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A METHOD OF EVALUATING HUMAN LIFE FOR ECONOMIC PURPOSES

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SUMMARY

A method of estimating a monetary value of life which can be used for the evaluation of safety precautions is presented. People are willing to spend money to reduce the risk of accidents, or to increase the risk for some benefit, and this method endeavours to estimate the value of life which is consistent with their behaviour. Examples of the application of this method are given which indicate that the value of a life is of the order of £50 000. The results obtained are compared with values given by discounted earnings. The evaluation of future risks and the importance of perceived risk are also considered. Factors influencing perceived risk are discussed.

KEY WORDS: Safety, cost-benefit, behaviour

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INTRODUCTION

In deciding what risks are acceptable and what precautions are worthwhile in the field of safety it is sometimes necessary to place a value on human life. This sum is required as a parameter in the economic assessment of safety expenditure to evaluate the benefit of increased safety. Such considerations are relevant in the field of fire prevention and fire fighting measures.

The use of a single sum for all types of hazard would enable safety expenditure to be optimised by ensuring that the marginal increase in safety per pound spent was the same in all fields. Values taken hitherto range from about £5000 to £30 000[1,2,3]. The method used to value life safety and the answer obtained depend on the purpose of the expenditure. If the object is to maximise economic return then output should be considered whereas if the object is to maximise satisfaction then the value of safety to the individual must be assessed.

Some methods which can be used for assessing the value of human life are:

i) replacement cost
ii) gross productivity
iii) productivity net of consumption
iv) marginal value, dG/dn, where G is the gross national product and n the population.

Discounted values can be taken, to allow for the lag with which the production or consumption occurs.

These methods of assessment often give small or even negative values[1]. This must be so since the community as a whole consumes most of what it produces.

PROPOSED METHOD

The above methods of assessment estimate the value of an individual to the economic life of the community and are appropriate in discussing investment for economic return. However, it is also relevant to take the value which an individual attaches to his own life[4]. This factor can determine his behaviour and choices in society. There are many activities in which, for a saving of money (or time), individuals are prepared to take risks. Fire precautions are paid for directly or indirectly, albeit collectively, by the people whose lives are being safeguarded. It can therefore be argued that the sum which is spent to avoid a given risk should be the same as people are willing to spend voluntarily to avoid risk in other contexts[5]. This figure is relevant to the question of how much the community should spend on safety since a safer life increases non-economic satisfaction.

The method used in this note is based on estimates of the expected loss and benefits to be gained in various common risky activities. The expected loss due to the risk of death is the product of the value placed on life and the probability of death. A value for life is obtained by equating minimum acceptable benefit with expected loss. The sum obtained is that which makes the behaviour of the individual consistent. The importance of perceived risk is also considered.

The method gives a level of expenditure which people can be expected to accept, thereby avoiding the disadvantages of compulsory regulations, which are often complex and ineffective and can destroy people's sense of personal responsibility[6].

Estimating the value people put on risks of death is complicated by several factors. Not only may people's assessment of a risk be unrealistic but monetary values must be put on any pleasure obtained (or opprobrium avoided) in the risk-taking activity, on the one hand, and on disadvantages such as the risk of injury on the other.

OPTIMISATION OF SAFETY EXPENDITURE

Money is spent on safety for the following reasons:

i) to avoid deaths and injuries
ii) to make people feel safer
iii) people's concern for the safety of others[7]

A social problem arises because the individual can often spend his resources only in co-operation with others, e.g. a person can refrain from going into a dangerous place but cannot himself improve it.

The method of valuation of life described in this note aims to measure what the average person is willing to spend on safety for the first two reasons above. Since only items of concern to the individual have been considered, the value of life obtained is a private as opposed to a social valuation. Distress to those not killed or injured, including those not at risk, is an additional consideration to the extent that people are willing to pay for the safety of others. People feel some concern for the safety of others. Such concern forms part of the basic instinct for the preservation of the species and increases the value to be placed on life in calculating safety expenditure acceptable to the community as a whole. However, people usually value benefits to others less than benefits to themselves and less in the case of anonymous persons than identified persons.

The distress and financial loss that an individual's death would cause to his family is included in his private valuation insofar as the individual takes account of these factors in deciding which risks are worthwhile. The financial loss to the rest of society can be considered as a small additional factor in the value of an individual's life.

It is difficult to differentiate between the benefit from reducing the number of deaths and that from increasing people's feeling of safety. Anxiety is a disbenefit even if the risk is much smaller than believed. Likewise, if a person dies from a risk of which he is unaware, he still suffers a loss.

Some examples of the procedure are given below. The analysis is somewhat tentative at this stage because many of the data necessary are not available. More reliable estimates could be obtained by collecting and analysing further data, in particular by surveys of attitudes towards risk taking[5,8].

EXAMPLES

1. ROAD TRAVEL

Driving[9] and crossing roads are fields in which most people consciously take some chances. These risks can be evaluated, as can the potential benefits to be gained. Two cases are considered below: average driving speed, and use of pedestrian subways.

i) Driving speed

Speed limits reduce fatal accidents by about 15 per cent and average speed by about 5 per cent[10]. These figures suggest that the average motorist is willing to increase the risk of a fatal accident by 15 per cent to obtain a 5 per cent saving of time, or by at least 3 per cent to obtain a 1 per cent saving of time, from which an upper limit to the value placed on a life can be obtained.

$$\text{Saving} = 0.01\ sv/S \tag{1}$$

where s = distance travelled

v = value put on unit time saved

S = average speed

$$\text{Increase in number of deaths} = 0.03\ n_d \tag{2}$$

where n_d = number of road accident deaths

Taking

saving = value of life x increase in number of deaths ,

then

$$\text{value of life, } V = \frac{\text{saving}}{\text{increase in number of deaths}} \tag{3}$$

Substituting from equations (1) and (2)

$$V = \frac{sv}{3Sn_d} \tag{4}$$

Taking $s = 3.5 \times 10^{11}$ passenger km pa[11]

v = one-third average wage rate[12]

= 23 p h^{-1}, assuming an average wage[2] of £1360 pa and a working year[12] of 2000 h

S = 50 km h^{-1}

n_d = 7300 pa[13]

then

value of life, V = £73 500

Many of the casualties from reckless driving are other road users. The above calculation assumes that motorists value the lives of others as highly as their own. If this is not so then their valuation of their own lives will be higher than the value above.

ii) Use of pedestrian subways

Most pedestrians will use subways only if it takes not more than about 27 per cent longer than crossing the road and will use a bridge only if it is as quick as crossing the road[10]. Equating risk and benefit

$$\text{value of life, } V = \frac{v\ t_c}{p_a\ p_d} \tag{5}$$

where t_c = extra time pedestrians are willing to spend to avoid risk from crossing road

p_a = probability of accident when crossing road

p_d = probability of these accidents being fatal.

At and within 46 m of 25 crossings in London with average flows of 834 vehicles and 550 pedestrians per hour there were 169 personal injury accidents to pedestrians during a four year period (three years in two cases)[10]. The number of crossings made was approximately 4.9×10^8 giving

$$p_a = 169/(4.9 \times 10^8)$$
$$= 3.5 \times 10^{-7}$$

If the use of a subway requires 2.5 m vertical descent[14] and 15 m walk on the level then, assuming velocities of 1.5 m s^{-1} on the level and 0.15 m s^{-1} vertically up and down steps[10],

time taken to cross by subway = 43 s
acceptable time by surface or bridge = 43/1.27
= 34 s

The minimum ascent to a bridge[14] is 5.5 m.

Thus the time spent to avoid 3 m ascent <u>or</u> the risk of crossing the road is 43 - 34 = 9 s. A 2.5 m descent is then equivalent to 7.5 s.

If there were no additional climbing (eg if the road were on a hill so that a climb was necessary even if not using the subway) then pedestrians should be willing to spend additional time $t_c = 9 + 7.5 = 16.5$ s to use the subway.

Taking t_c = 16.5 s
p_a = 3.5×10^{-7}
p_d = 0.035
= proportion of pedestrian casualties which are fatal[15] then,

from equation (5),

value of life, V = £86 500.

For each death there are about thirteen serious injuries and thirty-five slight injuries[2]. If each serious injury involves suffering of £500 on average[2], of which two-thirds is compensated by insurance, and each slight injury involves suffering of ten pounds[2], then loss due to injuries and not paid for by insurance

= 13 x £500/3 + 35 x £10
= £2500 per death

Material damage costs approximately £173m pa in the UK[2], or £25 000 per death. If 20 per cent or £5000 is borne by motorists directly and in loss of no claims bonuses then, deducting the loss due to injury and material damage,

value put on life = £66 000 from driving speed
84 000 from use of subways.

2. SMOKING

It is widely appreciated that there is a risk to health from smoking and the value put on life can be estimated from people's willingness to take this risk.

The sum spent on tobacco is about £1.7×10^9 pa in the UK[16]. About 27 500 people a year under 65 die from smoking[18]. If F is the extra amount as a fraction of the current cost which people would be prepared to pay for cigarettes which were safe but otherwise identical to ordinary cigarettes then the value put on a life if F x £1.7×10^9/27 500 = F x £62 000. Including deaths over 65, or ignoring the tobacco smoked by people over 65, might give a value 25 per cent lower or F x £46 500.

Most deaths due to smoking appear to occur within ten years of the smoking responsible[17]. If it is assumed that there is an average delay of five years and that the price of a death can be discounted at 6 per cent pa then, allowing for the chance of dying from other causes during that period and the effect of decreasing life expectancy on the value of life (see Valuation of Life Expectancy, below) the value obtained should be increased by about half, making the present value of a life F x £70 000. If a 10% pa discount rate is taken to allow for the possibility of an event such as a cure for cancer being found then the present value of a life becomes F x £85 000.

F could be estimated by market research. A pilot survey conducted at the Fire Research Station suggested that F is approximately 0.37, from which the value put on life is 0.37 x £70 000 = £26 000 taking a discount rate of 6%, and 0.37 x £85 000 = £31 000, taking a discount rate of 10% pa.

3. EMPLOYMENT

Payment for industrial work often contains an element for risks taken. Table 1 shows the risk of death in different occupations. It can be seen that there are certain occupations in which the risk is much higher than average. For about half the work force the risk is very small.

In job evaluation studies about five points out of 100 are typically assigned to the degree of danger[18]. It can be seen from Table 1 that 500 deaths per million employees per year represents a high degree of risk. If it is assumed that this risk is awarded the maximum of five points then each point corresponds to a risk of $500 \times 10^{-6}/5 = 10^{-4}$ pa. If each point is worth £15 pa after tax then £$15/10^{-4}$ = £150 000 danger money is paid per death. However, this sum does not represent the value put on a life since it includes compensation for the risk of injury.

For each death there are about 450 accidents involving disability beyond three days and perhaps 10 000 other accidents[19]. £95m was paid for industrial injuries in 1966[13], thus for each death there were accidents for which £95m/1450 = £65 000 industrial injury benefit was paid.

National insurance benefits are usually minimal and not all cases would involve a payment. If it is assumed that for accidents involving disability beyond three days the amount by which loss and suffering exceed the compensation received is of the same order as the industrial injury benefit paid and that for other accidents the average loss and suffering is two pounds per accident, then for each death:

Danger money paid	=	£150 000
Uncompensated loss due to accidents involving disability exceeding three days	=	65 000
Loss in other accidents 10,000 x £2	=	20 000
Value put on life = £150 000 − 65 000 − 20 000	=	£ 65 000

From these figures the value put on life is of the order of £65 000. Thus about half the danger money is for the risk of death.

VALUATION OF LIFE EXPECTANCY

If each year of life is assumed to have a fixed value y then the present value V of a life depends on the life expectancy and on the rate of discount r.

For zero mortality

$$V = yr^{-1}$$

Due to mortality, V is always less than this value. Values of V, obtained from tables for the valuation of life interests[20], are shown in Fig. 1 for male lives. The figures for females are approximately equal to those for males five years younger. The average value for males, obtained by multiplying the value at each age by the number of men in the UK at that age[16], is also shown. The average value for females is not greatly different since at any age the life expectancy of females is greater but there is a larger proportion of older women.

Taking $r = 6\%$ pa then from Fig. 1 the average present value of a male life is equal to the value of 12.9 years.

If the value of a life is £50 000 then the value y of a year is £50 000/12.9 = £3880, which is about £10 a day. If $r = 0$ then the value of a year is £1310, which is £3.60 a day.

Future risks can be discounted to the extent that people are willing to take immediate risks (eg a medical operation) to avoid greater risks at a future date. The rate of discount is equivalent to a rate of interest and would also reflect the fact that people tend to value the earlier years of their lives more highly than the later years. Alternatively, future risks can be discounted since the money required to reduce them can be obtained by investing a smaller sum beforehand.

ANNUAL LOSS DUE TO FATALITIES

About 7319 people per annum are killed in road accidents[13] and 819 in fires[21]. Taking the average discounted values of life, in Table 3, the loss as a result of these deaths is 7319 x £45 428 = £332m pa for road accidents and 819 x £41 244 = £34m pa for fire.

COMPARISON WITH OTHER METHODS

Values of life have been obtained previously by calculating discounted future earnings, plus a fixed subjective loss[2], and discounted production net of consumption[1]. For comparison, values of discounted earnings for different age groups are given in Table 2 together with discounted values of life obtained as discussed above from life interest tables, assuming a discount rate of 6% pa and an average value of life of £50 000, which corresponds to an annual value of £3880.

Also shown in Table 2 are the number of deaths due to road accidents[15], fire[21] and all causes[13]. These figures enable the average costs of deaths from different causes to be compared. Values are given in Table 3.

Discounted earnings in Table 2 were calculated following Dawson[1] assuming the same rate of discount (6% pa) and expectation of working life but average earnings of £1360 pa for men[2], which is 42 per cent higher than the value taken in reference 1. Average earnings assumed for women are those from reference 1 increased by the same proportion. Average earnings are likely to depend on age and social class. In particular, motorists are likely to have higher incomes than average while fire casualties tend to be poorer than average[22].

Victims of accidents, in particular fire fatalities, tend to be very young or very old. However, Table 3 shows that the average discounted earnings and value of life are only slightly lower for such deaths than for the population as a whole.

The value of life by the discounted earnings method is equal to the discounted earnings plus a fixed subjective sum which has been taken as £5000[2]. The values obtained seem too low to be likely to be acceptable to most people as the value of life. It can be seen that the discounted value of life method gives much higher values.

Schelling[5] has estimated the subjective value of life to be six times the discounted earnings, which gives an average value of 6 x £10 450 = £62 700. This value is in good agreement with estimates obtained in this note.

From Table 3, average earnings discounted at 6% pa are £10 450. Average consumption in the UK (1970) is £560 pa[16] so that, assuming the same rate of discount, discounted consumption is 560/3880 = 0.144 times the discounted values of life. Therefore

Average discounted consumption

= 0.144 x average discounted value of life
= 0.144 x £50 000
= £7200

Average discounted earnings less consumption

= £10 450 - 7200
= £3250

This sum represents the average net economic value of an individual to his family and the rest of society.

It has been suggested that a threshold level of risk should be taken below which risks are acceptable and above which they are not[23]. This theory may be in accordance with the way people sometimes think. However, it makes no allowance for the costs of reducing risks. Moreover, it is not clear what risk should be considered, eg the risk to the individual or the expected number of deaths amongst all those participating in an activity; the risk per unit time from an operation or the average for a process or over the whole day. This note shows that reasonably consistent results can be obtained from the assumption that people perceive risks and balance risks and benefits.

Cownie[24] found that subjects playing an electronic game involving risks adjusted their behaviour to make the risk per go independent of the hazard. However, the game was such that this behaviour is also the optimum obtained by equating marginal risk and benefit.

In the game the participants received a monetary reward in proportion to his score. He could choose the rate of scoring but was subject to a risk of a penalty. This risk increased with the rate of scoring and equalled hi^2 per go, where i was the increment chosen for that go and h depended on the hazard. For each hazard a fixed increment n had to be added to the score. Thus

$$\begin{aligned} \text{number of goes necessary} &= n/i \\ \text{total risk} &= hi^2 \times n/i \\ &= hin \end{aligned}$$

If the value of time spent on each go is v and the expected loss for unit risk is L then

$$\text{total expected cost, } c = Lhin + v\, n/i$$

For minimum cost,

$$\begin{aligned} dc/di &= Lhn - vn/i^2 \\ &= 0 \\ \text{risk per go} &= hi^2 \\ &= v/L \\ &= \text{constant} \end{aligned}$$

Thus the optimum is given by making the risk per go constant.

PERCEIVED RISK

Perceived risk (ie what the risk is believed to be) is important since it determines peoples behaviour and their degree of anxiety. If people feel safe they are more likely to behave dangerously[25]. On the other hand, anxiety is a disbenefit since it decreases peoples happiness. If a risk is overestimated then a person may suffer a loss by foregoing a benefit when he would not otherwise have done.

People probably estimate risks in three ways:

i) assessment of the situation (how dangerous it looks)

ii) knowledge of accidents suffered by others (including statistics and propaganda).

It may be important not only how many deaths occur but whether they occur singly or as a result of rare catastrophes involving many deaths[26]. Catastrophes are likely to have political consequences which an equal number of deaths occurring singly would not have. New safety requirements are often imposed as a result of such events.

iii) personal experience of near misses of accidents. It is possible that people assess not the risk of death or injury but the risk of a near miss or dangerous situation arising. Such events will occur relatively often. People appear to be able to estimate the probability of near misses fairly accurately given sufficient experience of them[24].

The frequency of near accidents in driving is[27] about 0.015 km^{-1}. Thus the average driver doing 15 000 km pa experiences about 225 near misses per year. There is thus ample opportunity to estimate from personal experiences the probability of near misses. Near misses are also likely to be experienced fairly often in other fields, particularly during childhood and when learning new skills. About two-thirds of accidental deaths are due to accidents other than road accidents[13].

The average individual does not personally experience accidents sufficiently often to be able to asses the risk directly. Moreover, it has been found[28] that the proportion of pedestrians who are nervous of traffic differs little between those who have been hurt in road accidents and those who have not.

Since anxiety is a disamenity it would be of interest to investigate the value of reducing anxiety. It may be possible to obtain a value by investigating people's willingness to defer risks for short periods and to bear risks small compared to their total assets.

Estimates of perceived risk can be obtained by comparing the amounts people are willing to spend to avoid different risks[29] or by asking them to rank hazards in order of risks.

CONCLUSIONS

It is suggested that it is possible to value human life by estimating the risks that an individual is willing to take as well as by taking the economic value of an individual's life to society, which will often be comparatively low. The method which should be used depends on the priorities chosen.

Some examples are given of estimates obtained. These are mostly of the order of £50 000. The estimate obtained from people's attitude towards smoking is lower than this figure, which implies that the risk of premature death due to smoking tends to be underestimated.

The results obtained depend very much on the assumptions made. To obtain more accurate estimates refinement and fuller analysis of the available data would be required. It would also be desirable to carry out surveys of attitudes towards risk taking.

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Table 1

Risk of death in different occupations

Occupation	Deaths in 1966 (a)	Employees, thousands (b)	Deaths per million employees
Industrial	413	9 163	45
Construction	288	1 681	171
Mines and quarrying	256	580	441
Railways	102	336	304
Shipping	90	97	928
Farms	115	430	267
Other	186	13 190	14
All	1 450	25 477	57

(a) from reference 19

(b) from reference 13

Table 2

Discounted earnings and value of life for different age groups

Age		Population UK, 1966 thousands	Discounted earnings £	Discounted value of life £	Deaths per annum All 1966	Road 1963	Fire* 1967/8
Males	0-4	2 467	9 928	61 527	12 952	174	81
	5-14	4 110	15 368	61 147	1 807	397	21
	15-39	9 129	19 547	56 912	11 110	2 241	84
	40-64	8 286	11 746	41 531	98 355	1 332	112
	65-79	2 170	1 432	23 452	138 105	667	73
	80+	343	45	11 156	67 428	236	40
Females	0-4	2 342	5 539	62 296	9 554	101	59
	5-14	3 912	8 652	61 907	1 088	137	17
	15-39	8 937	12 086	58 450	6 122	373	49
	40-64	8 828	5 495	45 376	56 420	561	94
	65-79	3 353	374	26 918	114 970	519	117
	80+	777	0	12 695	125 843	184	72

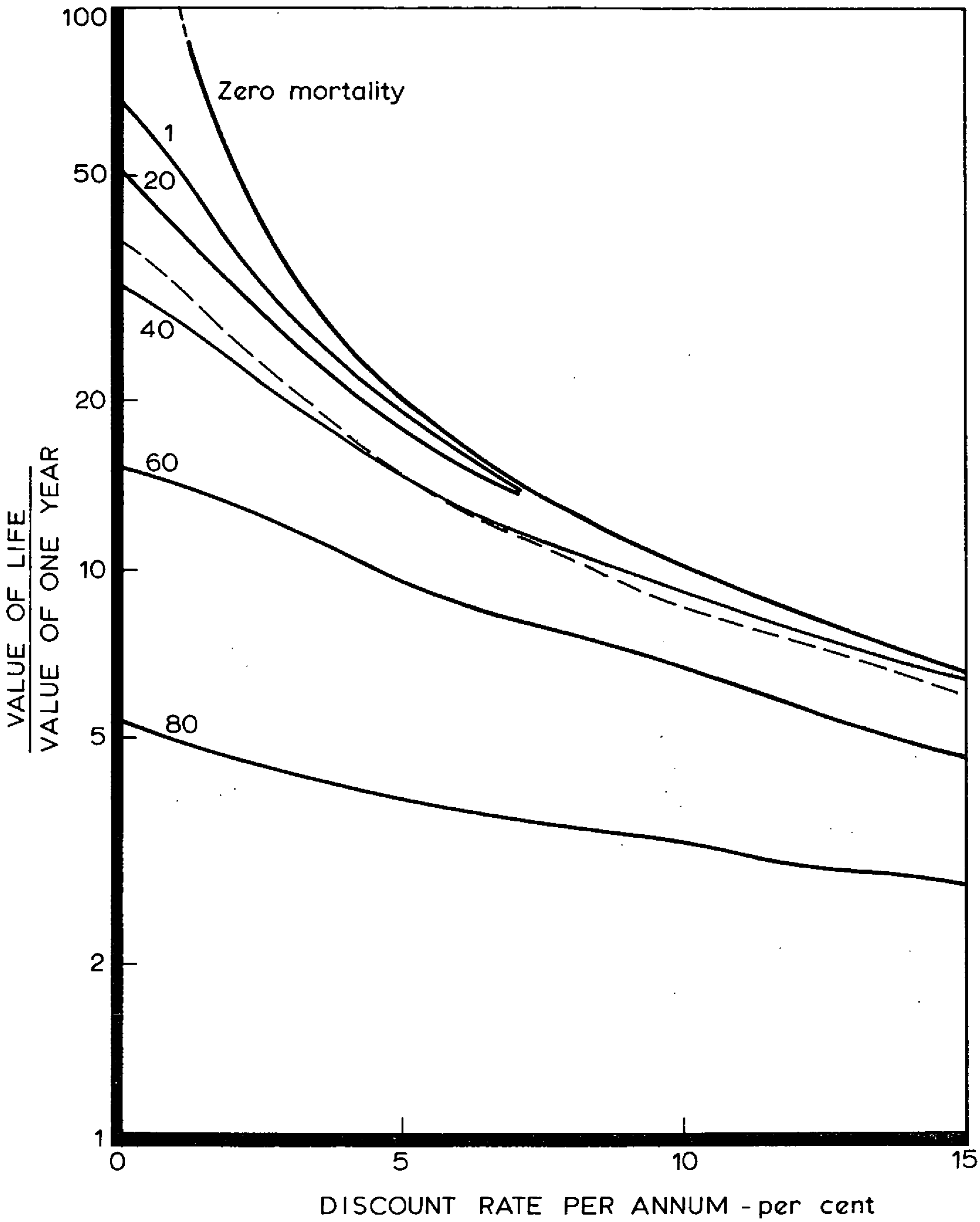
*, ages 0-5, 6-15, ... Unknown ages apportioned.

Where the age groups given in the source data do not correspond with those in this table the data have been apportioned (except last column).

Table 3

Average loss by deaths, per person

	All living	All deaths	Road deaths	Fire deaths
Average discounted value of life, £				
males	49 858	29 458	46 783	43 450
females	50 131	26 347	41 780	39 021
whole population	50 000	27 940	45 428	41 244
Average discounted earnings, £				
males	13 829	5 245	13 522	10 196
females	7 268	1 558	5 082	3 986
whole population	10 450	3 447	11 236	7 103



Numbers on curves are ages in years
Dotted line represents the mean

FIG. 1. PRESENT VALUE OF LIFE VERSUS DISCOUNT RATE, MALES

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