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A REVIEW OF RECENT STUDIES ON THE ECONOMIC VALUE OF A HUMAN LIFE

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Factors pertaining to the problem of quantifying the value of human life are enumerated, and some of the schemes and rationale that have been used in such quantification are reviewed. Factors considered in the loss of life involve direct economic costs such as hospitalization and legal services as well as indirect economic costs such as loss of future production and consumption. Also considered are non-economic losses such as the suffering of a bereaved family. Distinctions are drawn between economically motivated questions and those based on social and moral values. Other issues concern the difference between a statistical life and a specific individual, and scale effect (loss of X number of lives per X number of events). A survey of studies made in the U.S. and France on the value of human life is presented. Specific schemes used to assign a dollar value to a human life include assessments for traffic accidents, air crashes, and catastrophic events. In evaluating money costs due to illness or death, several calculations are given. It is noted that additional factors need to be considered in basing a valuation of human life on expected lifetime earnings. Results of various studies' estimates of the value of human life are presented in tabular form.

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A REVIEW OF RECENT STUDIES ON THE ECONOMIC VALUE OF A HUMAN LIFE

Introduction

In current applications of benefit-cost analysis, an increasing emphasis has been on evaluating expected costs and benefits in common units of measurement, particularly in terms of dollars spent or saved. In analyses where the risks of loss of human life have been considered, dollar values for the loss of a life have been assigned, either directly or implicitly. At any rate, various methods of quantification have been applied or proposed in such areas as policy making in public health expenditures (e.g., since October, 1965, HEW's cost-benefit analyses for measuring the effectiveness of health programs), selection of design criteria in potentially hazardous situations (e.g., design of nuclear power plants), and compensation for premature accidental death.

This report attempts to enumerate factors entering into the problem of quantifying the value of a human life, and to review some of the schemes and rationale that have been used in such quantification.

Factors Entering the Problem of Quantification of Human Life

The loss of a human life may cause both economic and non-economic hardships. For example, there may be direct economic costs (costs of hospitalization, legal services, police, insurance, and burial), as well as indirect economic costs (loss of future production and consumption). Non-economic losses may be the suffering of the bereaved family, society's loss of a contributing member, and the termination of the victim's own will to live. It is difficult (and perhaps impossible) to evaluate all these factors in order to answer the question, "What is the dollar value of a statistical human life?"; furthermore, when we consider the question, "What is the dollar value of a statistical human life to society? to a family unit? to the community?", we must select and combine these factors in a manner that gives a reasonable estimate of a man's value to society, to the family, etc. Finally, we must remember that in public works decisions, the question may perhaps be better stated as, "How much is the community prepared to spend to avoid the loss of an arbitrary human life?" For many social and moral reasons, this question may not have the same answer as the previous, more economically motivated questions.

Other issues that have been raised include the distinction between what is sometimes referred to as a "statistical life", on one hand, and a specific individual, on the other. For example, setting seismic safety provisions for a city involves concern about potential "statistical lives", i.e., unknown, perhaps almost randomly chosen individuals, whereas design of a specific structure for a particular organization may involve the lives of identifiable personalities. In between these ends of the spectrum are, of course, identifiable classes of persons, e.g., males and females, old and young, sick or not, rich and poor, etc. Should all be assigned the value of the "statistical life?"

Still another question is "scale effect". Should the loss of 100 lives in a major event, e.g., a major earthquake, explosion, or airplane crash, be assigned the value associated with 100 events, each involving a single life, e.g., small earthquakes, automobile accidents, accidents in the home,etc. It has been pointed out that the differences in press coverage may suggest that major losses have a greater effect on society. In a particular major earthquake, are 100 lives lost in a single building collapse equivalent to 100 lost in many independent buildings not suffering total failure?

We are not attempting to answer or even to directly address these issues in this report. The purpose is only to identify some of these questions and to summarize past studies that place an equivalent monetary value on a human life. The Boston study is considering these and other methods in its decision analysis.

Survey of Studies Made on the Value of a Human Life

In the United States, studies of the dollar value of man have dealt almost exclusively with the economic losses resulting from the loss of future production and/or consumption. However, it has been suggested that an economic measurement of the other, non-economic losses can be observed in court awards in loss of life lawsuits.(1) Specific schemes and rationale that have been used to assign a dollar value to a human life are discussed below.

In some cases, implicit valuations are derived from considering the extra amount of money people consent to pay for safety (for example, providing more or better life-saving devices on highways) versus the level of risk they are willing to accept. For example, the White House Office of Science and Technology decided that the average cost of death in a traffic accident is $140,000; while other government analysts in the National Highway Traffic Safety Administration calculated a cost of

200,000. A similar study on the victims of air crashes gives a loss figure of $275,000.[2] A Federal Aviation Agency study puts the value of life saving in commercial aviation accidents at $373,000.[3] H. J. Otway carried out interviews with a number of people concerning recorded catastrophic accidents involving both property loss and loss of life. Responses to his questions indicated that these people made a subconscious assessment of a life at $200,000.[3] Implicit valuations are also made when establishing hazardous duty pay: such pay in the U.S. Air Force indicates values ranging from $135,000 to $980,000 per life for Air Force pilots.[3]

While these implicit variations indicate more or less subconscious assessments of the dollar value of a life, they are not necessarily reliable for use in benefit-cost analysis, where it is desired to treat all variables explicitly. Perhaps a better indication of society's valuation of a human life is found in jury awards in loss of life lawsuits, where the awards range from $50,000 to $500,000, with a geometric mean of $250,000.[3] However, more formalized and quantitative studies have been made. In such studies, annual earnings data, mortality rates, productivity, and population censuses are analyzed to give the present value of expected lifetime earnings. For example, ASCE's Task Committee on Reevaluation of Adequacy of Spillways of Existing Dams, in developing a "rational" approach for calculating spillway heights, has determined the value of a human life in terms of the average loss in future lifetime earnings due to death at various ages. As a result, they obtained $150,000 for the value of a life and $250,000 for the case of permanent disability.[4]

In assessing expenditures in protecting the public from radiation exposure in nuclear reactor accidents, L. A. Sagan assumed a value for the loss of one day's productivity of $50 and an average 6000 working days (20 years) lost due to accidents, which indicates a cost of $300,000 for a fatality.(5)

Burton A. Weisbrod, in evaluating monetary costs due to illness or death, associates these costs with loss of production due to premature death, sickness which results in loss of production or partial/complete inability to work, permanent disability reducing future production, and temporary absence from work which may necessitate certain adjustments of the production process causing a reduction in the productivity of others. In his calculaitons, Weisbrod accounts for net future production by age and sex, discount rates of 4% and 10%, and values of household services of females (in terms of units of family responsibility). Using the formulas cited below, he calculated values as high as $48,969 (in 1950-dollars).(6)

The present value of net future earnings of a person age a is given by:

$$V_a = \sum_{n=a+\frac{1}{2}}^{\infty} Y_n \, P^n_{a+\frac{1}{2}} \, \frac{1}{(1 + i)^{n-a}}$$

where a = person's age at his last birthday

i = discount rate

$P^n_{a+\frac{1}{2}}$ = the probability a person of age $a+\frac{1}{2}$ will survive to age n

Y_n = average annual earnings, net of consumption, of a person of age n

Miller and Hornseth, in U.S. Bureau of the Census Technical Paper No. 16, present tables for the present value of estimated lifetime earnings in 1959 according to age, occupation, color, education level, discount rates of 0%, 3%, 4%, and 5%, and with annual productivity increases of 0%, 2%, 3%, and 4%. In addition, they present similar tables of consumption deductions from expected lifetime earnings for annual allowances of $1000, $2000, and $3000. Using the formulas below they estimated values as high as $147,000 (in 1959 dollars) for a discount rate of 4% and annual productivity increase of 2%.[7]

The total sum of earnings received between age A and age 64 is given by:

$$V_A = \sum_{N=A}^{64} \frac{Y_N \, P_N \, (1 + X)^{N-A+\frac{1}{2}}}{(1 + R)^{N-A+1}}$$

where Y_N = mean annual earnings at age N

P_N = relative number of survivors at age N of those alive at age A

X = assumed annual increase in earnings due to rising productivity

R = discount rate

Similarly, the total sum of personal consumption between age A and age 64 is given by:

$$M_A = \sum_{N=A}^{64} \frac{M \, P_N \, (1 + X)^{N-A+\frac{1}{2}}}{(1 + R)^{N-A+1}}$$

where M = mean annual consumption, i.e., $1000, $2000, or $3000.

In their study for the Department of Health, Education and Welfare, Rice and Cooper derived basic data for the valuation of the human life which they consider applicable to analysis of health expenditures as well as to other fields. They present their valuations according to age, sex, color, and degree of educational attainment. These estimates were derived from lifetime earnings data accounting for varying labor force participation rates, productivity increases, discount rates of 2%, 4%, 6%, and 8%, and the values of housewives' services. Their study indicates a maximum valuation of $131,416 (in 1964 dollars).[8]

Unlike the above-mentioned studies in the United States, which base their valuations strictly on present value of future lifetime earnings, Abraham and Thédié (French) presented a scheme to account for both the economic and the non-economic (i.e., pain, suffering, etc.) costs of a human life. They combined both the present value of future production (net of consumption) with values for pain and suffering inferred from court decisions involving loss of life, and suggest a total value of a life of 145,000 NF ($19,800 in 1960) for the case of highway accidents.[1] In calculating the present value of future earnings, Abraham and Thédié used the following formulas.

The present value of future production in year n for men of type q is given by:

$$V_n^q = P_n^q + \sum_{i=n+1}^{\infty} \left[P_i^q \left(\prod_{j=n}^{j=i-1} X_j^q Z_j^q\right)\left(\prod_{v=1}^{v=i-n} \frac{1+b_v^q}{1+a_v}\right)\right]$$

where P_i^q = mean annual production in year i

X_j^q = yearly survival rate

Z_j^q = rate of continued productivity

b_v^q = rate of productivity increase

a_v^q = discount rate

and the present value of future consumption in year n is given by:

$$U_n^q = C_n^q + \sum_{i=n+1}^{\infty} [C_i^q (\prod_{j=n}^{j=i-1} X_j^q)(\prod_{v=1}^{v=i-n} \frac{1 + d_v^q}{1 + a_v^q})]$$

where C_i^q = mean annual consumption

d_v^q = rate of increase in yearly consumption

The foregoing studies illustrate schemes and rationale used in current valuations of a human life. However, there are many conflicting opinions concerning the relevance of these studies, as well as the applicability of benefit-cost analysis to problems involving the risk of human life loss. For example, Metzger(9) feels that risk-benefit's use of a dollar value for a human life, where the scientist applies logic to derive his value, fails to include a parameter to account for the fact that the people affected by the analysis are not similarly inclined to scientific logic. These people may not be willing to take the chance that the "one statistical life" may be their own, or as Metzger aptly puts it, "It isn't the odds, it's the stakes."

On the other hand, Bob Buehler of the ASCE Task Committee on Reevaluation of Spillways of Existing Dams says that it is less acceptible not to rationally weigh the cost of human life loss, because the additional money spent in lowering* the spillway height beyond a certain point will save relatively few lives. Rather, it would be

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* While the original article implied that raising the spillway height makes a dam safer, Bob Buehler points out in the July, 1972 issue of Civil Engineering that the opposite is true, i.e., lowering the spillway height would save more lives.

more humane to minimize the total cost to society by allocating the money to efforts yielding more return in benefits.[4] Similarly, Jerry Cohen at the Lawrence Livermore Laboratory feels it proper to put a money value of life so long as it remains a "statistical" life, and he states that "when we're dealing with the safety of random individuals, then we need a limit on how much we'll spend to reduce the accident rate to an acceptable level."[10]

If we are to include a dollar value for the human life, what valuation study should we apply? Here too, much controversy arises. Should we accept the present value of lifetime earnings as an approach? It has been argued that if we use this approach in a benefit-cost analysis for determining public health expenditures, it would not be worthwhile for the government to invest any money in reducing diseases of the elderly, because such money spent would prolong life but not the individual's economic productivity.[2] In response to the article in Civil Engineering (March, 1972), "In a Spillway, How High is Safe?", James D. Davidson said that putting a value on the human life based on earnings implies that protection programs should be oriented toward protecting the community with the highest averge income.[11] Furthermore, according to William H. Culp, the costing procedure based on the value of a human life would force people in areas of sparce population to accept a much higher risk level than people in a densely-populated urban area (where the expected costs associated with a given spillway height are much higher than for its rural counterpart). Instead, he feels that safety guidelines should stipulate first "social responsibility" and second "economic justifications."(12) However, the latter viewpoint was contested by Dr. Asit K. Biswas, who suggests that it it impractival to equalize the geographical distribution of risk as has already been illustrated by the varying risks due to hurricanes (comparing coastal areas to inland areas), due to different crime rates (comparing urban areas to rural areas), or due to fire, earthquake, or collapse in residences (comparing high rise apartments to single-story houses).(13)

Further criticisms of basing a valuation of human life on expected lifetime earnings are that additional factors need to be considered and that such a priori estimates may not be accurate indicators of what society is actually willing to pay. Robert H. Thomas, in response to the spillway article, indicates that the Committee neglected both the future consumption of a person and the intangible value placed by society on human life and suggests that one should attempt to estimate the effective value which society has placed on life by its acceptance of projects which do and will cause deaths.(14) In regard to the French study by Abraham and Thédié, J. M. Faverge feels it is necessary that estimates of the value of a life should account for the differing manner in which an individual's death is perceived by the different groups to which he belonged. For example, an individual's death may threaten the survival of his family or the company where he worked.(15) M. Jensen suggests that any a priori valuations (such as that of Abraham and Thédié) should be avoided since the errors involved may be unacceptable, and the valuations obtained may not be at all related to what society is in fact willing to pay. Rather, valuations should be made after-the-fact, yielding figures that are both accurate and relevant.(15) To M. Jensen's comment, T. Thédié agrees that a posteriori studies should also be made, but that such studies indicate a lower bound on the value of a human life, while a priori studies attempt to give a mean value.(15)

Concerning a posteriori studies made for the cases of accidents resulting in death, J. Mélèse (referring to Abraham and Thédiè's study) indicates that, while using highway accident statistics is useful in determining appropriate levels of risk acceptance, it is not appropriate to apply these estimates elsewhere since the number of fatalities on highways is only a small portion of the total number of fatalities.(15)

Finally, when considering using the results of the above-mentioned studies, one should be aware of the possibility that some studies may have been based on data that are obsolete or were intended for application to only one very specific problem and are not available for use in other areas today. Also, it is interesting to note that the formulas used in calculating present values of future incomes are fundamentally the same. With these observations in mind, one may review the characteristics of each study and its valuations, summarized in Table I to facilitate comparison of the results and consideration of the applicability to specific problem areas. Also indicated in Table I are the values obtained for the economic value of a human life when non-economic factors are incorporated (by multiplying the net or gross value of future lifetime earnings by factors inferred from the French study).

	Productivity Increases	Median Values Used	Mean Values Used	Gross Future Production by Age	Gross Future Consumption by Age	Net Future Production by Age	Gross Future Production by Sex	Gross Future Consumption by Sex	Net Future Production by Sex	Account for Housewives' Services?	Discount Rate(s)	Year Study Was Made	Present Value of Future Earnings by Sex and by Discount Rate; Adjusted to 1972 Dollars ($x10^3$)				Economic Value of a Human Life 1972 Dollars ($x10^3$)			
													M		F		M		F	
													10%	4%	10%	4%	10%	4%	10%	4%
Weisbrod (Max) Weisbrod (Median)		✓				✓			✓	✓	4% 10%	1950	49.2 48.7	89.3 87.7	40.0 39.6	74.8 70.5	178.3 176.4	323.6 317.9	144.9 143.4	271.5 255.6
Rice & Cooper (Max) Rice & Cooper (Median)	✓		✓	✓			✓			✓	2% 4% 6% 8%	1964	-	179.6 175.6	-	97.9 94.4	-	254.2 248.5	-	138.6 133.5
Bureau of Census (Max) Bureau of Census (Median)	✓		✓	✓	✓		✓ (M)				0% 3% 4% 5%	1959	-	219.9 207.9	-	-	-	311.2 294.2	-	-
French Study (Max)	✓		✓	✓	✓					✓	8%	1960	<29.6	-	-	-	-	38.2	-	-

TABLE I

RESULTS OF VARIOUS STUDIES' ESTIMATES

OF THE VALUE OF A HUMAN LIFE

TABLE I (Continued)

RESULTS OF VARIOUS STUDIES' ESTIMATES

OF THE VALUE OF A HUMAN LIFE

FAA Study	$373,000
USAF Hazardous Duty Pay	$135,000 to $980,000
Otway	$200,000
Jury Awards	$250,000
ASCE-Spillway Study	$150,000
Office of Science & Technology	$140,000
National Highway Traffic Safety Administration	$200,000
Victims of Air Crashes	$275,000
Sagan	$300,000

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