>
<td>0.54</td>
</tr>
<tr>
<td>5</td>
<td>2.41</td>
<td>5.71</td>
</tr>
</tbody>
</table>


The discrepancies that have been observed between willingness to pay and willingness to accept are starkly different from what one would expect based on rational economic models. Consider the results that were revealed in a study of consumer-product risks by Viscusi, Magat, and Huber (1987). In that study, we gave consumers an opportunity to purchase successive reductions in various risks associated with household chemicals. The baseline risk value was a risk of various injury types of 15/10,000. Consumers then had the opportunity to purchase successive reductions of the risk in 5/10,000 increments by paying a higher price for the product. Table 21.3 provides a summary of these willingness-to-pay values for risk reductions. Consumers’ willingness to pay for risk reduction diminishes with successive purchases of risk reductions, as one would expect. However, consumers have a willingness to pay that reflects a substantial premium for the final risk reduction that leads to complete elimination of the risk. Thus, there is evidence of certainty premiums as individuals are willing to pay an unusually large amount of money to be assured of safety of the product.

One might also expect that if consumers were faced with risk increases of the order of 5/10,000 there would be a willingness-to-accept value comparable to the willingness-to-pay values for risk reductions of 5/10,000. Respondents confronted with this choice refused to give any finite response that would induce them to purchase the product after the risk had increased in this manner. As a result, the survey was reworded so that the risk increase was only 1/10,000.
Table 21.4. **Response to risk increases of 1/10,000 for pairs of product risks**

<table>
<thead>
<tr>
<th>Injury pair</th>
<th>Percentage for whom product is too risky to purchase</th>
<th>Mean value ($/bottle) of positive responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insecticide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhalation–skin poisoning</td>
<td>77.2</td>
<td>2.86</td>
</tr>
<tr>
<td>Inhalation–child poisoning</td>
<td>68.1</td>
<td>3.19</td>
</tr>
<tr>
<td>Toilet bowl cleaner:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eyeburns–gassing</td>
<td>61.5</td>
<td>5.52</td>
</tr>
<tr>
<td>Gassing–child poisoning</td>
<td>74.3</td>
<td>1.28</td>
</tr>
</tbody>
</table>

This question asked subjects what price discount they would require on the new product to accept an additional risk of 1/10,000 for both injuries, starting with risks of 15 injuries per 10,000 bottles sold for both injuries. See W. K. Viscusi et al., “An Investigation of the Rationality of Consumer Valuations of Multiple Health Risks,” *Rand J. Econ.* 18(4) (1987), 477.

Consumer reactions to this risk change are indicated in Table 21.4. As can be seen, the consumers who were willing to name a finite price for accepting a risk increase indicated that they needed a much higher level of compensation for this risk increase that was five times smaller than the risk decrease that they were purchasing in the previous manipulation. For the willingness-to-pay amount, the implicit value of the health outcome involved was only $420 for the injury pair inhalation–skin poisonings, whereas the comparable implicit value of the health outcome generated by the willingness-to-accept values was $28,600. This divergence in values by a factor of more than sixty reflects an asymmetry in the way in which risks are treated.

For wars, the main implication is that people are likely to be particularly averse to risking changes that imply that an increase in the risk level has occurred from their accustomed risk amount. What consumers may be reacting to is the fact that they are now facing an unaccustomed risk that they did not previously encounter, whereas many more familiar risks may be of much larger magnitude. Willingness-to-accept amounts will overstate the deterrence value of reducing risks to war.

A variety of explanations have been put forth to explain this phenomenon. What is noteworthy about these explanations is that they all involve departures from rational expected utility maximization. In one study, Viscusi, Magat, and Huber term this phenomenon the "reference
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risk effect,” whereby individuals have reference risk levels.\textsuperscript{26} Once these risk levels are disturbed through policy shifts, consumers will react in an alarmist manner, as was indicated above.

More generally, these kinds of phenomena reflect differences in attitudes towards errors of commission and errors of omission. Errors of commission, whereby a new risk is initiated through a war or other instances, tend to be viewed quite adversely. In contrast, errors of omission, such as the failure to take action to save lives, tend to be less highly valued. The errors of commission tend to involve identified lives at risk, whereas errors of omission impose costs on statistical lives. Since the statistical lives at risk are not a well-organized lobbying group, the losses to them are less visible and receive less attention.

The question then becomes: what should be the role of government policy in the presence of these various forms of irrational behavior? One might argue that the role of the government in a democratic society is to promote the preferences of its citizens. However, in the case of irrational choices, it makes little sense to foster programs that simply institutionalize the irrationalities that are displayed in our private choices. A more sensible approach would be to maximize the expected utility of the citizenry in the manner in which they would choose if they fully understood the risks that were present and could act upon them in a rational manner. Thus, we would not jettison the legitimate differences in tastes that people had, but biases in risk perception and similar anomalies in behavior should not become the driving force for government action. Alarmist and irrational responses to novel risks, in particular, pose a threat to innovations that may promise to yield much greater expected health benefits to the public than the associated costs that may be based on unfounded fears.

A similar kind of bias in decisionmaking may arise with respect to ambiguous risks. As the Ellsberg paradox\textsuperscript{27} demonstrated, individuals would prefer to have a precise opportunity to win a prize rather than have an imprecise chance in which the subjective probability was the same but the odds were uncertain. Viscusi, Magat, and Huber later generalized this phenomenon to the loss situation.\textsuperscript{28} That article showed that, when facing

ambiguous environmental risks, individuals displayed ambiguity aversion as they would be willing to incur a higher mean risk level if doing so could provide them with a choice that had a smaller degree of risk ambiguity associated with it. From the standpoint of subjective expected utility maximization, the precision of the probabilistic judgments should not enter. However, in practice, when facing the prospect of losses imprecisely understood probabilities tend to be avoided.

The implications of this result for wars are similar, in spirit, to the implications of the willingness-to-pay/willingness-to-accept discrepancy. Novel risks, such as those that arise through new weapon systems or chemical exposures, will tend to be less precisely understood. People consequently will tend to overvalue these risks relative to more familiar risks that have been more precisely identified. Once again, the role of the government should be to act upon the best information regarding these risk judgments rather than to be deterred by the presence of imprecision.

Conclusion

Establishing the appropriate economic principles for wars is relatively straightforward. If the objective is compensation, as in the case of the US tort system, the basic principles for compensation should follow those used by the judicial system. In the case of wrongful death, the appropriate compensation is the present value of lost earnings less the decedent’s consumption. For non-fatal injuries, the present value of lost earnings plus medical expenses should be the guide.

Situations in which the objective is not insurance but rather deterrence would require a different methodology, such as that now used to value the health-enhancing effects of government regulations. However, it is difficult to envision situations in which these deterrence values would be applied in war contexts, except to judge liability. In setting compensation, it would not be appropriate to use these amounts since they would provide for excessive insurance of the individuals who were being compensated. An alternative approach if the objective is to provide deterrence is to use the willingness-to-pay measures to set the appropriate level of the total economic damages, part of which will be paid in compensation and the rest of which will be a fine paid to the state. That approach will yield efficient deterrence and also will not provide excessive insurance for the victims of wars.
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The appropriate measure for deterrence is society's willingness to pay for the changes in risk that result from these wars. A variety of approaches have emerged in an effort to estimate these willingness-to-pay values. The literature pertaining to quality-adjusted life years is a frequently employed approach in the medical decisionmaking literature. However, the usual empirical implementation of this framework imposes very severe restrictions on the character of individual preferences across health states that are unlikely to hold generally.

Since the appropriate matter of interest is society's willingness to pay for small variations in risk, there is no barrier to eliciting these values explicitly. In some instances market evidence is instructive. In others, survey data can be used to obtain individual valuations of the risks involved. This effort is also not necessarily a trivial proposition, as any such undertaking must adequately convey to respondents the nature of the health outcomes and the character of the tradeoff so that they can think about these issues in a sensible manner and give reasonable responses. If the deterrence values for health outcomes of wars become important, undoubtedly there will be an emerging body of work undertaken to address these concerns. At present, the literature is dominated by studies targeted at efforts in policy areas where implicit values of life and health now provide the basis for policy judgments, as in the case of health, safety, and environmental regulations.

Although the empirical techniques for estimating these values undoubtedly will continue to undergo development and further refinement, even current methodologies can shed considerable light on pertinent health effect assessment issues. In many cases simply avoiding the most extreme policy errors is most important. In particular, one should not fall prey to the potential irrationalities that often impede choices in these areas, such as excessive attention to risks of commission as opposed to risks of omission. Rather, policies should focus on all risk consequences in a manner that reflects the preferences the citizenry would express if they were fully informed and could make rational choices with respect to these risks.