ADB-ASEAN Regional Road Safety Program

Accident Costing Report: AC 8

The Cost of Road Traffic Accidents in Singapore

ADB

asean

Asian Development Bank-Association of Southeast Asian Nations Regional Road Safety Program

Accident Costing Report AC 8: Singapore

Regional Project Team

C. Melhuish, Asian Development Bank project officer
A. Ross, road safety adviser and project leader
M. Goodge, road safety specialist

Singapore In-country Team

C. Hoong-Chor, Asian Development Bank in-country consultant
E. Tan, member of in-country team

ACKNOWLEDGMENT

This report was prepared according to the methodology provided by the Asian Development Bank-Association of Southeast Asian Nations regional team and under its periodic guidance and advice. In preparing this report, the authors also drew on the resources of several organizations that provided valuable information and support, as well as encouragement. The authors would like to acknowledge the support of the following organizations: General Insurance Association of Singapore, KK Women's and Children's Hospital, Land Transport Authority, Ministry of Health, Ministry of Transport, National University of Singapore, and Traffic Police of Singapore.

ABBREVIATIONS

ADB	Asian Development Bank
LTA	Land Transportation Authority
RTA	road traffic accident

NOTE

In this report, "$" refers to US dollars.

CONTENTS

1 INTRODUCTION

1.1 General

Among transportation accidents, road accidents generally received less public attention. Road accidents tend to be less dramatic because they contribute casualties in ones and twos, compared to, for example, air transport accidents, which occur much less frequently but usually result in more deaths. Consequently, the large-scale economic and social impact of road accidents may not be fully appreciated. Where estimates are available, accident costs are found to be very considerable. For example, the total cost per fatal road accident was estimated at ₤983,710 (at 1996 prices) in the United Kingdom (Department of Environment, Transport and the Regions, 1999 and US$977,000 (at 2000 prices) in the United States (Blincoe et al 2002).

However, information regarding the costs of road accidents is important if governments are to accord equitable priority in resource allocation for accident prevention programs. In many European countries, detailed cost evaluations of road accidents are made periodically (Department of Environment, Transport and the Regions, 1999; Putignano et al 1999; Peter Bacon & Associates 1999 Groeger 1998). The United States and Canada have also used various approaches to estimate road accident costs (Blincoe et al 2002; Insurance Corporation of British Columbia, 1995), while Australia and New Zealand have established similar costing analyses to facilitate their decision-making process for investments in traffic safety countermeasures (Bureau of Transport and Regional Economics 1992; Elvik 1999).

Some Asian countries, including Viet Nam and Nepal, have also undertaken similar accident cost analyses (Trawen et al 2000 Jacobs et al 2000). Interestingly, even though one of the most developed countries in Asia, Singapore has not published accident cost values for such purposes. An evaluation of accident costs was undertaken by the Land Transport Authority (LTA) as part of an update of economic and planning parameters used in the strategic transport model (Scott et al 2001). The accident costs are primarily used for the purposes of strategic planning and performing cost-benefit analyses of major projects exceeding S$20 million.

The often cited reason for nonuse of accident costs for ranking remedial safety interventions is that insufficient data are available to allow a proper assessment. Yet, ironically, the very absence of such an assessment results in the magnitude of economic losses not being fully appreciated by decision makers. As a consequence, resources have not been allocated for improvements of road safety, and huge annual economic losses continue to drain national resources.

1.2 Motivation

The desire to reduce road traffic injuries or fatalities is usually humanitarian in nature. For this reason, an argument could be made for not waiting until an accident occurs or a fatality is registered before taking some preventive measures. However, highway authorities are commonly unwilling to be persuaded by such an argument and adopt a reactive approach to solving road safety-related problems. The usual reasons for adopting this approach are that safety measures can be costly, and, where competing needs for funding exist, devoting resources to safety-related expenditures can be less readily justifiable. Even within the highway and transportation sector, where funding is available, allocating these funds for road building and development projects is often easier than allocating funds for schemes to enhance safety on roads, especially since building and development projects can result in immediate congestion reduction and are therefore politically attractive.

Another strong motivation to improve road safety is financial. In line with this, by considering the massive financial resources that are consumed because of accidents, accident prevention measures can be justified as investments. This has been the approach adopted in many developed and developing countries where the economic value of preventing accidents can be considerable.

Following this approach, any safety improvement scheme to be adopted on highways can then be evaluated on the basis of cost-benefit analyses. Systematic procedures to select the best or most cost-effective schemes can then be put in place. While this may appear to be straightforward, many obstacles can make this goal rather difficult to attain in practice.

A closer look shows that before a quantitative analysis can be applied to evaluate a specific road safety improvement scheme, valuations must be derived. Support data on costs are seldom available because they are either not systematically captured or are poorly recorded. The effort to establish accurate cost figures can be such a significant task that few agencies are willing to invest time and resources to pursue this exercise.

It appears then that an important initial step needed to convince national authorities to accord road safety a higher ranking at the national resource planning level is to demonstrate the huge losses incurred annually to the Singapore economy as a result of road accidents. In the longer term, resources need to be devoted to building a suitable database for cost estimation.

Fortunately, for this purpose, the level of accuracy in estimating these initial cost figures need not be too precise. In other words, what is needed for a start is to estimate the approximate scale of the cost of accidents, rather than obtaining a precise cost. Such less precise estimates can be used to get some idea of the magnitude of the losses, which will suffice until more precise estimates are available. This is the focus of this report.

1.3 Objective and Scope of Study

The objective of this study is to prepare an initial approximation of the costs of different types of road accidents and use that to estimate the scale of annual economic losses being borne by Singapore as a result of road accidents.

For the purpose of this report, the year of study is 2001, from which accident data and cost figures are to be computed.

1.4 Outline of Report

The report is divided into five chapters. Chapter 2 identifies the commonly available methods of traffic accident costing and outlines the different approaches involved. Chapter 3 presents the cost components, together with a computation of the estimates in the Singapore context. Chapter 4 extends the cost computations to the national level. Chapter 5 summarizes the findings. Appendixes supplement and support the findings presented in the report.

2 METHODOLOGY

2.1 Introduction

The valuation of accidents is controversial because life is too important to be valued simply in monetary terms. When given the choice of trading their lives for a sum of money or incurring added expenses to acquire safety devices or some inconvenience to ensure an acceptable level of personal safety on roads, most people would choose to spend money or be inconvenienced.

The cost of accidents may consist of two components, often regarded as the cold-blooded material cost and the warm-blooded willingness-to-pay component. Material costs may include damage to property, charges related to administration, fees for medical services, charges for hospitalization, and loss of productive work.

The problem with determining accident costs is obtaining accurate relevant data for computation. The desire and the resulting willingness to pay the economic cost of reducing the risk are likely to be much higher than the material cost resulting from accidents. That explains why most developed countries adopt an ex ante method of estimation. However, considerable difficulties are involved in estimating the willingness-to-pay component.

Estimating the cost of traffic accidents involves two important steps: (i) identifying the cost components and (ii) placing a monetary value on each of these components. The direct costs include medical and rehabilitation expenses incurred by the injured and replacement and repair costs due to property damage and other expenses (e.g., transportation costs). However, in economic assessments and insurance claims, costs arising from loss of earnings by those affected as well as compensation for pain and suffering are often included. Indirect costs are also associated with maintaining emergency and other essential services. Furthermore, there may be other social costs, including those related to congestion and delays arising from accidents or even the perpetuation or increase of poverty among low-income families whose top wage earners are killed or permanently disabled.

2.2 Available Methods

Placing a value on each of the cost component may not be straightforward, as this depends on not only the availability of data but also the manner in which the estimates are derived. The costs can be estimated in several ways. Hills and Jones-Lee (1983) and Jacobs (1995) have discussed the six methods for evaluating the cost of fatal accidents. These are the gross output method, net output method, life insurance method, court award method, implicit public sector valuation method, and willingness-to-pay method.

The gross output or human capital method is based on the assessment of economic consequences, usually supplemented by a notional sum, to reflect the pain, grief, and suffering of victims and their family members. In contrast, the net output method deducts the future consumption of individuals killed in accidents, reflecting a more conservative economic cost to society. The life insurance method measures the valuation of risk associated with road usage and is determined by the life insurance premiums drivers are willing to pay. The court award method is based on the actual compensation settlements awarded, which may be influenced by the degree of negligence found. In the implicit public sector valuation method, a set of implicit values are used to value human lives. The willingness-to-pay method estimates the amount of money people affected would pay to avoid an accident.

Considerable overlaps are found in the different methods, but the derived values are also substantially different. Based on the objective of reducing accidents, articulated in the form of either a call to maximize national output or social welfare, two methods (i.e., the willingness-to-pay method or the gross output method) are most appropriate. The approaches adopted in the two methods are different. The first is to adopt an ex ante approach, which attempts to estimate the true costs by considering what a person would do to avoid being involved in an accident. The second is the ex post approach, which estimates the true costs based on historical data of costs incurred following accidents.

Willingness-to-Pay Method. The ex ante approach involves some assessment of risk and the willingness of individuals to commit resources to reduce this risk to an acceptable level. This trade-off between risk and economic resources, measured in terms of the marginal rate of substitution of wealth for risk of death or injury, gives rise to the concept of willingness to pay in accident cost analysis. Willingness to pay to avoid a lost statistical life is affected by the context effects, which are the perceived seriousness of an accident and the scale effects (i.e., the number of casualties the accident will involve). That being the case, the willingness-to-pay approach appears to be more concerned with reducing the risk for the entire population than saving a specific life.

Under this approach, the cost components or the willingness-to-pay values are assessed for three parties: (i) the individual road user facing the risk of accident; (ii) the family, relatives, and friends of the individual exposed to the risk; and (iii) the rest of society affected by the risk exposure.

The willingness-to-pay approach is conceptually appealing but has practical problems when being applied to developing countries, because of incomplete or inaccurate data. In determining the values, three types of information are needed: accident or casualty risk, risk elasticity, and valuation (economic). First, accident or casualty risk is assessed by considering individual transport modes, vehicle types, and road user categories. This is done by stratifying accidents or casualties into several categories of injury severity. Second, risk elasticity is assessed, and this describes the changes in risk in relation to other road users and is often measured in terms of probability per million vehicle-kilometers of travel. Obtaining the elasticity values for different casualty types and vehicle types is necessary but extremely difficult. This being the case, the value of statistical life is determined by combining the willingness-to-pay values with other cost components, such as gross production losses and health costs, administration costs, and property damage, as well the as the subjective pure human value.

Human Capital Method. In contrast to the willingness-to-pay method is the ex post approach, also known as the gross output or human capital method. The main component in this approach is the discounted present value of a victim's future income forgone due to premature death. Added to the present value are market costs, such as medical costs, administration costs, and property damage costs, and nonmarket output. This approach has disadvantages as it focuses only on the output effects and does not account for the value and enjoyment of life forgone. This approach grossly underestimates the true costs of accidents and will produce significantly lower values than any ex ante estimate. As a partial correction for this shortcoming, a life component involving pain, grief, and suffering is often added. Although this increases the value derived, it still results in a valuation that is generally much lower than values derived from the willingness-to-pay method.

Although a few of the more developed countries have moved toward willingness-to-pay approaches, the human capital method is very common in many countries where extensive surveys to obtain perceived risks of different groups of individuals are difficult or impossible to conduct. One appealing aspect of using the human capital method is that the cost estimates derived are conservative. Furthermore, where accident databases may not be well integrated, so that cost estimates cannot be made with a high degree of precision, the human capital method will suffice. In comparing the ex ante and ex post approaches, Robinson (1986) argued that the latter is more reliable and internally consistent and has a strong theoretical foundation. This is the method recommended by the Asian Development Bank (ADB) for use in the ADB-Association of Southeast Asian Nations regional project, and the method used in this report.

Indeed, various methods of costing are built on very diverse premises and thus result in vastly different cost figures. The choice of method depends on the purpose of the costing exercise. In developing a suitable methodology to estimate road accident costs for the purpose of maximizing national output as well as social benefits, Jacobs et al. (1995) evaluated these methods and proposed that only the gross output and willingness-to-pay methods are most appropriate. The willingness-to-pay method is considered the better approach for conventional cost-benefit analyses and the most efficient way of allocating scarce financial resources. However, where relevant data to produce reliable willingness-to-pay estimates may be lacking, Jacobs et al. (1995) recommended the gross output method. In this study, to estimate the cost of road accidents in Singapore, the more conservative gross output method was adopted. This method, which is recommended by ADB for the Association of Southeast Asian Nations region for the present, is outlined in a recent research report (Babtie Ross & Silcock and Transport Research Laboratory, 2003).

2.3 Gross Output Method

The basis of the gross output method is the concept of a statistical life whose value is considered to be the output that an individual can produce over the period of his or her productive life (Giles 1999). Based on this argument, the cost of an accident will then be the loss of output or the output forgone by the economy as a result of an accident. In general, the productivity of any casualty is assumed to be equal to the average in the economy. The overall cost to the national economy is then the accumulated lost output obtained.

This approach views each person as a unique and valuable economic entity. The main strength is that this approach provides an objective means of arriving at an estimate. Data values are generally measurable, and the method is also useful in providing an estimate of the cost to society of a casualty over and above the private cost.

However, the methodology ignores the value of leisure and only considers work performed. As a result, it places no value on the emotional content of life. Hence, the methodology generally produces estimates well below those obtained by other means (Peter Bacon & Associates 1999). Supplementing the estimates with a component of subjective costs, including pain, grief, and suffering, is possible.

The conservative approach is recommended, because this ensures an indisputable minimum value obtained for road accident costs in a country. The argument is that if the investment can be justified on the basis of such a minimum value, it will certainly be justified on the basis of any other value (ADB 1997).

The cost components in the gross output method can be divided into two categories: those involving current resources that are consumed or diverted because of accidents and those resulting from loss of future output. In the latter, the loss of output may be due to absence from work resulting from medical leave or reduction of potential productive output arising from long-term or permanent disabilities and deaths. The former includes costs associated with medical services and rehabilitation treatment; reported damage to property; and administrative, professional, and emergency services.

For this study, the analysis was made for 2001, and all data and considerations are consistent for that year. As tracing the cost incurred in every accident record is impossible, the cost assessment is done on an aggregated scale, typically according to the classification of accident severity.

In Singapore, accidents are classified into four severity categories: fatal, serious injury, slight injury, and property damage only. These categories are examined in Box 1.

To ascertain the correct cost values, the cost components are evaluated in two groups: casualty-related (in which the unit cost is for each casualty) and accident-related (in which the unit cost is for each accident). Costs due to lost output and medical expenses, as well as pain, grief, and suffering, are associated with each casualty involved in the accident, while property damage and administration costs are more likely to be accident-related.

Box 1: Definitions of Accidents

A **fatal casualty** in a road accident is one in which the victim dies within 30 days of the accident.

A **seriously injured casualty** is one who has suffered injuries such as fractures or a concussion and/or internal lesions, crushed body parts or organs, severe cuts, or severe general shock requiring medical treatment or hospitalization that prevents the person from performing ordinary tasks for at least 7 days.

A **slightly injured casualty** is one who is transported to a hospital from the scene in an ambulance or, otherwise, one who requires subsequent medical treatment entailing hospitalization and medical leave of no less than 3 days.

Accidents are assigned to a severity group according to the most seriously affected casualty in the accident. All reported accidents not involving injuries are classified as property damage only accidents.

Once the unit cost for different categories of accidents is determined, the total national accident cost can be computed, based on the known number of classified accident counts. Since this computation makes use only of reported accident counts, it is usual also to consider, though difficult to account for, cases of unreported accidents. This will require the degree of underreporting to be established.

3 COST COMPONENTS

3.1 Introduction

The human capital method involves determining five cost components: property damage, administration costs, costs of medical treatment, output lost, and human costs. For most purposes, computing these from aggregate values obtained from summarized reports is sufficient.

3.2 Damage to Property

Damage to property can be obtained from insurance companies based on property damage claims for motor vehicle accidents. Property damage costs can vary considerably, depending on the degree of wreckage sustained. Obtaining estimates based on accidents stratified according to severity may therefore be necessary. To further improve the aggregate measure, specific surveys may be conducted among fleet operators or motor vehicle workshops for different categories of vehicles, although these surveys may not include nonvehicle damage. Another problem is the disparity between the definitions of accident severity. For most purposes, accident severity is measured in terms of injuries sustained, but for property damage, severity is based on the degree of wreckage. While there may be some correlation between injury sustained and wreckage caused, the relationship is not always proportional. For example, in a pedestrian accident, the vehicle may have little or no vehicle damage but the injury sustained can be extremely serious.

Singapore Estimates. Almost all accidents result in some damage to the vehicles involved, and, in some cases, damage to public infrastructure, such as lampposts, guardrails, traffic signs, and road surface. The associated costs will include repairs and replacement of vehicle parts and infrastructure elements. Costs associated with property damage may also include car rental charges during the period the damaged vehicles are out of service.

The estimate of property damage can be ascertained through insurance records. However, practical difficulties exist in obtaining comprehensive figures. First, not all properties are insurable and hence may not be reflected in insurance claims. Second, numerous unreported accidents occur, for which no insurance claims were made. These claims usually involve small amounts. Third, the amount of damage to property can vary considerably from one accident to another, and this may not be correlated well with the degree of injury sustained in an accident. Therefore, assigning different property damage costs for the different severity classes of accidents is difficult.

Using statistics from the General Insurance Association of Singapore, the total compensation for property damage from traffic accidents amounted to S$253.7 million. This works out to an average claim of S$2,853.58 per accident for property damage. While the damage is somewhat correlated with injury severity, the available data prevents computing property damage by severity category. Nevertheless, using the same cost distribution among the different categories of injury severity, as used by the Transport Research Laboratory (Babtie Ross & Silcock and Transport Research Laboratory 2003), the average costs of property damage for a fatal accident is S$8,364, while that of serious and slight injury accidents are respectively S$5,476 and S$4,480. Where no injuries are involved, the average damage cost is S$2,701.

3.3 Administrative Costs

The presence of traffic accidents in the system necessitates the devotion of resources for accident prevention and safety promotion, as well as following up on accident cases. This incurs administrative costs consumed by a number of entities, including traffic police, emergency response services, and insurance and legal service providers.

In most cases, these entities do not only handle road accidents, and the expenditures may not be grouped neatly enough to allow a correct evaluation of the administrative cost of managing road safety objectives. For example, besides attending to road accidents, traffic police officers also perform traffic control duties that may also involve ensuring safe traffic movements. In some instances, administrative costs associated with activities linked directly or indirectly to accident occurrences may be well defined. An example of this is the accident investigation unit of the traffic police, which maintains its own accounts.

In any accident, the associated administrative costs are likely to depend on severity. In a more serious accident, vehicles may remain on the road longer, and more police officers may be deployed for traffic control. The process of investigation, claim, and follow up will also be longer and more complicated, potentially with drawn out legal proceedings. All these imply a higher administrative cost. Assigning different cost values for various categories of accidents is therefore necessary. Apportioning costs in this way can be difficult, unless detailed records are maintained (e.g., hours spent on duty for each case). Obtaining precise values is difficult, but perhaps such efforts may not be necessary, since the contribution of administrative costs to overall accident costs is generally low. As argued before, this cost is likely to be underestimated, so again the final computed accident cost is a conservative one. In apportioning the distribution of administrative costs to the different classes of accidents, the ratios recommended by the Transport Research Laboratory (Babtie Ross & Silcock and Transport Research Laboratory 2003) are used.

Singapore Estimates. Using statistics from the General Insurance Association of Singapore, the cost of administration associated with motor insurance amounted to S$75.20 million in 2001. The average estimated cost of deploying an ambulance for a road accident was S$302.00, making a total ambulance cost of just under S$1.01 million in 2001. Furthermore, traffic police estimated that the cost of administration for managing safety-related work was S$6.50 million in 2001. These add up to an annual administrative cost of almost S$82.71 million.

The annual administrative costs are apportioned to the different categories of casualties, according to the recommended cost distribution for fatal, serious injury, slight injury, and damage only accidents of 50:1, 8:1, 5:1, and 1:1, respectively. The administrative cost of a fatal accident is S$32,683, while that of a serious injury accident is S$5,229. In an accident involving slight injuries, the administrative cost is S$3,268. A damage only accident incurs an administrative cost of S$654.

3.4 Medical Costs

Medical costs resulting from accidents cover a large number of items associated with the medical attention disbursed. First, victims may be given first aid and treatment and incur costs associated with ambulance service. In the more serious cases, victims require hospital treatment and emergency services and may require further nonhospital and outpatient treatment. Where a victim is hospitalized, the costs will increase, due to hospital occupancy charges and the need for inpatient medical care, surgeon and specialist services, nurse and sometimes follow-up care, and outpatient services. There may also be costs associated with the use of aids and appliances to facilitate patient movement and rehabilitation. When an accident victim dies instantly at the accident scene or shortly after the accident, the medical cost is usually lower. However, those that die after admission to a hospital will incur costs associated with emergency and intensive care services, including special room charges and medication.

Singapore Estimates. Medical costs vary widely, depending on the nature and severity of injuries, which are translated into duration of hospitalization and rehabilitation. Different classes of hospitals and wards offering services to accident victims also exist. Some hospitals handle specific cases. For example, the KK Women's and Children's Hospital treats only children and women victims. For the purpose of the analysis, the Singapore General Hospital, being the largest public hospital and handling all types of accident treatment, was approached to provide information on the direct cost of medical services offered for road traffic accident (RTA) victims. As no official data on the cost of treating RTA patients are recorded, a survey of RTA patients seen in March 2001 was undertaken by Singapore General Hospital staff members. In this, various costs were itemized according to the three classes of victims treated.

For fatal cases, the number of days in the hospital before death and the associated costs for performed operations; medical checkups; and specialized treatment, such as X rays, were noted. In the case of seriously injured victims, information gathered included the itemized costs incurred at the Accident and Emergency Department, the number of days of hospitalization, the number of medical checkups and specialized treatments needed, and the estimated charges. Other information related to outpatient treatment, including number of follow-up appointments within the year, duration of medical leave granted, and patient earning rates was obtained. For slightly injured victims, the itemized costs at the Accident and Emergency Department, the duration of medical leave granted, the number of follow-up appointments, and the associated charges were recorded.

Based on the consolidated computations, medical costs per fatality amounted to S$12,760, while medical costs per seriously injured casualty and slightly injured casualty were S$30,668 and S$4,656, respectively.

3.5 Lost Output

Lost output relates to the potential loss to the national economy because of productive time lost from an accident. Time for productive activities is lost because of delays at the accident scene and when drivers must send vehicles to workshops. Where casualties are a factor, time is lost when casualties receive medical attention in hospitals or outpatient centers. In more serious cases, time losses occur when casualties undergo follow-up treatment and/or rehabilitation and possibly attend court proceedings. For cases involving long-term or permanent disabilities or fatalities, substantial losses of productive years can occur. This last component constitutes the greatest contribution to accident costs.

Delays at an accident scene affect other road users more than the parties involved in the accident. In general, estimating congestion costs is difficult, since congestion effects depend on traffic flow on an affected road and may be influenced by location and time of day. The costs computed based on the period of congestion and the extent to which this affected other road users may not be readily available. Consequently, when estimating lost output, congestion effects are at times excluded.

The time casualties spend consulting with doctors, staying in hospitals, and remaining on medical leave can be obtained from patients' records. While identifying the source of this information is easy, extracting the information may not be as simple, largely because the databases are generally designed for medical reference, rather than safety studies. Also, in cases involving serious injuries, records on the extended loss of productive days may not be as well documented.

To complete the calculation of lost output, the value of productive time must be considered. This can be done by considering the wage rates of the victims. The wage rates are dependent on the occupations of the casualties and very likely their ages as well. Hospitals often capture such data, but, in the absence of such information, the average wage rate can be used.

In many instances, productive loss not only affects the casualty but also the voluntary caregivers, who may be relatives of the casualty. This loss is seldom captured, since the total amount of time lost and the wage rate cannot be easily ascertained. This problem is particularly acute when the victims are children, since they suffer no productivity loss but may impose economic losses on their caregivers. Accounting for this can be difficult.

In the case of a fatality, the lost productivity is the number of years of productive work forgone due to premature death. The extent of productive life lost depends on the age of the casualty, the potential retirement age, and the wage rate. The age distribution of accident casualties is generally well captured in the traffic police database. The potential retirement age may vary but is sufficient to assume a single common and acceptable retirement age.

The wage rate needed to compute the lost output from premature death plays an important part in the overall cost assessment. From the individual standpoint, the annual wage rate is dependent on the age of the victim and also grows dynamically with time. Taken over the population, the annual wage rate varies across professions and age. While adopting a distribution of annual wages is possible, adopting a single annual wage rate is generally acceptable, and this is usually taken from the average national annual wage rate. An alternative to using the annual wage rate is to use the value of per capita gross domestic product. The wage rate and gross domestic product value are key economic indicators and are readily available.

The estimate of lost output usually takes into account the expected increase in wage values accomplished (e.g., by applying a growth factor based on the anticipated percent of gross domestic product growth). The future lost output is then expressed in present values by applying a discount rate. Naturally, the choice of the gross domestic product growth rate and the discount rate will significantly affect the final computed value of lost output.

Singapore Estimates. In computing the economic rate of productivity for fatalities, no weight is given to the different types of individuals involved, except for the consideration of their age. An average value is assumed (i.e., all victims are assumed as average workers capable of an economic production measured by the average wage rate). This simple formulation obviates the often-raised problem of associating the economic value of life and injury with attributes such as race, profession, and wealth. However, it does not deal with the objection of reducing life and its quality to just an economic value; an issue that if dealt with will make economic evaluation impossible. For injured victims, the lost output is computed based on the average wage rate of patients obtained from the survey sampled at the Singapore General Hospital.

From the age distribution of fatal accident victims in 2001 (Table 1), the average age of fatal accident victims is 39.3 years.

Table 1: Age Distribution of Fatal Casualties

Age	Distribution of Fatalities (%)
< 15	2.82
15–20	11.30
20–25	19.21
25–30	12.43
30–35	3.95
35–40	6.78
40–45	7.91
45–50	5.65
50–55	3.95
55–60	3.39
60–65	5.08
> 65	27.51

< = less than, > = greater than.
Source: Singapore data

The average loss of productive years is computed based on a retirement age of 65. The age of 65 is chosen because at this age a significant number of individuals are still economically active and employable. For example, in a June 2002 labor force survey, a total of 33,357 people who were 65 years of age or older were employed and another 1,260 in the same group were actively seeking employment (Ministry of Manpower, 2003). The average number of years forgone by fatal casualties is 25.7 years.

Wage rates in Singapore fluctuated significantly in recent years because of the economic downturn (Table 2). Given the uncertainty, projecting growth in wages is difficult. A conservative estimate would be to assume that the discount rate is similar to the growth in the wage rate.

Table 2: Average Wage Rates

Year	Nominal Average Wage Rates (S$)
1992	1,804
1993	1,918
1994	2,086
1995	2,219
1996	2,347
1997	2,480
1998	2,740
1999	2,813
2000	3,063
2001	3,134
2002	3,158

Source: Singapore data.

Using the average wage rate of S$3,134 per month, or S$37,608 per annum, the lost output for an average fatal casualty was found to be S$967,822 at 2001 prices. Based on the lost output due to medical leave granted and the period of incapacity due to injuries sustained, as well as the average wage rate sampled, the average lost output for a seriously injured victim is S$22,565, while that of a slightly injured victim is S$715.

3.6 Human Costs

The ex post method of accident costing makes use of data relating to accidents that have occurred. This method is often criticized for its consistent underestimation of the true costs of accidents, because it fails to capture the intangible desire to enjoy life and avoid risk. To correct this, the human capital method incorporates a component of human costs. This is often termed pain, grief, and suffering.

Peter Bacon & Associates (1999) showed that victims and their family members suffer from psychological deterioration following accidents. The computation of cost-benefit analysis in many countries usually includes a social cost component. And, for accidents, a notional value of pain, grief, and suffering is often included, to reflect an aversion to death shared by societies and individuals.

The cost associated with pain, grief, and suffering is, by virtue of its character, rather subjective. This includes the physical and mental suffering of victims and their relatives and friends. Trauma and damage to the quality of life can be included. Research undertaken to estimate this cost has involved correlating this cost component to resource costs, which can be objectively measured.

While many attempts have been made to quantify and valuate the pain, grief, and suffering experienced by affected parties, there appears to be no single rigorous method that is well accepted. A higher value of human costs implies a greater willingness of society to prevent an accident from occurring. As the method of valuation is a rather subjective one, the assigned quantum will be more likely to be based on a political decision than an economic analysis. For example, in the United Kingdom, the proportion of human costs to the overall costs has fluctuated considerably with each era of political and social change. The values also vary considerably from one country to another, even among developed nations.

Given this property that the value is subject to political influence, the valuation method has also been considered to serve the objective of poverty reduction. Thus, it has been applied in less-developed countries to account for the inability of the poor or more vulnerable to cope with the aftermath of accidents. Babtie Ross & Silcock and Transport Research Laboratory (2003) listed a number of case studies to illustrate the drastic financial consequences for the poor who are involved in road accidents. Box 2 examines why the poor are more likely to be involved in accidents.

Given the lack of a rigorous method of objective assessment, the difficulty in placing an appropriate value on pain, grief, and suffering is overcome by making use of benchmark values established elsewhere. The values adopted by the Transport Research Laboratory appear to be quite widely accepted and reflect the percentage of human costs to overall accident cost for an injury accident. The values are as follows:

(i) 28% of total costs for a fatal accident,
(ii) 50% of total costs for a serious injury accident, and
(iii) 8% of total costs for a slight injury accident.

Singapore Estimates. Currently, little if any work is done in Singapore to establish a reliable estimate of pain, grief, and suffering associated with road accidents. To circumvent this lack of information, the correlation estimates adopted in the United Kingdom (Jacobs 1995) are assumed. In this, the cost of pain and suffering for each fatality is assumed to equate to 38% of the resource cost associated with a death from a traffic accident. In the case of a seriously injured victim, the pain and suffering is equivalent to 100% of the corresponding resource cost of a person with a serious

Box 2: Road Accidents in Developing Countries

In developed countries, the poor are known to be at greater risk to crashes. For example, the United Kingdom Road Safety Strategy acknowledges how children in the lowest economic stratum are five to six times more likely to be killed or seriously injured than those in the highest stratum. It has been long suspected the same applies to developing countries, as the poor will have limited, if any, transport mode choice, and they will be less able to protect or distance themselves from the exposure to traffic. Both their homes and work place are assumed to be physically closer to the threat of crashes.

Sources: Babtie Ross & Silcock and Transport Research Laboratory (2003).

injury, while for a slightly injured casualty, this is assumed to be 8% of the associated resource cost.

Table 3: Summary of Costs per Casualty and per Accident (S$)

Item	Fatal	Serious Injury	Slight Injury	Property Damage Only
A. Per Casualty 1. Lost Output	967,822	22,565	715	—
2. Medical Costs	12,760	30,668	4,656	—
3. Pain, Grief, Suffering	388,219	63,939	1,050	—
Total	**1,368,800**	**117,171**	**6,420**	**0**
B. Per Accident 1. Administrative Cost	32,683	5,229	3,268	654
2. Property Damage	8,364	5,476	4,480	2,701
Total	**41,047**	**10,705**	**7,748**	**3,355**

— = no data available.
Source: Singapore Data.

Based on these computations, the costs attributed to pain, grief, and suffering is S$388,219 for each fatality, S$63,938 for each seriously injured victim, and S$1,050 for each slightly injured casualty.

3.7 Aggregate Cost

The individual cost components in each accident and casualty category are summarized in Table 3. If the crude estimates of pain, grief, and suffering are included in the computation, the human costs total about S$1.37 million for a fatal casualty, S$117,000.00 for a seriously injured casualty, and S$6,400.00 for a slightly injured casualty. Even where the pain, grief, and suffering are to be excluded, the cost of a fatality will be S$0.98 million.

Computed based on accident occurrence, the total noninjury costs will be about S$41,047 for a fatal accident and S$10,705 per accident involving serious injuries. If accidents involve slight or no injuries, noninjury costs will be almost S$7,748 and S$3,355, respectively.

Table 4: Casualty Rates per Accident (2001)

Casualties / Accident Category	Fatal	Serious Injury	Slight Injury
Fatal Accident	1.04	0.13	0.36
Serious Injury	—	2.17	0.67
Slight Injury	—	—	1.27

Note: Figures were rounded.
Source: Singapore Data.

Most accidents involve multiple casualties. Because of this, the casualty rates per accident must be established when computing the cost on a per accident basis. Table 4 gives the 2001 casualty rates for each class of accident. Taking into account multiple casualties in an injury accident, the average cost was S$1.48 million per fatal accident, S$269,500.00 per serious injury accident, S$15,900.00 per slight injury accident, and S$3,400.00 per property damage only accident.

It is worth noting that in an earlier LTA study designed to update the parameters of the strategic transport model (Scott, et al 2001), the cost of a fatal accident, without considering the human cost, was S$627,005, based on 2001 accident statistics. Several reasons exist for the lower estimate. While minor differences exist in the approach and computation details, the main difference lies in the choice of the discount and growth rates. LTA adopted a discount rate of 6.0% and a growth rate of 2.5%, while this study assumes equal discount and growth rates. LTA values are also based on lower medical costs (e.g., S$1,853 for a fatal accident).

4 NATIONAL ROAD ACCIDENT COSTS

4.1 Introduction

Once the costs of individual accidents by severity and casualty are established, determining the total national cost of accidents by aggregating all individual accident costs is possible. While this may appear straightforward, several difficulties relate to the accuracy and quality of accident data.

4.2 Quality of Data

Insurance data constitute one of the richest sources of data for the evaluation of costs of accidents. However, limitations exist in the use of such data.

Normally, insurance companies assess costs based on several categories (i.e., actual loss of earnings due to injury, direct medical and rehabilitation costs incurred or imminent, actual compensation for pain and suffering, direct losses due to damage to property, and any other direct costs that arise). Many of these costs can give direct insights into the economic costs of accidents. The approach in assessing the loss of earning is however different from that of the human capital method. Loss of income in the insurance database is based on the wage rates of the affected individuals, whereas in the human capital method, an aggregate value is employed (e.g., the national average wage rate or per capita gross national product).

Problems are also associated with an ill-defined time frame. While gross outputs require a well-defined time period of usually 1 year, say 2002, and consequently give a spot-time measurement, insurance claims necessarily span over a period that depends on the complexity of the claims. Therefore, using insurance data on a fixed calendar year is biased, since total claims are likely to increase over time. Problems can also result from unclear case definitions. For example, in Singapore, the General Insurance Association merely collates information on claims but does not follow up on details. Moreover, insurers may submit records of claims in different ways. For example, a claim may be based on a particular casualty or may be insured by an insurer but regarded as an accident case involving several people insured by another insurer. Such discrepancies may result in a distorted average claim value.

Deductibles or excess has a very strong effect on the number of reported accidents. Therefore, many small claims are unlikely to be captured, and there appears to be little empirical study to determine the scale of such accidents. One insurance source suggests that claims are not filed for about 5% of accidents. Nevertheless, when these accidents are not reported, the administrative burdens on insurers may be relieved. Given the absence of these accidents in the computation, the true cost of accidents thus computed will likely be underestimated.

In cases involving minor injuries, the involved parties may also seek medical treatment without reporting accidents to the police. The greater the injury severity, the greater the likelihood of an accident being documented, either by hospitals or the traffic police. In some less developed countries, the level of underreporting to the police can be particularly high, even among fatal cases. The consequence of this is that there can be great disparity between the accident data kept by the traffic police and the data kept by other sources, such as hospitals.

Besides the problem of underreporting, incorrect recording is a problem. Maintaining a reliable database is almost always difficult. Coding and data entry mistakes will always be present, especially for those data items that are less crucial, such as if a casualty was a passenger in the front or rear of a vehicle. Data quality depends on the design structure of the database as well as the training and ability of those responsible for data entry. Some amount of quality control is assured for those data items that are considered important for follow-up actions. That being the case, hospital staff members may pay more attention to entering injury details than to entering the details related to what actually caused an accident, while insurance agencies may be more careful recording data related to what happened before an accident occurred. Data might also be missing, either because these were not recorded at the accident scene or because some information can only be known at a later stage (e.g., the severity of the injury). Consequently, entries can be incorrect, incomplete, or missing.

In the extreme, incorrect recording involves ignoring some recorded cases because they are irrelevant to the function of a particular organization. For example, few organizations will be interested in capturing data purely for recording purposes. In line with this, a minor injury may be captured in the medical record database but may not be attributed as a road traffic accident.

The degree of underreporting will affect the computation of the national accident costs. As the amount of underreporting is unlikely to be properly accounted for, the cost values will then be underestimated.

To ascertain the quality of the traffic accident data and estimate the level of underreporting associated with injury accidents, a survey was conducted to compare the medical records at the KK Children's and Women's Hospital with the data records maintained by the traffic police. The results appear in Appendix 1, and the survey is further examined in Appendix 2.

The study shows that while the underreporting of traffic injury cases to the traffic police may be apparent, the situation is not as serious as in many countries. About half of the unreported cases are those that the traffic police would not consider traffic accidents, even though they occurred within the wider vicinity of the road environment. For the other half, which can be considered traffic accidents, only minor injuries were sustained, and these injuries were caused by conflicting vehicle movements on roads that resulted in no or only minor collisions.

4.3 Computation of National Costs

Using the unit cost values of the individual components shown in Table 3 and the number of accidents that have occurred, the overall national accident costs can be computed.

In 2001, 186 fatal accidents occurred, and these resulted in 194 fatalities. In addition, 302 accidents involving serious injuries and 6,603 accidents involving slight injuries occurred. Nearly 82,000 damage only accidents were reported. As shown in Table 5, the total cost of traffic accidents occurring in 2001 was S$699.36 million, of which about 40% were attributable to damage only accidents, and an almost similar proportion were attributable to fatal accidents.

Table 5: National Cost of Accidents

Accident Type	Overall Costs ($$ million)
Fatal	273.18
Serious Injury	43.07
Slight Injury	108.70
Property Damage Only	274.40
Total	**699.36**

Note: Figures were rounded.
Source: Singapore data.

Based on a 2001 gross domestic product value of S$152.1 billion, the cost of accidents was about 0.46% of the gross domestic product. This percentage appears low when compared with many international estimates (Trawen et al 2000), particularly estimates involving more developed countries. However, the individual cost components are comparable with those of developed countries.

5 CONCLUSION

In comparison with other countries in the region, Singapore has a relatively efficient and safe road network and a good road safety record. However, the accident rates, especially in terms of fatal cases, are still unacceptably high by the standards of developed countries.

This report has shown that the costs of accidents in Singapore are high, even when conservatively estimated. In 2001, the annual costs of accidents amounted to nearly S$0.7 billion, representing nearly 0.5% of the gross domestic product.

Given this high cost, the authorities should invest more in road safety research, to better understand the causes of road accidents, and in road safety programs, to improve the road environment.

Appendix 1 Reported Road Accidents and Other Statistics

The following tables (A1.1–A1.10) provide data related to road accidents in Singapore. Figures A1.1–A1.3 show accident trends.

Table A1.1: Road Accidents Resulting in Injury or Death
(2001 and 2002)

Accident Severity	2001	2002	Difference	
Fatal	186	190	4	2.2%
Serious Injury	302	145	(157)	(52.0%)
Slight Injury	6,603	6,544	(59)	(0.9%)
Total	**7,091**	**6,879**	**(212)**	**(3.0%)**

Table A1.2: Accident Rate per 10,000 Vehicles
(2001 and 2002)

Accident Severity	2001	2002
Fatal	2.6	2.7
Serious Injury	4.3	2.1

Table A1.3: Road Accident Casualties
(2001 and 2002)

Type of Casualty	2001	2002	Difference	
Fatality	194	199	5	2.6%
Seriously Injured	340	172	(168)	(49.4%)
Slightly Injured	8,963	8,900	(63)	(0.7%)
Total	**9,497**	**9,271**	**(226)**	**(2.4%)**

Table A1.4: Casualty Rate per 100,000 People
(2001 and 2002)

Type of Casualty	2001	2002
Killed	4.7	4.8
Seriously Injured	8.2	4.1

Table A1.5: Number of Fatalities by Road User Groups (2001 and 2002)				
Road User Group	**2001**	**2002**	**Difference**	
Motorcyclists and Pillion Riders	88	101	13	14.8%
Automobile Drivers and Passengers	25	21	(4)	(16.0%)
Pedestrians	54	49	(5)	(9.3%)
Pedal Cyclists	12	16	4	33.3%
Others (Including Bus Passengers and Drivers and Heavy and Light Goods Vehicle Drivers and Passengers)	15	12	(3)	(20.0%)

Table A1.6: Number of People Injured in Road Accidents by Road User Group (2001 and 2002)				
Road User Group	**2001**	**2002**	**Difference**	
Motorcyclists and Pillion Riders	4,811	4,637	(174)	(3.6%)
Motorcar Drivers and Passengers	2,233	2,232	(1)	(0.04%)
Pedestrians	870	874	4	(0.5%)
Pedal Cyclists	343	349	6	(1.7%)
Others (Including Bus Passengers and Drivers and Heavy and Light Goods Vehicle Drivers and Passengers)	1,046	980	(66)	6.3%)

Table A1.7: Number of Motorcyclists Involved in Fatal and Injury Accidents by Age Group (2002)		
Age Group	**2002**	**Rate**
Age 30 and Below	2,505	339.3
Age 31–50	1209	65.3
Age 51 and Above	456	55.7

Table A1.8: Number of Motorcyclists Involved in Fatal Accidents by Age Group (2002)		
Age Group	**2002**	**Rate**
Age 30 and Below	63	8.5
Age 31–50	27	1.5
Age 51 and Above	17	0.9

Table A1.9: Number of Motorcyclists Killed in Accidents by Age Group (2002)		
Age Group	**2002**	**Rate**
Age 30 and Below	53	7.2
Age 31–50	21	1.1
Age 51 and Above	16	2.0

Table A1.10: Number of People Arrested for Driving While Intoxicated (2001 and 2002)			
Reported Cases	**2001**	**2002**	**Difference**
Accident Cases	439	342	(97) (22.1%)
Nonaccident Cases	1,452	1,483	31 (2.1%)
Total	1,891	1,825	(66) (3.5%)

Source: Traffic police records.

Figure A1.1: Injury and Fatal Accident Trends

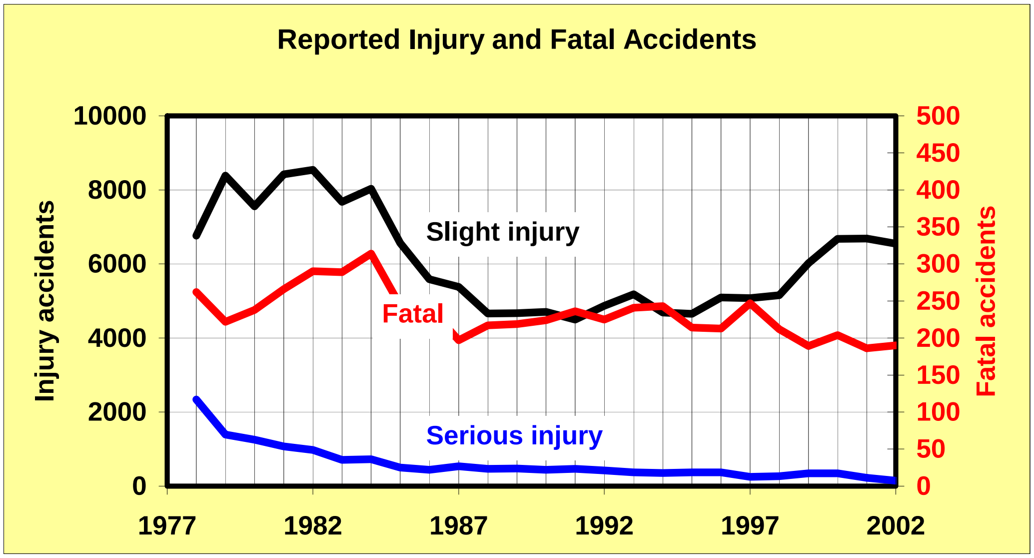


Figure A1.2: Reported Accident Trends

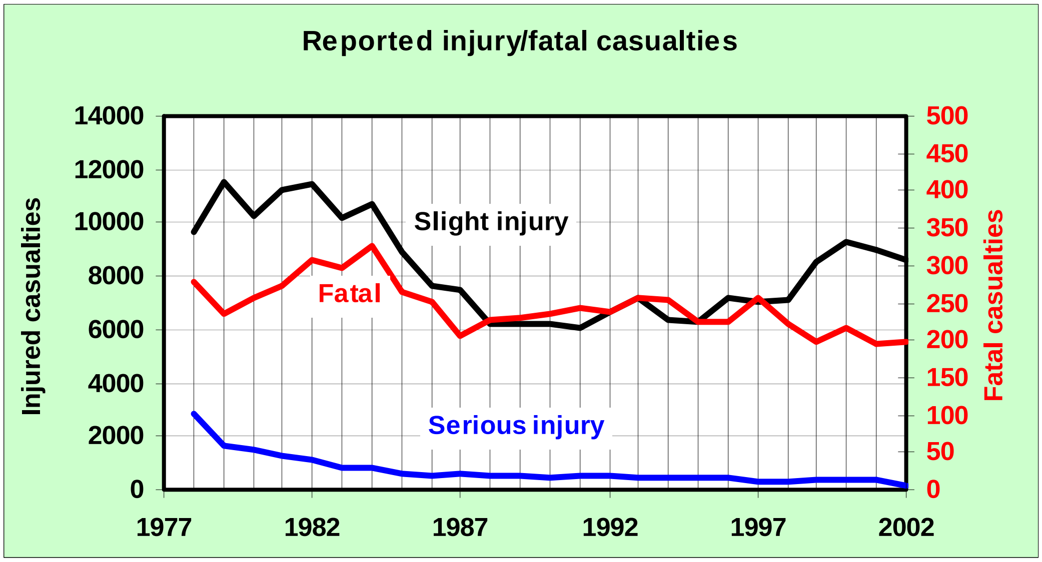
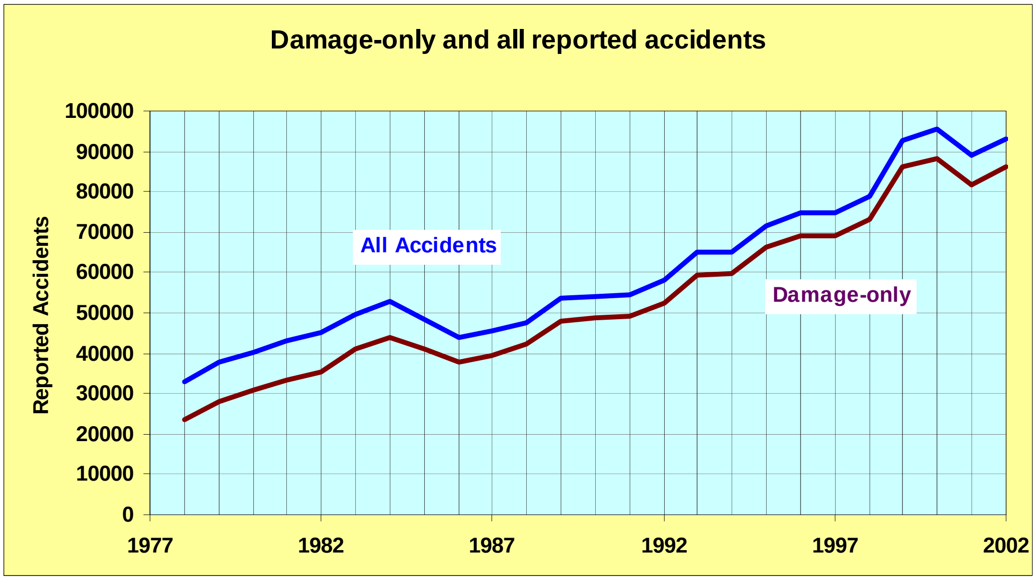


Figure A1.3: Reported Casualty Trends



General and Transport Statistics of Singapore (2002)	
Population and Area	
Land Area	685.4 square kilometers
Population (midyear estimate)	4,171,300
Population Growth	1.8%
Economic Indicators	
Gross Domestic Product	S$155,726.6M
Per Capita Gross Domestic Product	S$37,333
Road Network	
Expressways	150 kilometers
Major Arterial Roads	575 kilometers
Collector Roads	405 kilometers
Local Access	2014 kilometers
Total Road Length	3144 kilometers
Vehicle Population	
Registered Motorcycles	130,287
Registered Cars	426,011
Registered Other Vehicles	148,761
Total Registered Vehicles	705,059
Driver's Licenses	
Motorcyclist Licenses	654,933
Automobile Driver's Licenses	1,202,486
Other Types of Driver's License	209,719
All Licenses (Multiple Licenses Consolidated)	1,247,550

Source: Department of Statistics and police records.

Appendix 2 Sample Survey Comparing Hospital and Traffic Police Records

Introduction

In estimating the national cost of accidents, the traffic police database was used. While all fatal traffic accidents were captured in the traffic police database, there remains uncertainty as to the number of unreported injury accidents. To establish the degree of underreporting of injury accidents as well as possible incorrect recording in the data captured in the traffic police database, a study compared hospital records with traffic police records.

It would be an extremely extensive exercise if all hospital records of traffic accident casualties were cross-checked with traffic police data. Given that there may also be recording errors in both databases, it would be difficult to ascertain the quality of data recording without establishing a satisfactory benchmark. To limit the problems involved, and because the study is a preliminary assessment of the quality of accident data, only a limited sample is used.

Comparative Study

The study involves cases reported to the KK Women's and Children's Hospital, which handles most of the cases involving children. The period of investigation was from January 2002 to July 2002, and the study involved children less than 17 years of age. All cases of road traffic accidents are tracked, with details carefully recorded. These cases were matched with records in the traffic police database. Where records matched, a further check was made to find out how many entry errors were made. For this preliminary study, four fields were examined: the date of the accidents, gender, age, and race of the victim.

During this period, total of 283 road traffic accident cases were admitted to KK Hospital While the traffic police recorded 287 cases of children injured in traffic accidents. Of these, 80 cases were matched. Among those matched, discrepancies occurred in the data entries. Of the 80 cases, 12 had age differences. Another 11 cases had different dates. Two cases had different records of race, and another two had different genders recorded.

Differences in the value of ages recorded arise partly because the hospital uses a resolution of 0.1 year, while the traffic police use a resolution of 1 year. Of the 12 cases of age differences, eight can be attributed to possible misreading of the age, since the two recorded values do not differ by more than 2 years. The other four records are clearly miscoding errors.

Accounting for the differences in the recorded date of injury is more difficult, largely because no clear pattern exists. This may simply mean that these are mistakes made when entering the data. In some cases, the error is obvious (e.g., "01" becomes "02" or the date and month are transposed). In most cases, the difference is not easily distinguishable, and this may be due to poor handwriting or misreading the date.

Apparently, greater accuracy occurs in entering the gender and race fields. This may be because these are single-key entries with a limited number of options.

What is more interesting are the mismatched cases, since these accounted for 203 of 283 cases. This high proportion of mismatches may be largely due to the difference in definitions adopted by the two institutions. The traffic police consider road traffic accidents as those involving vehicles on a road. Cases captured in the traffic police database are those reported by drivers where at least one vehicle is involved. For the hospital cases, road traffic accidents are defined by the locality of the accidents. Reports to the hospital are made for the injured parties who in this study are not drivers. This difference accounts for 129 mismatches. Since any accident in the vicinity of a road may be considered a road traffic accident, there will be numerous cases where no road vehicles are involved. Obvious cases include children hurt after walking into lampposts or children falling into drains. In many instances the accident may not even be near a road, although some type of vehicle is involved (e.g., children falling from bicycles or children falling while skateboarding).

The remaining 74 cases clearly involve road vehicles and may be classified as road accidents. These may represent cases where no traffic police reports are filed. They fall into two categories: pedestrian and passengers, the latter covering private cars, public service vehicles, and commercial vehicles. Most of these involve only very minor injuries.

Twenty-three cases of pedestrian conflicts were recorded, usually while children were crossing or walking along roads. Of these, 10 involved conflicts with cars and four with taxis.

In some of these cases, injuries were sustained when the children took evasive actions, so no contact was made with the vehicles.

Among the 51 cases of those injured while traveling in a vehicle, 28 cases involved passengers in private cars, 10 in buses, and 6 in taxis. Many of these cases do not involve collisions. They involve conflicts in the road environment (e.g., children sustaining injuries after hitting some part of a vehicle after a driver stopped suddenly).

Conclusion

In conclusion, based on the limited survey of accidents involving children, about 46% of the cases in which medical treatment was sought were not the usual traffic accident cases of interest, because vehicles did not collide. Adopting a stricter definition of road traffic accidents, in which injuries are sustained because of conflicts in the road environment, 48% of these accidents are not reported to the police. However, as these do not involve collisions between vehicles, the injuries sustained are minor, and drivers probably do not see the need to make the usual traffic police report, because they would have already made an accident police report at the hospital.

REFERENCES

Asian Development Bank. 1997. *Road Safety Guidelines for Asian and Pacific Region, Regional Initiatives in Road Safety*. Manila.

Babtie Ross Silcock and Transport Research Laboratory. 2003. *Guidelines for Estimating the Cost of Road Crashes in Developing Countries, Final Report, Department for International Development Project R7780.* Transport Research Laboratory. Available: http://www.transport-links.org/transport_links/filearea/publications/1_807_R%207780.PDF

Blincoe, L., A. Seay, E. Zaloshnja, T. Miller, E. Romano, S. Luchter, R. Spicer. 2002. *The Economic Impact of Motor Vehicle Crashes, 2000.* Washington, DC: National Highway Traffic Safety Administration, United States Department of Transportation.

Bureau of the Transport and Regional Economics. 1992. *Road Crash Costs in Australia, Report 102.* Singapore.

Department of Environment, Transport and the Regions. 1999. *Valuation of the Benefits of Prevention of Road Accidents and Casualties, Highway Economics Note No. 1.* Singapore.

Elvik, R. 1999. An Analysis of Official Economic Valuations of Traffic Accident Fatalities in 20 Motorised Countries. *Accident Analysis and Prevention 27 (2): 237-247.*

Giles, M. 1999. Human Capital Theory: An Australian Road Crash Costing Review. Working Paper 99.8 presented at Edith Cowan University, Churchlands.

Groeger, J.A. 1998. *Targeting Traffic Safety: A Perspective on Traffic Safety Initiatives.* Kananaski, Alberta: Missions Impossible.

Hills, P.J., and M.W. Jones-Lee. 1983. The Role of Safety in Highway Investment Appraisal for Developing Countries. *Accident Analysis and Prevention* 15(5): 355-369.

Insurance Corporation of British Columbia. 1995. *The Economic Cost to Society of Motor Vehicle Accidents.* Vancouver.

Jacobs, G., A. Aeron-Thomas, A. Astrop. 2000. *Estimating Global Road Fatalities, Transport Research Laboratory Report 445. Crowthorne, Berkshire: Transport Research Laboratory.*

Jacobs, G. 1995. *Costing Road Accidents in Developing Countries, Overseas Road Note 10.* Crowthorne: Transport Research Laboratory (TRL).

Ministry of Manpower. 2003. *Singapore Yearbook of Manpower Statistics, 2003.* Singapore.

Peter Bacon & Associates Economic Consultants. 1999. *The Study of the Benefits and Costs of the Government Road Safety Strategy 1998-2002.* National Safety Council, Ireland.

Putignano, C., and L. Pennisi. 1999. *Social Costs of Road Accidents (Italian Case Study). International Association of Traffic and Safety Sciences* 24 (2).

Robinson, J.C. 1986. Philosophical Origins of the Economic Valuation of Life. *The Milbank Quarterly 64 (1): 133-155.*

Scott, W., (M) Sdn. B. 2001. *Update of Economic Valuation and Transport Model Parameters, Phase 2 Report Analysis & Results, Contract 3789.* Singapore: Land Transportation Authority.