THE VALUE OF LIFE AND SAFETY
M.W. Jones-Lee (editor)
North-Holland Publishing Company

ESTIMATING THE VALUE OF LIFE AND SAFETY: RECENT DEVELOPMENTS

Glenn Blomquist

Department of Economics
University of Kentucky
Lexington, Kentucky 40506
U.S.A.

I. THE THEORETICAL BASIS - WILLINGNESS TO PAY

Individuals continually made decisions which reveal that they are willing to make exchanges between their own health and safety and other desirables which make life worth living. People give up nutritious but bland diets for tasty food and drink which tend to increase weight and blood pressure. They give up comfortable, secure dwellings for skiing and climbing in the mountains and accept the accompanying risks to life and limb. To gain better health and safety, people devote time and effort to physical conditioning, which for some means enduring discomfort and boredom. They will travel great distances, wait for hours, and pay high fees to get the medical care they feel is warranted even when the suspected diagnosis is not life threatening.

Societies, too, continually make decisions which demonstrate that collectively people are willing to make exchanges between health and safety and other national goals. War is a striking and, unfortunately, frequent reminder of the sacrifices made in the name of patriotism and freedom. Exploration of new territories on earth and in outer space and research and development with substances and organisms which are only partly understood can involve risks to life. To promote improved health and safety, societies often devote considerable resources through medical research, traditional public health programmes and (social) regulation to promote safer work, travel and natural environments.

A fundamental difference does exist between the exchanges made by individuals and societies. Within limits the individual is free to consume and live as his income and personality allow and to make his own decisions about his health and safety. However, the public budget can be readily changed through taxation (subject to the national political process and the total national resource endowment). Typically public servants must decide which and how much of other national goals and/or how much of individual consumption will be exchanged for public health and safety programmes. Inescapably, society must deal with how it will value the physical benefits of these programmes; it must place finite values on life and safety.[1] Since a preponderance of public health and safety programmes involves improving an individual's probability of living by a small amount, it is with the values of these small increments that policy-makers typically have dealt. In the past analysts recommended values based on some variant of the potential beneficiaries' future labour earnings. After decades of concern about empirical estimates based on foregone earnings, the last several years have been spent developing the theory for valuing life and safety. These developments which were initiated by Schelling (1968) and Mishan (1971) are distinguished from foregone earnings by emphasis on the individual beneficiary's willingness to pay for improvements in his own health and safety rather than on production capacity. While Linnerooth (1979) has reviewed the recent theoretical models, this paper considers the growing body of associated empirical research on values of life.

The purpose of this paper is to examine the methodology and results of the various studies which estimate values of life based on individual willingness to pay. Major theoretical advances and analyses of entire health-safety programmes can be found in these studies as well as estimates of values of life. For this reason alone it would be an injustice to judge the studies by the reported values of life alone. (Another is that each study suggests a range of values, while for expediency only, the best point estimates are reported.) This is not a search for some elusive, single, all-purpose number. Weinstein, Shepard and Pliskin (1980) show theoretically, what is frequently argued, that the value of life should vary among individuals and circumstances. It will become clear that no single value emerges.

The remainder of this paper is organised as follows. Section II is an evaluation of estimates of values of life based on willingness to pay. Implicit values from labour market and consumption activities are considered along with direct values from hypothetical markets. Section III summarises the estimates and identifies some of their limitations for those who would use them in formulating and administering public health and safety policy.

II. AN EVALUATION OF ESTIMATED VALUES

The evidence on value of life and safety comes from two different types of sources although both yield information on individual willingness to pay. One type is implicit values derived from observable individual behaviour with respect to goods and services whose markets are well-developed. Much of this type of evidence comes from the labour market through the estimation of risk-compensating wage differentials. Implicit values are estimated from consumption activity also, including housing and travel choices. Another type of evidence comes from creating hypothetical markets for health and safety and asking individuals directly how much they would pay for improvements contingent on the existence of such markets. Both types have their redeeming features, but each has its drawbacks as well. This evaluative paper seeks to clarify their advantages and disadvantages in addition to summarising the estimated value.

IMPLICIT VALUES FROM LABOUR MARKET ACTIVITY

Since the time of Adam Smith economists have entertained the notion of compensating wage differentials for jobs with different characteristics and working conditions. For a job with an extraordinarily high associated risk to life and limb workers will demand to be compensated through higher wages. By accepting a premium for extra risk individuals implicitly reveal information about their values of life.

Ample evidence has been accumulated showing that such risk-compensating wage differentials do exist. The first conclusion Smith (1979, p.346) reaches after reviewing fifteen studies of job danger and wages is that (with one exception) all studies using a risk of death variable find it to have a positive, statistically significant coefficient. Representative of these studies are those by Thaler and Rosen, Smith, Viscusi and Dillingham.

Thaler and Rosen (1975) apply the theory of hedonic price and implicit markets to the labour market. By matching actuarial data on risk of death on the job to earnings data for 900 workers in 37 risky occupations, they estimate the premium individuals are willing to accept in the labour market for assuming extra risk of death through multiple regression analysis; they find an average implied value of life between $346,000 and $642,000 with a best point estimate of $494,000 in 1980 U.S. dollars.[2] Using a similar technique but a broader sample of employees in manufacturing industries, Smith (1976) estimates a risk-compensating wage differential. Based on estimates from regressions corrected for some previously omitted job characteristics, the study shows the average value of life for these 3,183 workers, who perhaps are more risk averse and less talented at dealing with risk, is approximately $2.78 million. Paying even greater attention to non-pecuniary job characteristics other than risk of death, Viscusi (1978) estimates compensating differentials and finds an average value of life for 496 employees (blue-collar workers) between $2.25 and $3.38 million.[3] The midpoint of Viscusi's range is $2.82 million which is quite close to Smith's estimate. Dillingham (1979) investigates the importance of using more individual-specific risk data, industry-by-occupation. Based on a broad sample of 4,000 blue-collar employees of manufacturing and construction firms, the study reveals an average value of life of $378,000. His estimate is much lower than either Smith's or Viscusi's and is closer to that of Thaler and Rosen. Smith suggests that the difference in the estimates of these two groups is due to aggregation of risk data by industry or occupation, but recent preliminary simulations by Dillingham (1980) using the same data set have not supported the aggregation hypothesis or yielded an alternative explanation. Viscusi argues that the difference is due to the various levels of risk faced by the average worker in the samples.

While these efforts represent the state of the art, they are far from faultless. There is a fundamental concern about the nature of the implicit market for job safety and whether it is being properly used to estimate the value of life. Brown (1980) criticises cross-sectional analysis for failing to account for important, unmeasured, individual-specific dimensions of worker quality. Using longitudinal data, which he reasons is superior because these factors are held constant, he finds that compensating differentials are often wrong-signed or insignificant. Brown interprets the results as evidence against the existence of compensating wage differentials. An alternative interpretation is that not the data, but the methodology is lacking.

The compensating wage differentials are the outcome of a market clearing process for job characteristics. The differentials are determined by the demand for job characteristics by workers and the supply of job characteristics by employers. Since the differentials do not reflect demand (or supply) alone, as Thurow (1978) shows, no predictions of the sign, size, or statistical significance of hedonic wage coefficients can be made. The differences in estimated values of life from the labour market are surely due, in part, to different relative demands for job safety among the groups studied.

In general, estimating the demand for occupational health and safety involves more than a hedonic wage equation. Since the job safety is traded in an implicit market, the market prices are unobservable. According to Rosen (1974), these implicit market prices must be estimated from a hedonic wage equation first. If there is less than complete arbitrage, then prices can vary among workers which is the case if the hedonic wage equation is non-linear. Second, these prices are used along with whatever is necessary for identification to estimate the demand for job safety. The data and computational requirements are severe. The hedonic wage equation requires human capital variables and job characteristics including risk of death. Implicit prices of safety and non-safety characteristics must then be calculated for each observation. Using the amount of safety, the implicit price of safety, the implicit prices of related job characteristics, worker income and other demand determinants, one can estimate the demand for job safety. The values of life can be determined from the demand for safety. The potential problems of earnings and education in the hedonic equation, and income in the demand equation, and the computational burden of the two-step estimation procedure are formidable. Nevertheless Blomquist and Worley (1981) find that for the housing market studied, the hedonic equation over-estimated the value of some housing characteristics by as much as 56% and under-estimated the value of others by as much as 60%.[4] Whether the values of life estimated from hedonic wage equations are over-estimates or under-estimates due to this methodological problem is unclear.

IMPLICIT VALUES FROM CONSUMPTION ACTIVITY

Individuals making exchanges between health and safety and other desirables are not confined to making these at work but make exchanges through consumption activity as well. The available evidence is derived from protective or defensive activity in which the individual gains additional safety by incurring some additional housing or travel costs.

Residential housing is a heterogeneous commodity composed of various important features other than structural characteristics. These non-structural housing characteristics can be grouped as follows: (1) publicly-provided services such as schools, streets and garbage collection and (2) neighbourhood amenities such as accessibility to employment and shopping, serenity and air quality. They make a substantial contribution to the total price of a house and play a major role in residence site choice.

Portney (1981) combines what he calls a conventional property value study of single family dwellings with an epidemiological study which relates mortality to air pollution to get implied values of life for residents of Allegheny County, Pennsylvania. Essentially the value is the hedonic price of clean air, which is the coefficient for air quality in the hedonic housing equation (the regression of property values on housing characteristics), divided by the estimated effect of air pollution concentration on annual mortality rates (the coefficient on total particulate in the mortality regression).[5] Since age and sex-specific mortality rates are used, the values of life depend on these factors. For the typical household, which Portney argues is more representative than those people studied in the analysis of risk-compensating wage differentials, the value of life implied by residence site choice is $180,000.

This estimate is subject to an unknown bias due to ignored potential complementarity or substitutability between air quality and other housing characteristics and the effect of air quality on amenities. The value is biased upward because it attributes the entire effect of air quality on property values to the decrease in the risk of death; any value of decreased morbidity, material damage or visibility is assumed to be negligible. Also, the estimated value might well change with the mortality rate set which includes information on smoking, diet and other potentially important personal characteristics.

Portney's estimate, like the wage differential estimates, is subject to bias because of estimating the value of a characteristic directly from the hedonic rather than from the demand for that characteristic. In general the coefficient on air quality in the hedonic housing equation reflects supply conditions in addition to demand conditions. To find the value of clean air the demand for clean air could be estimated using the marginal implicit prices calculated from the hedonic equation and other demand determinants. Other housing studies have demonstrated that estimating the value of cleaner air or any other housing characteristic directly from the hedonic housing equation can bias the estimate by 60% in either direction.[6] Despite its shortcomings Portney's study suggests that future analysis of the housing market could be fruitful especially if the variations in risk due to fire and neighbourhood crime are considered.

There is a bit more evidence which is related to housing and that is the value of life implied by the voluntary purchase of smoke detectors for residences. By warning occupants of fire while it is in its first stages death and injury can be prevented. Taking into account the purchase price of the smoke detector, the replacement cost of batteries, and the changes in the probabilities of death and injury, Dardis (1980) estimates the average value of life is $274,000 to $428,000 depending on whether non-fatal injuries are weighted as equal to one-half a fatality or zero, respectively. The midpoint of the two estimates is

$351,000. Two shortcomings which bias this estimate in opposite directions are the omission of installation costs and the treatment of household size. The inclusion of installation costs means that the amount which residents are giving up to obtain more safety is greater than estimated and that the implied value of life is higher than estimated by Dardis. Recognising that usually there will be more than one person per household means that the implied value of life per person is perhaps 1/2 to 1/3 of the household value.

Highway travel is another consumption activity in which individuals can be observed making exchanges between safety and other desirables. Two such trade-offs which have been investigated are automobile driver use of seat belts and speed of travel on the highway.

Blomquist (1979) develops a method for estimating value of life from analysis of automobile seat belt use. Through probit analysis of seat belt use, it is found that use is greater, the greater the productivity of seat belts in preventing injury. Use is reduced where usage costs are higher. Use is greater, the greater the value the driver places on his life. Future earnings is found to be an important value of life variable.

The life saving benefit is the reduction in the probability of death on the highway multiplied by the appropriate value of life. The time cost of seat belt use is estimated from the time required for buckling, adjusting, and unbuckling, and the wage rate of the driver. With no costs other than time costs and no benefits other than mortality benefits, the implied value of life is the time cost divided by the reduction in mortality risk. However, the method used accommodates disutility costs, broadly defined to include discomfort, inconvenience and lack of knowledge; it also accommodates morbidity benefits. The value of life is imputed using estimated seat-belt-use time costs and the probit coefficient on driver wage rate to convert standardised to actual costs. The probit equation is used to find the implied value of life for the typical driver who does not use seat belts. The average value of life is found to be between $290,000 and $1,037,000, where the estimate for the most reasonable case is $466,000. One suspects that the disutility costs are the parameter most subject to error in this estimate.

Through analysis of the relationships between speed, accidents and gasoline consumption Ghosh, Lees and Seal (1975) find the value of life implicit in an individual's choice of speed for travel on British motorways. The speed chosen is the result of balancing the extra benefits of time saved against the extra costs associated with increased fuel consumption and casualties caused from traffic accidents. The implied value of life is equal to the value of time saved, less the additional fuel and non-fatal injury costs (the difference), divided by the additional risks of death from driving faster.

The production function for road casualties is estimated through regression analysis of British data on traffic casualties, volume, speed and weather. Information about the mix of fatal and non-fatal injuries and also the relationship between fuel consumption and speed are taken from other research. If it is assumed that the value of time saved is £1.00 per hour and gasoline costs 35p per gallon, the observed average speed of 58.8 m.p.h. implies a value of life of £95,000 (1973 £'s) which is approximately $419,000 (1980 $'s). This value of life is biased upward if the value of time is less than the average wage rate, there are passengers in the car, or there are nonhuman costs to accidents. The weighting scheme for fatal, serious and slight injuries could be a source of error in calculating the implied value of life.

Inherent in the methodology of estimating values of life from risk-compensating wage differentials, differences in property values, purchases of smoke detectors, use of automobile seat belts and choice of highway speed is the assumption that individuals know and perceive the changes in risk of death as they are calculated from data for the respective activity. For example, the average value of life implied by seat belt use is based on the typical driver perceiving that seat belt use will reduce by 50% the 3.027×10^{-4} probability of being killed in an accident and reduce by 25% the 1.392×10^{-2} probability of incurring a non-fatal injury. If the typical driver believes that the probability of being killed in an accident is less than that estimated from the measured frequency, then the implied value of life would be greater than $466,000, the value for the most reasonable case. The same effect results from drivers' believing that the productivity of seat belts in potentially fatal accidents is less than 50%. Of course, if drivers believe that the productivity of being killed or the productivity of seat belts is greater than measured, then the implied value of life would be less than $466,000. Similar comments can be made for the other implied premiums which have been examined. For each premium the differences between the perceived and measured phenomena can be due to either incorrect perceptions or measurement error.

There is evidence on the perception biases associated with risks of death from various causes. Lichtenstein et al (1978) have conducted laboratory experiments to study how people judge the frequency of lethal events. They investigate ordinal and cardinal relationships and find that people (1) have a consistent underlying scale (ordering) for the frequency of lethal events, but (2) under-estimate the frequency of high frequency events and (3) over-estimate the frequency of sensational events. For all accidents and for motor vehicle accidents, judgements are relatively accurate because the tendency to under-estimate them due to their frequent occurrence is almost offset by the tendency to over-estimate due to their sensational nature. For death by fire and flames, people tend to under-estimate the frequency more than for all accidents or motor vehicle accidents. For lung cancer, which is approximately as frequent a cause of death as motor vehicle accidents yet less sensational, the frequency is greatly under-estimated. The ratios of the observed to perceived frequencies, for a group of 34 people who were given the observed frequency of electrocution for a starting point, were found to be: for all accidents 1.235, for motor vehicle accidents 1.634, for fire and flame accidents 2.529, and for lung cancer 7.735. Adjustment of the implicit values of life for perception bias would increase each of the implied values since the perceived risk was under-estimated. The values of life implied by the risk-compensating wage differentials would be 23.5% higher, the values implied by highway speed and seat belt use would be 63.4% higher, and the value implied by smoke alarms would be more than doubled. The greatest change would be for the housing market with long-term effects of air pollution where the implied value of life would be increased from $180 thousand to $1.392 million. Adjustment for misperception transforms the housing market estimate from the smallest of the values implied by consumption activity to the largest.

CONTINGENT VALUES

One way to avoid the problems with the differences between perceived and measured changes in risk and, in general, avoid problems with data on observable behaviour is to collect information which deals directly with values of life.

The idea is to carefully construct a hypothetical market for making exchanges for risk and ask people explicitly how much they would be willing to pay for small changes in the probability of their survival. Contingent valuation is gaining an increasing amount of attention where there is keen interest in valuing extra-market goods, e.g., Brookshire, Randall and Stoll (1980) use contingent valuation to measure the value of aesthetic dimensions of environmental quality. At an early stage Mishan (1971) urged using questionnaires to evaluate life and limb.

Acton (1973) constructs a hypothetical but realistic market for five public programmes designed to reduce the risk of death due to heart attack. The programmes are: (1) screening for high-risk persons and pretreatment with drugs, (2) an ambulance with specially trained non-physician personnel, (3) a mobile coronary care unit with a physician, (4) a community triage centre and (5) a combination of triage centre and ambulance with non-physician. In the basic question individuals were asked how much they would be willing to pay for a programme which, given they had a 1/100 probability of a heart attack, would reduce the chance of death from 2/5 to 1/5. For the sample of 100 Bostonians the average response for this 0.002 change was $119 which implies an average value of life of $59,000. Acton considers this value to be the most relevant for evaluation of heart attack programmes, but makes it clear that the value of life is affected by factors such as the level of risk. When the reduction in the probability of a fatal heart attack is 0.001 (half of the first programme), the value of life is greater, $91,000. While Acton's sample is small enough to raise questions about small sample bias, the design of the survey instrument is commendable. The good (risk exchange) is described well, the situation is realistic enough that respondents can contemplate the existence of such a market, and the method of payment is clear. These qualities tend to produce reliable results from surveys.

Jones-Lee (1976) conducts an experiment in which he proposes an exchange of money for a decreased risk of being killed in an airline accident. The individual has the choice of two different airlines with different safety records and air fares. For risk reductions on the order of 10^{-5} and 10^{-6}, Jones-Lee finds a value of life of £3 million (1975 £'s) which is approximately $10.12 million (1980 $'s). This value is two orders of magnitude greater than Acton's best estimate and must be scrutinised closely given the high quality of Acton's study. The major drawback to Jones-Lee's survey (and one he explicitly recognises when reporting his results) is the sample he draws. The respondents consist of academics and research workers mainly, along with a few public sector employees. Also, only 30 of the 90 people who were sent questionnaires responded. (Acton's random sample was stratified along the lines of income, family size and sex.) Another difference is that Jones-Lee specified very small risk changes of 10^{-6} while Acton concentrated on risk changes of 10^{-3}. In contrast to the first difference this second difference does not necessarily detract from the Jones-Lee estimate, but may simply indicate a different value for a different level of risk. The small exploratory empirical effort of Jones-Lee is only an appendix to a considerably more successful theoretical endeavour.

Independently, Frankel (1979) is conducting a contingent valuation study which is similar to that of Jones-Lee in several ways. He asks what amount an individual would be willing to pay for "a magic amulet" which would reduce the probability of being killed in an airline accident from 1.5×10^{-6} to zero. The group he surveys, like that of Jones-Lee, consists of highly educated individuals with high incomes who are either academics or executives. The sample size is 169. The average (median) value of life for this extraordinary group is $3.37 million for a change in risk similar to that of Jones-Lee. Interestingly, when Frankel asks for the willingness to pay for a change in risk of 10^{-3}, the change considered by Acton, he finds the average value of life is $57,000 which is incredibly close to Acton's $59,000 estimate. Frankel attributes the difference in his estimated values to individuals' exaggeration of extremely small risks - an explanation analogous to Lichtenstein's finding of over-estimation of the frequency of low frequency events.

In her investigation of individuals' willingness to pay for decreased risk from nuclear plant accidents, Mulligan (1977) obtains responses which (after some calculations to obtain the values of life) show the same pattern of decreasing value of life as the size of the risk reduction grows larger. Following environmental economists, she uses an iterative bidding game technique to elicit the maximum amount individuals are willing to pay for the specified decreases in risk. This improvement over the other three contingent valuation studies aside, the imprecise description of the extramarket good to be contemplated by the respondent is troublesome. Respondents probably perceive the proposed exchange to be as follows: "What is the maximum amount you are willing to add to your monthly energy bill in order to get a reduction in the annual risk of death due to a nuclear accident from 1 in 1,000 to 1 in 10,000?" (It is not clear that the increased bill goes on forever or that the change in risk is yearly.) If respondents so interpret the exchange, the value of life for this risk reduction of 10^{-3} is $62,000. Under the same interpretation the value of life for a risk reduction of 10^{-4} is $428,000, and for a risk reduction of 10^{-5} the value of life is $3.58 million.

Given that contingent valuation of life is still in its infancy and that the studies are of uneven quality, it is surprising to find the close agreement of estimates for changes of 10^{-3}; the estimated values of life are $57, $59 and $62 thousand. Alone, this consistency does not validate the questionnaire approach, but the position is defensible that a carefully designed and implemented contingent valuation study can yield reliable results. Noteworthy is the study of air quality in Los Angeles, California, by Brookshire et al (forthcoming). They find that the contingent values for air quality improvements compare well with the values implied by analysis of the Los Angeles housing market. They view the results as verification of the survey approach for estimating the value of public goods. As the research on empirical validation of the approach accumulates, research for which Acton (1976) prudently called, it appears that future investigation based on contingent valuation of health and safety will be rewarding. The investigations will be particularly promising if they devote more attention to research design and more resources to data collection than the four existing studies and if they continually guard against and check for bias. Induced and strategic biases can be overwhelming even though they are avoidable.

III. VALUE OF LIFE AND SAFETY IN PUBLIC POLICY

Even with recent developments in estimating values of life and safety, it is clear that each approach has its drawbacks. Implicit values may be affected by individual misperception, the absence of a competitive market equilibrium, associated (dis) utility components, measurement error and other econometric difficulties. Contingent values may be unreliable due to hypothetical, induced or strategic bias. All things considered, the magnitude of the empirical problems appears to be neither negligible nor infinitely large. If these estimates of private values of life are to be useful for public policy, it may be helpful to hold these concerns in abeyance and consider the estimated values as a group in order to gain a perspective.

A SUMMARY OF ESTIMATED PRIVATE VALUES

The implied values of life estimated from investigations of risk-compensating wage differentials, the housing market, highway travel, and the stated values of life contingent on markets for heart attack prevention, safer air travel, and safer nuclear power are reported in Table 1. It should be remembered that only point estimates are given and that each study should be consulted for a discussion of the upper and lower bounds of the values of life. It is worth remembering also that theoretically there is no reason to expect to find a single value of life, since generally it should vary with risk, income, age, family status and other circumstances.

Several patterns can be observed by looking at the values of life based on observed or stated risk in Table 1. (The patterns are unchanged if one looks at the values based on adjustments for bias in risk perception.) The first observation is that when grouped by the range of estimated values of life the contingent values show the greatest range (from $57 to $10,120 thousand) followed by the values based on risk-compensating wage differentials (from $378 to $2,820

TABLE I

VALUES OF LIFE FROM IMPLICIT AND CONTINGENT VALUATION

Source of Evidence	Authors	Value of Life (Thousands of 1980 U.S. Dollars)[a] Based on Observed or Stated Risk	Adjusted for Biased Risk Perception[b]	Risk Reduction
Implicit Values from Labour Market Activity:				
Blue-collar workers in manufacturing and construction	Dillingham	$ 378	$ 467	10^{-4}
Workers in risky occupations	Thaler & Rosen	494	610	10^{-3}
Males in manufacturing industries	Smith	2,785	3,439	10^{-4}
Blue-collar workers	Viscusi	2,820	3,483	10^{-4}
Implicit Values from Consumption Activity:				
Residential neighbourhood air pollution	Portney	180	1,392	10^{-4}
Residential smoke alarms	Dardis	351	888	10^{-5}
Highway speed	Ghosh, Lees & Seal[c]	419	685	(10^{-4})
Auto seat belt use	Blomquist	466	761	10^{-4}
Contingent Values:				
Air Travel	Frankel	57	--	10^{-3}
		3,372	--	10^{-6}
	Jones-Lee	10,120	--	10^{-6}
..rt attack prevention	Acton	59	--	10^{-3}
Nuclear power	Mulligan	62	--	10^{-3}
		428	--	10^{-4}
		3,576	--	10^{-5}

[a]All values are converted to June 1980 dollars using the Consumer Price Index.

[b]Adjustments are based on the relevant relationships between observed and perceived risks of death found in Lichtenstein et al (1978). The values of life implied by the observed risks are multiplied by the ratios of observed and perceived risk. For labour market estimates the ratio is that for all accidents (1.235); for air pollution the ratio is that for lung cancer (7.735); for smoke alarms the ratio is that for fire and flame (2.529); and for highway speed and seat belt use the ratio is that for motor vehicle accidents (1.634).

[c]Since risk reduction is not specified, it is assumed to be the same order of magnitude as that in the Blomquist study.

thousand) and values from consumption activity (from $180 to $466 thousand).

A second observation is that when the values are grouped by risk reduction the estimated values of life tend to increase as the risk reduction declines. For values of the largest changes in the probability of survival (10^{-3}) the range is from $57 thousand to $494 thousand, and the average value is $168 thousand. For the values of intermediate (10^{-4}) changes, the range is from $180 thousand to $2,820 thousand, and the average value is $1,068 thousand. For the smallest risk reductions (10^{-5} or 10^{-6}) the values range from $351 thousand to $10,120 thousand with an average value equal to $4,356 thousand. (If the high estimate from Jones-Lee's illustrative study is excluded, the average is $2,435 thousand which still is well above the values for the larger risk reductions.)

A third observation is that for risk reductions of 10^{-3} and 10^{-4} the implicit values of life tend to be greater than the contingent values. The mean value of these implicit values is $1.077 million which is much higher than the mean value of these contingent values, $151 thousand.

A pattern which is emphasised in Blomquist (1981) is that the values are greater than average future labour earnings for each of the respective data sets and studies. The pattern holds for this set of studies also, although the future labour earnings are not shown in Table 1. (An exception is the value of $62,000 for a 10^{-3} change in risk in the Mulligan study where the average future earnings are $157,000.)

Future research will reveal whether these patterns are representative, not simply quirks of the small sample of existing studies, and why the patterns exist. For the present, two conclusions can be drawn: (1) the values of life are finite, and (2) even among the higher quality studies the range of values is wide with estimates differing by one or two orders of magnitude.

INDIVIDUAL WILLINGNESS TO PAY AND PUBLIC POLICY

Presumably, the foregoing research to establish what individuals are willing to pay for improvements in health and safety is motivated by the belief that these values are useful in formulating, administering, and evaluating public policy. The results surveyed will be of little comfort to either those who want to justifiy programmes by infinitely high values of life or those who want to mechanically accept or reject programmes on the basis of a single ratio or number. With a judicious appreciation for the strengths and weaknesses of the empirical evidence these individual values can be integrated into the public policy process. However, correct integration is more complicated than is readily apparent.

If there are health and safety externalities then the social values of life, those relevant for public policy, are different than the estimated individual values reviewed even if empirical problems are non-existent. Arthur (1981) shows that, in a general equilibrium context, increases in the probability of survival can involve changes in per capita consumption (and transfers) depending on the productivity of the beneficiaries. The social value of life becomes then the sum of the individual's value of an improvement in his own health and safety and the value to others of that improvement. Bailey (1980) estimates several components of this externality. For the average value of life based on willingness to pay estimated by Blomquist, Bailey adjusts upward $21,495 for imprecise insurance classifications including social security, 9.0% for indirect business taxes and $18,210 for medical costs borne by others. The total adjustment increases the private value of $466 thousand by 17.5% to $548 thousand.

If the population which is to be affected by policy is atypical, then average (even average social) values of life will be unsatisfactory. In some instances the size of external effects can be quite different compared to the typical individual, and this difference must be taken into account. In other instances the quality of life enjoyed can be atypical, and this too must be considered. Zeckhauser and Shepard (1976) suggest that this could be done by defining the output of a health and safety programme in terms of a quality-adjusted life year (QALY). Use of QALY then involves determining how much people are willing to trade off survival security for improvements in health status under various health conditions. Distinctions could be made between improvements in the safety of healthy people who have long expected lives and improvements in safety of those people who are ill with what is diagnosed to be terminal cancer.

These two complications, externalities and quality of life, are sufficient to suggest that the evidence on individual willingness to pay (accept) for improvements (reductions) in health and safety can be misused. Unfortunately, some believe that good policy can be formulated and implemented by simply valuing the physical benefits using private values of life and mechanically relying upon some evaluation criterion. They fail to appreciate that a great deal of the evidence is the product of efforts to understand, explain and predict individual behaviour when physical risk is an important factor, e.g., wage premiums for risky jobs, and not the product of research on health and safety policy, e.g., highway safety programmes which are in the public interest. The latter is concerned with making good decisions and not necessarily directly concerned with understanding individual behaviour.

Explicit recognition of the complex nature of policy decisions involving risks to life and limb is essential - a point which Zeckhauser (1975) makes emphatically. While this recognition could take place within an expanded benefit-cost analysis, several recent efforts have used decision analysis. Keeney (1980) estimates a decision-maker's utility function for alternatives involving potential fatalities. An example of complications worth considering is that he finds that the social value of the first involuntary risk fatality is 28 times the private value of that risk fatality. Bodily (1980) offers a methodology for decision-making which incorporates individual willingness to pay and externalities, and considers such diverse effects as voluntary and involuntary risks and the bunching effect of catastrophes. Through a model such as Bodily's or an enlightened, benefit-cost analysis, the recent evidence on individual values of life can be fruitfully incorporated into the public policy process.

FOOTNOTES

For helpful comments I am grateful to Alan Dillingham, John Hoehn, Ralph Keeney, Gavin Mooney and Paul Portney.

1. Value of life is the marginal value of a change in risk of death. It can be interpreted as an individual's value of a small change in his own probability of survival or alternatively as an individual's value of saving the life of an unidentifiable person in a large group to which the individual belongs. See Jones-Lee (1976). Although there is no generally accepted change in risk, Zeckhauser's RU (risk unit) which is equal to a change of 10^{-3} would serve well. See Shepard and Zeckhauser (1981).

2. For ease of comparison, estimated values are reported in 1980 U.S. dollars throughout this paper. The Consumer Price Index for June 1980 and the year of the data collection are used.

3. Viscusi estimates that the average premium for non-fatal injuries is $22,505.

4. The values of the housing characteristics are calculated from the hedonic equation and the demand equations. The values are the benefits of a hypothetical 5% increase (from the means) in the supplies of each characteristic.

5. Sulphur dioxide (SO_2) did not have a statistically significant effect on mortality rates. It was the only pollutant considered other than particulates.

6. See Harrison and Rubinfeld (1978) and Blomquist and Worley (1981).

REFERENCES

(1) Acton, J.P. Evaluating Public Programs to Save Lives: The Case of Heart Attacks, Research Report R-73-02, (Rand Corp., Santa Monica, CA, 1973).

(2) Acton, J.P. Measuring the Monetary Value of Lifesaving Programs, Law and Contemporary Problems 40 (Autumn 1976) 46-72.

(3) Arthur, W.B. The Economics of Risks to Life, American Economic Review 71 (March 1981) 54-64.

(4) Bailey, M.J. Reducing Risks to Life: Measurement of the Benefits, (American Enterprise Institute for Public Policy Research, Washington D.C., 1980).

(5) Blomquist, G. Value of Life Saving: Implications of Consumption Activity, Journal of Political Economy 87 (June 1979) 540-558.

(6) Blomquist, G. The Value of Human Life: An Empirical Perspective, Economic Enquiry 19 (January 1981) 157-164.

(7) Blomquist, G., Worley, L. Hedonic Prices, Demands for Urban Housing Amenities, and Benefit Estimates, Journal of Urban Economics 9 (March 1981) 212-221.

(8) Bodily, S.E. Analysis of Risks to Life and Limb, Operations Research 28 (January/February 1980) 156-175.

(9) Brookshire, D.S., Randall, A. and Stoll, J.R. Valuing Increments and Decrements in Natural Resource Service Flows, American Journal of Agricultural Economics 62 (August 1980) 478-488.

(10) Brookshire, D.S., Thayer, M.A., Schulze, W.D. and d'Arge, R.C. Valuing Public Goods: A Comparison of Survey and Hedonic Approaches, American Economic Review (forthcoming).

(11) Brown, C. Equalising Differences in the Labor Market, Quarterly Journal of Economics 94 (February 1980) 113-134.

(12) Dardis, R. The Value of a Life: New Evidence from the Marketplace, American Economic Review 70 (December 1980) 1077-1082.

(13) Dillingham A.E. The Injury Risk Structure of Occupations and Wages, Ph.D. Dissertation, Cornell University (1979).

(14) Dillingham, A.E. The Relationship Between Estimates of Wage Premiums for Injury Risk and the Measurement of Injury Risk: Results from One Population, Department of Economics, Illinois State University (September 1980).

(15) Frankel, M. Hazard, Opportunity and the Valuation of Life, Unpublished preliminary report (Department of Economics, University of Illinois at Urbana-Champaign, November 1979).

(16) Ghosh, D., Lees, D. and Seal, W. Optimal Motorway Speed and Some Valuations of Time and Life, Manchester School of Economic and Social Studies 43 (June 1975) 134-143.

(17) Harrison, D. Jr., Rubinfeld, D.L. Hedonic Housing Prices and the Demand for Clean Air, Journal of Environmental Economics and Management 5 (March 1978) 81-102.

(18) Jones-Lee, M.W. The Value of Life: An Economic Analysis (The University of Chicago Press, Chicago, 1976).

(19) Keeney, R.L. Evaluating Alternatives Involving Potential Fatalities, Operations Research 28 (January/February 1980) 188-205.

(20) Lichtenstein, S., Slovic, P., Fishhoff, B., Layman, M., and Combs, B. Judged Frequency of Lethal Events, Journal of Experimental Psychology: Human Learning and Memory 4 (November 1978) 551-578.

(21) Linnerooth, J. The Value of Human Life: A Review of the Models, Economic Enquiry 17 (January 1979) 52-74.

(22) Mishan,E.J. Evaluation of Life and Limb: A Theoretical Approach, Journal of Political Economy 79 (July/August 1971) 687-705.

(23) Mulligan, P.J. Willingness-To-Pay for Decreased Risk from Nuclear Plant Accidents, Working Paper No.3, Energy Extension Programs, Pennsylvania State University (November 1977).

(24) Portney, P.R. Housing Prices, Health Effects and Valuing Reductions in Risk of Death, Journal of Environmental Economics and Management 8 (March 1981) 72-78.

(25) Rosen, S. Hedonic Prices and Implicit Markets, Journal of Political Economy 82 (January/February 1974) 34-55.

(26) Schelling, T.C. The Life You Save May Be Your Own, in: Samuel B. Chase, Jr., (ed), Problems in Public Expenditure Analysis (Brookings Institution, Washington D.C., 1968).

(27) Shepard, D.S., Zeckhauser, R.J. On Purchasing Survival, this volume.

(28) Smith, R.S. The Occupational Safety and Health Act, American Enterprise Institute for Public Policy Research, Washington D.C. (1976).

(29) Smith, R.S. Compensating Wage Differentials and Public Policy: A Review, Industrial and Labor Relations Review 32 (April 1979) 339-352.

(30) Thaler, R., Rosen, S. The Value of Life Saving, in: Nestor E. Terleckyj (ed), Household Production and Consumption (Press for NBER, Columbia University, New York, 1976).

(31) Thurow, L.C. Psychic Income: Useful or Useless, American Economic Review 68 (May 1978) 142-145.

(32) Viscusi, W.K. Labor Market Valuations of Life and Limb: Empirical Evidence and Policy Implications, Public Policy 26 (Summer 1978) 359-386.

(33) Weinstein, M.C., Shepard, D.S. and Pliskin, J.S. The Economic Value of Changing Mortality Probabilities: A Decision-Theoretic Approach, Quarterly Journal of Economics 94 (March 1980) 373-396.

(34) Zeckhauser, R. Procedures for Valuing Lives, Public Policy 23 (Fall 1975) 419-464.

(35) Zeckhauser, R., Shepard, D.S. Where Now For Saving Lives? Law and Contemporary Problems 40 (Autumn 1976) 5-45.