Estimation of social costs of traffic accidents and injuries in New Zealand

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Abstract:

Estimation of social costs of traffic accidents is essential for determining road transport safety programmes. This is discussed in the paper using limited available data in New Zealand and relationships observed between concerned economic factors in overseas studies.

The cost of permanent disability is complex to determine. The paper uses the following two simple approaches: (1) use of a relationship between length of hospitalisation of serious injury victims and their average level of permanent disability to determine the average loss of life quality due to permanent disability and (2) value the social cost as 'value of life quality lost' due to the disability.

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Introduction

Estimation of social costs generated by traffic accidents is an essential element in the decision making process of road transport safety programmes. Estimates of social costs indicate the need for appropriate measures for saving these costs and provide the basis for benefit-cost analysis of a project. Problems in measurement of certain components of social costs cause significant limitations to efficient decision making. Estimation of social costs of death, injuries, impairments and permanent disabilities, though very important, is unreliable in many cases because of either over-simplification or non-consideration of certain components.

In land transport investment decisions, improvement of efficiency of the road network and provision of safety measures are two important factors. Optimality of the resource allocation clearly depends on the weights assigned to them. These two factors are strongly influenced by the values of time and safety respectively. If the value assigned to time, for example, is inappropriately high in comparison with those assigned to costs of death and permanent disabilities, investment decisions are likely to be biased in favour of expansion of the road network and against safety measures where these two functions compete for funding. The costs of death and permanent disabilities on one hand and the cost of time on the other can be inappropriately high or low due to either measurement errors or methodologies followed. This paper concentrates on the valuation of safety.

Permanent disabilities cause loss of quality of life. Certain disabilities not only limit physical functioning of the victim but also cause pain and suffering throughout the rest of the victim's life. The health status in some cases is even considered worse than death.

The Land Transport Division of the Ministry of Transport, in association with Transit New Zealand sponsored a "willingness to pay" survey to estimate value of statistical life. The survey has been carried out by an Australian Firm; Ampt Applied Research over the period: October 1989 - February 1990. The data are being analysed. The value currently used in benefit-cost analysis of road investment projects in New Zealand is generally considered low. The present paper, therefore, uses preliminary results of this survey in estimating social costs.

An objective of the present paper is to develop a methodology and estimate social costs of traffic accidents in New Zealand using the available information.

The paper is divided into six sections. The first section provides the introduction. The structure of the social costs estimated in the paper is discussed in the second section. The third section discusses briefly the current debate on estimation of value of life and presents preliminary results of the "willingness to pay" survey. The fourth section discusses the estimation method used for social costs of permanent disabilities. The estimates of social costs of traffic accidents and injuries are presented in the fifth section and the sixth section draws conclusions from the study.

Cost structure

Social costs are the opportunity costs of resources required as a result of accidents, i.e, resources which could be used elsewhere in the economy if accidents did not occur. These also include costs of resources which are lost as a result of these accidents. These are costs borne by society as a whole, irrespective of who actually incurs them. Social costs of accidents and injuries can be broadly divided into six categories. These are:

1. Medical treatment
   - Emergency / pre-hospital medical treatment
   - hospitalisation or other initial medical treatment
   - follow-on treatment
2. Property damage
3. Legal system
   - traffic enforcement
   - court system
4. Loss of output due to temporary incapacitation
5. Permanent disability and fatality
6. Pain and suffering

The first category includes costs of all resources required to provide medical treatment to accident victims. Depending on the severity of injury, resources are used in three phases. Emergency medical treatment is required by most injury victims. Further treatment in a hospital or by a medical practitioner outside the hospital system is required in more severe injury cases. Some accident victims require continuation of medical treatment after discharge from hospital. These are termed above as follow-on treatment.

The second category is the damage to vehicles and other properties resulting from accidents.

The third category comprises resource costs imposed on the legal system by traffic accidents. Traffic enforcement constitutes the major part in this category. It also includes costs of resources used by the court system.

Some accident victims are only temporarily incapacitated and then go back to normal life. In such cases, the loss of output is the output that would otherwise be produced by the person. In case of fatal injury, the social cost is much higher than the loss of potential output. It includes both tangible and intangible costs. The social cost of pain and suffering experienced by the victim and his/her loved ones may itself outweigh the loss of output. This aspect is further discussed later while addressing the issue of valuing statistical life.

The cost of permanent disability also has similar implications. There are three common measures of social costs of permanent disability as listed by Steadman and Brian (1988):

(a) the compensation awarded by the court
(b) the implicit value of life in public sector decisions and

(c) the loss of production capacity.

The first category suffers from two major limitations, as noted by Kind, Rosser and Williams (1982): (i) it does not consider the out of court settlements and (ii) the judge could be influenced by the economic circumstances of the plaintiff. The main problem with the second category is that implicit values from public sector decisions are not always consistent. It should also be noted that society treats the life of an identified person differently from a statistical life and that influences public sector decisions. As Linnerooth (1982) notes, a mountain climber stranded in a blizzard gets priority over a future possible cancer death. As further observed by Atkins (1981, p 10) the implicit value method "reflects some lack of consumer preference orientation", and is, therefore, not justified by social optimization criteria. The third category does not include the costs of pain and suffering.

Emphasis has been placed, considering these aspects, on the loss of quality of life. It is the composite product of loss of output, pain and suffering and loss of enjoyment in life. The loss of quality of life is first estimated as a percent of normal i.e, unimpaired quality of life. Then it is valued at the same proportion of the value of statistical life society considers for one hundred percent loss of life quality.

The social costs of pain and suffering are implicit in the valuation of life and hence permanent disability. Pain and suffering caused by minor injuries have not been considered here primarily because of measurement problems.

Value of life

While a reduction in physical risk i.e, an improved level of safety is always welcome, it can be achieved, as noted by Jones-Lee (1989, p 1), only "at the cost of a curtailment in some of the other desirable ways in which society might make use of its scarce resources". Furthermore, decisions in allocating resources between alternatives may involve exchanges of economic goods and human lives. "The necessity of such decisions suggests that even in 'matters of life and death' there must be a logic of choice and thus a theory of 'pricing the priceless'" (Bergstrom, 1982, p 3). Thus even though only a few may disagree with Broome (1978) that life is priceless and cannot be valued by a finite amount of money, a statistical measure is needed to determine the value of risk changes.

The two commonly used approaches to estimating value of life are: human capital approach and willingness to pay approach. In the first case, the social value of human life is estimated from a person's earning ability or the net contribution to society and in the second case from the person's willingness to pay to reduce the risk level. Jones-Lee (1989, p 9) observes that "the appropriate definition of the cost or value in any context will ultimately be determined by the *objectives* being pursued by whoever is concerned with the cost or value". He relates these two approaches to two broad sets of objectives: the human capital approach to output maximization

and willingness to pay approach to social welfare maximization.

Human capital approach

The human capital approach values a human life by the value of net output produced by the person. It is the discounted present value of output produced by the person less the discounted present value of consumption during the lifetime of the person. The output is measured either by age specific net average earnings over a life cycle or by per capita GNP. A variation from this is by Dawson (1971) who advocates that the value of preventing a fatal accident is the gross output that would otherwise be lost. Since the person is alive and enjoying from consumption, Dawson argues, it should not be deducted from the benefit of preventing the accident. A limitation of this view according to Jones-Lee (1976) is that it is coherent with GNP maximization but does not lead to potential Pareto improvement. The main argument in favour of the human capital approach is that "it is actuarial: it uses full age specific accounting to evaluate changes in mortality" (Arthur 1981, p 54). Arthur criticises it on the grounds that the human capital approach ignores the individual's own desire to live, a view supported by Jones-Lee (1989). The net output approach is strongly criticised by Jones-Lee (1989, p 10) on the ground that "it will treat the death of anyone past retirement age as a negative cost (i.e, as a benefit) to the rest of society - a conclusion that is understandably repugnant to the majority of people".

Willingness to pay approach

The second approach to estimating the value of life appears to have originated from Dreze (1962), (noted by Jones-Lee, 1989) and developed later by Schelling (1968) and Mishan (1971). In this approach the value of statistical life is derived from the amount of money an individual is willing to exchange for a reduction in risks to life. Deriving from maximization of a social welfare function (sum of individual utility of wealth functions in society) Jones-Lee (1989, p 16) concludes that "under a wide range of conditions the value of statistical life is given by the population mean (or possibly by a weighted average) of individual marginal rates of substitution of wealth for probability of death". The most commonly used method of determining willingness to pay is compensating variation observed in the market place or in a hypothetical market generated through surveys.

The first one is known as the revealed preference method in which implicit values are determined from the observed trade-off between risk and wealth/income. Implicit values of compensating variation has been estimated by many researchers, from the labour market, use of smoke detectors, use of seat belts, speed, accident and gasoline price relationships, etc. Blomquist (1982) provides a survey of these empirical studies. For the purposes of illustration, let us look at the estimation from the labour market. Different jobs are associated with different levels of risks and

the remunerations are also different. It is assumed in these studies that "by accepting a premium for extra risk individuals implicitly reveal information about their values of life" (Blomquist, 1982, p 28). Without getting into details, it can be pointed out that information on safety, in most circumstances, is far from complete and the associated uncertainties are not always objectively valued. Due to uncertainties particularly with low risk activities, the risk itself may be underestimated. Besides, the attitude toward risk varies between individuals. Another important factor, we must keep in mind, is that wage differentials are the results of demand and supply in particular market segments. The relative values of different job characteristics change over time and since comparison is made between jobs which differ not only in safety levels but also in other characteristics, observed compensating variation may be time specific. Over time, the demand for labour in activities with different risk levels changes. Similarly the supply depends on the general economic conditions. Unless these complexities are taken care of by econometric analyses, the errors in estimation may be quite high. It is not surprising that compensating variations observed in different fields vary quite widely as observed in the surveys of Jones-Lee (1976) and Blomquist (1982).

In the stated preference method marginal rates of substitution for probability of risk are estimated from survey responses. This method asks individuals to express their willingness to pay for a 'small' reduction in risk or accept compensation for a 'small' increase in risk. The marginal rate of substitution of wealth for risk is then determined by dividing the amount offered or compensation accepted by the difference in probabilities of risk. A major advantage of the questionnaire method is that "this approach is capable of generating estimates of marginal rates of substitution (together with data concerning factors such as age, income, etc., that are likely to affect the latter) for particular individuals whereas the revealed preference approach provides information only at a far more highly aggregated level - market equilibrium wage premia for risk, for example" Jones-Lee et al (1985, p 51). A major limitation of this method is that estimates are based on choices in hypothetical situations and not situations faced by respondents in real life.

The New Zealand survey

A "willingness to pay" survey has just been completed in New Zealand. The questionnaire was designed to provide estimates of marginal rates of substitution of wealth for time and for risks of death, injury and accident in general and marginal rates of substitution of risk of death for risk of injury and permanent disability. The survey was carried out in conjunction with a travel exposure survey which included questions on socio-economic characteristics of the respondent as well as their exposure to risks. A sample of 973 adults was chosen for the "willingness to pay" survey. The survey included one question on risk reduction for

the individual and two questions on risk reduction for all members of the household.

A complete analysis of the survey data is not available at the time of writing this paper. However, a preliminary analysis indicates that the value of statistical life in New Zealand estimated from the average of marginal rates of substitution of wealth for probability of risk of death ranges between \$0.8 million and \$2 million. Since the final estimate is not yet available, a value of \$1 million has been used in this analysis for demonstrating the cost estimation method used in the paper. Though the survey questionnaire included questions on trade-off between serious injury and death and also between death and permanent disability, these have not been used in the estimation of costs. This is due to the fact that the questions were very specific and did not cover the whole range of serious injuries and permanent disabilities resulting from these injuries.

Valuation of costs of permanent disability

Following the classification used in the traffic accident report of the New Zealand Ministry of Transport, injuries are grouped into three categories: minor, serious and fatal. Fatal injury is one where the victim dies within 30 days from the date of accident. All other injuries requiring hospitalisation are described as serious and other injuries as minor. In the present context, only serious injuries are considered with an assumption that minor injuries do not lead to permanent disability. The categorisation is based on the worst injury suffered the victim. A serious injury victim may have more than one injury, some of which are minor. Thus the number of serious injury is the same as the number of serious injury victims. The cost per injury victim is referred here as the cost per serious injury.

Permanent disability not only causes limitations on the functioning ability of the person, it imposes costs to society in terms of loss of output, resources required for improving the functional ability under the circumstances, dependence on others and in some cases additional pain and suffering experienced by the person and their relatives and friends. As noted by Calhoun and Miller (1988), there are certain disabilities which are as bad as death to the person or in some cases even worse than death. Because of these limitations, the impact on the person and the social welfare can be considerably high. Calhoun and Miller further observe that permanent disabilities have "implications for the age-profile of consumption, production and mortality", in addition to individual loss of utility.

It is generally observed that more severely injured victims tend to require longer period of hospitalisation. Though at any length of hospitalisation it is only logical to expect a wide variation in the level of permanent disability of patients, a strong relationship is observed between these two variables at average levels. This has been shown by the author in a separate paper (Guria, 1990). The level of

disability is described here in terms of percent loss of quality of life as determined by Bull (1985) following ratings of the American Medical Association. The relationship is based on data provided by Bull (1985). It is then applied on intervals of length of hospitalisation in New Zealand data to determine the average level of permanent disability.

The value of statistical life includes costs of pain and suffering, desire to live and enjoyment of life in addition to the contribution made by the person to society. A loss in quality of life indicates a reduction in all or most of these aspects. With this understanding, the social cost of permanent disability is measured here in terms of the "value of life" lost as a result of permanent disability.

Cost estimates

Relative cost structures observed elsewhere, viz. Australia and the USA have been used in situations where appropriate New Zealand data are not available. It is assumed that the probability of their being considerably different in New Zealand is low. The cost estimates are based on accidents and injuries in 1988 and are expressed in June 1989 prices.

An accident is categorised as fatal, serious or minor depending on the worst injury caused by the accident. Costs have been estimated per accident and per injury. Except in case of property damage only accidents, the costs are estimated first by injury severity. Fatal accidents produce fatal as well as serious and minor injuries. Similarly, serious injury accidents produce serious and minor injuries. Minor injury accidents produce only minor injuries. For each category of accident the total cost of all injuries are estimated. It is then divided by the total number of accidents of that category to get the average cost per accident.

Medical treatment

The estimate of average cost of hospital treatment per serious injury is based on the total cost of hospital services and the number of in-patient days. The average costs per out-patient and per day-patient are considered as 10% and 40% respectively of the average cost per in-patient day. [This relative cost structure is based on information obtained in discussions with staff of the National Health Statistics and the Wellington Hospital Board.] This approach provides an estimate of the average cost per hospital day at $326.38 for the year 1988 in June 1989 prices. All other costs of medical treatment are estimated relative to these costs.

The average cost of hospitalisation per serious injury (i.e, serious injury victim), with an average duration of 10.5 days per injury observed during 1988, is estimated at $3427. A study in the USA by the National Highway Traffic Safety

Administration (NHTSA)(1983) indicates that the average cost of hospitalisation of fatal and minor injuries are 40.5% and 1.4% respectively of the average cost per serious injury. Accordingly the average cost per fatal and minor injuries are estimated at $1388 and $49 respectively. Averaging these costs over the number of accidents of each category indicates that the average costs of hospital and other medical treatments per accident are $3,283, $4,047 and $65 for fatal, serious and minor injury accidents respectively. [For other costs only the average cost per accident are mentioned here.]

Table 1: Cost per injury relative to cost per serious injury (%)

Item	Fatal	Minor
* Medical		
Emergency / Pre-hospital	270.0	0.6
Hospitalisation	40.5	1.4
Follow-on treatment		2.4
** Property damage	184.0	86.0
** Legal system	786.0	50.0

* Based on National Highway Traffic Safety Administration (1983)

** Based on Atkins (1981)

The average cost of emergency services: medical treatment, ambulance services etc. has been assumed to be 5% of the average cost of hospital treatments for serious injuries based on a study by Fairhall and Fahey (1983). Adjustments have been made, on the basis of overseas study results, for minor and fatal injuries, as they are very likely to differ from those of serious injuries. The relative cost structure is given in table 1. Estimates of the average cost of emergency / pre-hospital treatment per accident are $668, $253 and $135 for the three types of accidents.

The NHTSA (1983) study suggests that the average cost of follow-on treatments is about 49% of the average cost of hospitalisation per serious injury. Based on this and the relative cost structure mentioned in table 1, the average costs of follow-on treatment are estimated at $823, $1,991 and $53 for the three types of accidents. These are costs of medical treatment after the initial hospitalisation or the initial medical treatment outside the hospital system. There is obviously no follow-on treatment for fatal injuries. However, fatal accidents i.e, accidents resulting in at least one fatality, also produce serious and minor injuries, some of which require follow-on treatments.

Property damage

Property damage is a major component of social costs of accidents. The only study in this area in New Zealand is by Murray-North Partners (1983). It provides information on property damage costs for injury and non-injury accidents, but not by injury severities. These have been estimated here using relative cost structure observed in overseas studies (table 1), as in the case of medical treatment costs. The estimates of average cost of property damage are $5,996, $4,135, $3,556 and $1,551 per accident respectively for fatal, serious, minor and property damage only accidents.

Legal system cost

Two major components of legal system costs are costs of time spent by traffic officers and the court system. Three categories of costs of traffic officers' time have been considered for social costs of accidents. These are times spent by them at courts and bureaus, accident investigation and alcohol and drug control. The first and the third activities are not necessarily caused by accidents A part of these activities are for accident prevention. Considering that these programmes would not be required if accidents did not occur, it was thought to be appropriate to assign the total cost of time spent on accident investigation and prevention activities to social cost of accidents.

Costs of court time have been estimated from number of court hours spent on traffic cases and average cost per hour of running the district courts. The costs have then been apportioned between injury severities based on overseas studies (table 1). The average legal system costs are estimated at $4,135, $589, $275 and $29 per accident for fatal, serious, minor and property damage only accidents respectively.

Loss of output due to temporary incapacitation

Temporary incapacitation occurs while undergoing medical treatment. The loss of output during the period is estimated here from the average gross incomes of people affected by serious injuries. This is assumed to be equivalent to the loss of output during the period. The National Health Statistics data include age-sex distribution of serious injury victims. From these data and income distribution by age and sex during 1988, the average income of all serious injury victims has been determined. Assuming that the age, sex distribution of fatal and minor injury victims would, more or less, be the same as that for serious injuries, the same average loss of output per day of incapacitation has been used for these injuries as well The estimates of loss of output are $263, $469 and $163 for fatal, serious and minor accidents respectively.

Loss of life / permanent disability

The distribution of average level of permanent disability by length of hospitalisation obtained from the relationship observed between the two variables (Guria, 1990) is given in table 2. This suggests that the average cost of permanent disability suffered from serious injuries is $15,000, at a value of statistical life = $1,000,000. Since fatal accidents include fatalities and serious injuries and serious injury accidents include more than one serious injury in some cases, the average cost per fatal and serious injury accident are estimated as $1,173854 and $17,455 respectively. This is due to the fact that in majority cases, the level of disability is small and only in few cases it is almost equivalent to loss of life. The situations worse than death could not be included due to data limitations. Since frequency of their occurrence is low, it is unlikely to affect the average considerably.

Table 2: Estimates of average disability

Length of hospitalisation (days)	Average Disability (%)
0 - 7	0.58
8 - 14	1.41
15 - 30	2.68
31 - 60	5.21
61 - 120	10.16
121 or over	15.61
Weighted Average	1.50

Total cost

The total unit cost per accident estimated as above are $1,188,983, $28,855, $4,223 and $1,580 for fatal, serious, minor and property damage only accidents respectively. At these costs, the total social cost of traffic accidents in 1988 at June 1989 prices would be $742 million, $201 million, $107 million and $426 million for fatal, serious, minor and property damage only accidents, with a overall total of $1,476 million.

Conclusions

The paper provides estimates of social costs of traffic accidents in New Zealand based on available data and relevant information from overseas which appear to be good proxies for those currently not available. So far as overseas information are concerned, the paper uses only the relative cost structure.

The social costs of permanent disability are complex to determine. The paper uses the following two simple approaches: (1) use of a relationship between length

of hospitalisation of serious injury victims and their average level of permanent disability to determine the average loss of life quality due to permanent disability and (2) value the social cost due to permanent disability as the 'value of life quality lost' due to the disability.

The value of statistical life used in the estimation process is a rough figure based on a preliminary analysis of the willingness to pay survey data. This is a crucial factor in estimating the social cost of fatal and serious injury accidents. If for example, the value of statistical life were $500,000, the social cost in these two categories for the year 1988 would be $376 million and $140 million respectively and the total cost would be $1,047 million.

It is expected that the value of statistical life used in benefit cost studies in New Zealand will be revised soon based on the 'willingness to pay' survey results.

The total cost of property damage accounts for a large proportion of the total social cost. At the value of statistical life = $1,000,000, the cost of property damage is 37% of the total social cost. It is extremely important that this cost is properly estimated. Currently, a study is being carried out to determine the feasibility of carrying out a detailed study on cost of property damage only accidents. A data collection procedure is also being planned for property damage costs for injury accidents.

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References

Arthur, W B (1981) The economics of risks to life, *American Economic Review*, 71(1), pp 54-64

Atkins, A S (1981) *The Economic and Social Costs of Road Accidents in Australia*, Office of Road Safety, Department of Transport, Australia

Bergstrom, T C (1982) When is a man's life worth more than his human capital? pp 3-27 of Jones-Lee, M W (ed.) *The Value of Life and Safety*, Amsterdam: North Holland Publishing Company

Blomquist, G (1982) Uncertainty in welfare economics, and the value of life, pp 201-216 of Jones-Lee, M W (ed.) *The Value of Life and Safety,* Amsterdam: North Holland Publishing Company

Broome, J (1978) Trying to value a life, *Journal of Public Economics*, 9, pp 91-100

Calhoun, C and Miller, T (1988) So you don't want a broken leg: how much will you pay? *Presented at the TIMS/ORSA joint meeting, Washington D.C.*

Dawson, R F F (1971) *Current Costs of Road Accidents in Great Britain*, London: Road Research Laboratory, Department of Environment

Dreze, J H (1962) L'utilite sociale d'une vie humaine, *Revue Francaise de Recherche Operationelle*, 22, pp 139-155

Guria, J C (1990) Length of hospitalisation - an indicator of social costs of disabilities from traffic injuries, *Accident Analysis and Prevention*, 21(4), forthcoming

Jones-Lee, M W (1976) *The Value of Life: An Economic Analysis*, London: Martin Robertson

Jones-Lee, M W (1989) *The Economics of Safety and Physical Risk*, New York: Basil Blackwell

Kind, P, Rosser, R and Williams A (1982) Valuation of quality of life: some psychometric evidence, pp 159-170 of Jones-Lee, M W (ed.) *The Value of Life and Safety,* Amsterdam: North Holland Publishing Company

Linnerooth, J (1982) Murdering statistical lives....?, pp 229-261 of Jones-Lee, M W (ed.), *The Value of Life and Safety*, Amsterdam: North Holland Publishing Company

Mishan, E J (1971) Evaluation of life and limb: a theoretical approach, *Journal of Political Economy*, 79, pp 687-705

Murray-North Partners Ltd. (1983, redraft 1984) *Property Damage Costs of Road Accidents*, a draft report to the Administrative Committee of the Road Research Unit, New Zealand

National Highway Traffic Safety Administration (1983) The Economic Cost to Society of Motor Vehicle Accidents, U.S. Department of Transportation, DOT HS 806 342

Schelling, T C (1968) The life you save may be your own, pp 127-162 of Chase, SB (ed.), *Problems in Public Expenditure Analysis*, Washington, D.C: Brookings

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Steadman, L A and Bryan, R J (1988) *Cost of Road Accidents in Australia* (Occasional Paper 91), Bureau of Transport Communications and Economics, Canberra: Australian Government Publishing Service