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Human Capital Approach for road accident costing in an Indian City

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Abstract

The monetization of road crashes helps improve road safety awareness. This study focuses on the cost of Road Traffic Accidents (RTAs) in Ernakulam, a South Indian city, based on the Human Capital (HC) methodology, as it is most effective to estimate the cost of RTAs in developing nations. The loss is calculated from various data sources, including in-depth accident databases (police), questionnaire surveys, private hospital records, and vehicle garage bills considering the collision types. Most of the total costs are attributed to lost productivity, followed by medical expenses, vehicle damage, and human costs. Administrative costs comprise the smallest portion (0.73%) of the overall accident costs. The total cost estimation of RTAs in Ernakulam city for the years 2018 to 2021 is in the range of INR 66,96,04,438 to INR 103,05,12,440, which represents 0.44% to 0.7% of the city's Gross Domestic Product (GDP), which is a non-repairable loss to the nation.

Keywords: Human capital approach, Road accident costs, Lost productivity cost, Medical cost, Vehicle damage cost, Developing countries.

1. Introduction

The tremendous rise in road accidents across the globe in the past few years drives the significance of improving efficient resource allocation towards road safety enhancement. This process requires that the associated costs and benefits be properly quantified. The monetization of accident costs can improve the general attitude towards personal safety. Negative impacts of road transport include the challenging task of valuation of road accidents in addition to environmental and noise pollution and congestion. According to the Global status report on road safety (WHO, 2018), Road Traffic Accidents (RTAs) result in between 20 and 50 million non-fatal injuries and approximately 1.3 million fatalities worldwide annually. Young men under 25 are more prone to road traffic crashes than women of the same age group. Alarmingly, young males in this age group represent 73% of total deaths in road accidents. Higher rates of RTAs are recorded in developing

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economies. Low and middle-income countries contribute to 93 % of total fatalities, even though these countries contribute to only 53% of the total registered vehicles worldwide.

According to a recent study commissioned by the Ministry of Road Transport and Highways (MoRTH), the socioeconomic costs of traffic accidents in India amount to Rs 1,47,114 crore, or 0.77 percent of the Gross Domestic Product (GDP) of the nation (MoRTH, 2019). The same study calculates the crash costs at Rs 5.96 lakh crores, or 3.14 percent of the GDP, taking into account the underreporting issue and crash ratios for MoRTH crash numbers. At the individual level, traffic accident injuries and fatalities place a heavy financial strain on families.

Table 1 shows the accident statistics of Ernakulam, a city in Kerala, India. Even after stringent practices to reduce RTAs and deaths, there is no significant change in the accident rates. Even though the number of accidents decreased in 2021, the deaths from the accidents increased, which needs special attention.

Table 1: Accident statistics – Ernakulam city

Year	*No. of Accidents*	*Deaths*	*Total Injuries*
2018	2411	141	2619
2019	2290	155	2409
2020	1437	101	1507
2021	1781	141	1899

Source: Kerala Police, 2022

Figure 1 illustrates the accident statistics for the years 2018 to 2021 collected from District Crime Records Bureau (DCRB), Kerala Police. It clearly demonstrates the current trend of economic losses due to RTAs, especially grievous injury accidents, in the city of Ernakulam and emphasizes the relevance of this study.

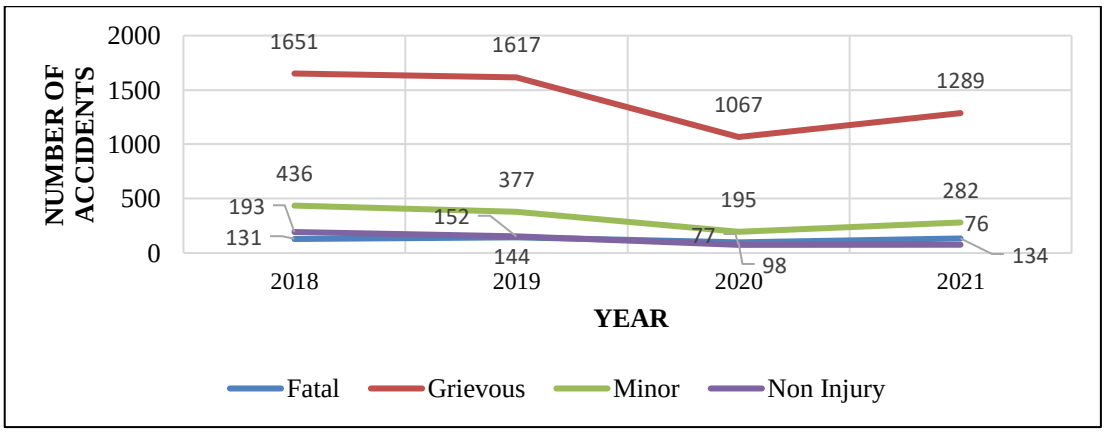

Figure 1: Severity level trends from 2018 to 2021 in Ernakulam city.
Source: DCRB data

The above statistics show a strong need to improve road safety, consequently reducing accidents and determining how much the nation must invest or risk losing its economy solely due to road accidents. It clearly emphasizes the necessity to estimate the cost of road accidents. The objectives of this study are 1) to calculate the RTA cost and build an accident cost framework that works as a tool to estimate the RTAs cost, 2) to provide a

comparative study of the cost components with the variation of severity level, and 3) to estimate the socio-economic loss of Ernakulam city from RTAs in terms of its GDP.

In general, six methods have been identified in the literature for estimating accident costs, especially RTAs. Any of these may be the best in estimating the accident cost depending on the objective choice. When appropriately modified, all these methods apply to both non-fatal and fatal accidents. According to various researchers, the six different approaches to the costing and valuation of accidents (Hills and Jones-Lee, 1981; Bora, Landge and Dalai, 2018) are the Human Capital (also known as Gross Output or Damage Cost approach), Net Output approach, Life-Insurance approach, Court-Award approach, Implicit Public Sector Valuation approach, and Willingness to pay (value of risk-change) approach.

All the above methods generate different costs and values for both fatal and non-fatal accidents. Human Capital (HC) approach, adopted by various researchers (Olukoga, 2004; Leon, Cal and Sigua, 2005; Thongchim and Taneerananon, 2007; Mohamed A. Ismail and Samar M. M. Abdelmageed, 2010; Ahadi and Razi-ardakani, 2015; Alrukaibi, Alotaibi and Almutairi, 2015; Ghadi, Török and Tánczos, 2018), has been used in this study to estimate the total RTA cost since it is well suited for the objectives of the study.

The impact of losses on the taxpayer's income can be found by identifying the cost of accidents along with their components with reference to socioeconomic aspects. Furthermore, the cost-effectiveness of selecting certain road safety interventions can be measured by estimating accident costs.

2. Methodology

The methodology of the present study is shown in Figure 2. Estimating the socio-economic loss due to RTAs, involve an understanding of each cost component involved. Various cost components considered in the estimation of economic loss are medical cost, productivity loss, vehicle damage cost, administrative cost, and human cost. The data required for the RTA cost estimation were collected from various sources such as DCRB, hospitals, and garages using different sets of questionnaires. The DCRB data was the basis of the overall RTA cost estimation as it provided the details of the RTAs that took place in the study area during the study period, i.e., from 2018 to 2021. The data from hospitals and garages substantiated the requirements for the calculation of medical and vehicle damage costs, respectively. Further, additional data required for various cost components were collected directly from the victims via telephone survey. The details of the data collection are explained in section 3. Each of these cost component calculations is described below. In the end, the various cost factors are summed to get an estimate of the loss brought on by RTAs. A comparison of cost components at different injury severity levels was also carried out. The annual RTA cost estimates are then expressed as the percentage of the GDP of the city.

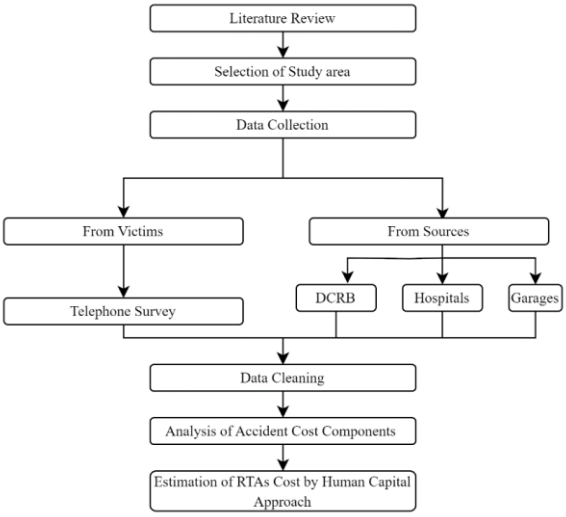

Figure 2: Flow chart of the methodology.

2.1 Study Area

As this study focuses on accident costing, the place where the accidents are concentrated needs to be identified. The study area is selected based on the district-wise number of road crashes in Kerala, a South Indian state. Ernakulam district tops the above list as per the study conducted by the National Transportation Planning and Research Centre (NATPAC, 2022). As per the number of road accident cases registered by Kerala Police from 2018 to 2021, Ernakulam District has registered the highest number of Road accident cases among all the districts in Kerala. As reported by Census, 2011, the total population of Ernakulam in the Urban Agglomeration/Metropolitan region is 21,19,724. The city limits have 68.07% of the population of the district. Ernakulam district has a total area of 3,063 km^2. The city limits possess an area of about 750 km^2. The population density of Ernakulam district is 1,072 inhabitants per km^2.

The number of vehicles in Ernakulam has increased by 26.84% over the past five years, and the district holds the highest percentage (14.35%) of the vehicle population in the state (State Planning Board, Government of Kerala, 2022). The rapidly increasing vehicular population in Ernakulam has resulted in the highest fatal road accidents in recorded history. The lack of awareness among citizens may also contribute as one of the reasons behind road accidents along with drunken driving, traffic violations, rash driving and speeding. Therefore, it is necessary to quantify the economic loss caused by RTAs to Ernakulam.

2.2 HC Approach

The HC approach has been used for the estimation of the cost of RTAs by several researchers (Olukoga, 2004; Leon, Cal and Sigua, 2005; Thongchim and Taneerananon, 2007; Mohamed A. Ismail and Samar M. M. Abdelmageed, 2010; Sugiyanto and Santi, 2011; Ahadi and Razi-ardakani, 2015; Alrukaibi, Alotaibi and Almutairi, 2015; Ghadi, Török and Tánczos, 2018) in many ways, especially in the developing countries.

Risbey, De Silva and Tong (2007) augmented the HC approach, which was used in the accident cost estimations of the Bureau of Transport and Regional Economics by using

additional socio-demographic and other factors to adjust the present value of lost productivity to value human life. Mofadal and Kanitpong (2016) used comprehensive data on road traffic accident fatalities, classified by the level of severity, type of vehicle, and other crucial factors like discount rates and medical and insurance information, to evaluate and compare the significance and impact of the economic loss caused by accidents. An overview of the global trends in assessing the social cost of road accidents, including the value per fatality, overall cost, breakdown of the cost components, etc., is provided by Wijnen and Stipdonk (2016). Thus, injury prevention becomes essential in reducing the socioeconomic cost of traffic accidents. Jadaan *et al.* (2018) developed a crash cost estimation method by identifying the main components of road crashes by finding out the characteristics and nature of road crashes. Paul (2019) developed an Accidents Common Framework that works as a tool for estimating the cost of RTAs and provides an estimation of the cost for each category of road traffic injuries and fatalities. Chantith, Permpoonwiwat and Bertrand (2020) updated earlier estimates of the costs of national economic harm caused by road traffic accidents and calculated the value of productivity loss as a result. Through significant data collection and analysis, it is feasible to calculate the revenue losses over time due to fatalities, and permanent disabilities, including major and minor injuries.

The analysis of RTA cost using the HC approach should meet the required eligibility criteria for achieving the most reliable accident cost estimate. The criteria are as follows;

1) data analysed should be relatively new,
2) accident data that has been under-reported should be addressed,
3) only the damage to property should be included in the total estimation, and
4) the direct and indirect costs of accidents, and the cost of the lost quality of life (Elvik, 2000).

It should be highlighted that the present study meets the requirements to be used as an initial step towards accident cost analysis in Ernakulam city. The scope and importance of each cost category and its component, as well as the sort of accident data currently accessible in that location, determine the suitable analysis methodology for each region. The expenses associated with injuries and the costs associated with crashes are distinguished. As shown in Figure 3, the accident cost framework suggested for HC accident cost analysis in Ernakulam city has been modified based on Silcock and Transport Research Laboratory (2003). The inclusion of the medical and Property Damage Only (PDO) cost categories are the major distinctions between the structure used in this study and the conclusions by Silcock and Transport Research Laboratory (2003). As per Figure 3, the PDO cost category is now known as the vehicle damage cost. The HC technique, which is popular in RTAs cost studies and is straightforward, was chosen for this investigation.

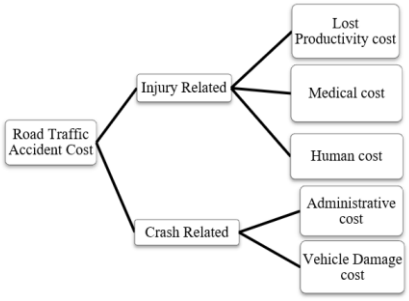

Figure 3: HC road traffic accident cost analysis framework for Ernakulam city

2.2.1 Lost Productivity Cost

In RTA cost estimations, productivity loss is usually the highest related cost. Future productivity loss for road fatalities is estimated based on the average retirement age. Future productivity loss for road injuries is calculated based on the number of days lost by the victim due to the injury. This estimate involves the calculation of a future value in present value terms; hence suitable economic methods utilizing the discount and future economic growth rates are used. These parameters take into consideration the discounted value of future earnings in present-day terms and the increment in one's wages during the course of life. Productivity loss reflects the estimated future economic earnings of the road accident victim based on the severity. The productivity loss for the number of days a fatal victim was hospitalized and the losses incurred due to traffic jams, caretakers, and reduced quality of life are not considered.

Equation 1, employed in most HC studies, was used to generate the production loss due to mortality (Alrukaibi, Alotaibi and Almutairi, 2015; Mofadal and Kanitpong, 2016) .

$$Lost\ productivity\ (fatality) = \sum_{i=1}^{N} \frac{W(1+g)^i}{(1+r)^i} \quad (1)$$

where,
W = average year per capita GDP, g = annual growth rate, r = discount/interest rate, i = average number of years of lost productivity per accident fatality.
Also, other cost components were estimated by multiplying the unit cost for each category by the total number of each accident severity level. Like in the case of lost productivity for grievous and minor injuries, cost estimation is done using Equations 2 and 3, respectively.

Lost productivity due to grievous injuries = Number of injuries x Number of days spent in hospital x Average daily wage (2)
Lost productivity due to minor injuries = Number of injuries x Number of days spent in hospital x Average daily wage (3)

2.2.2 Medical Cost

Road accident victims are rushed to hospitals for treatment, and medical costs are the first tangible costs that have to be borne by the victim or the victim's family. Non-medical costs include expenses for food, phone, transportation for family members or caregivers, compensation paid to the other party involved in the accident, costs associated with obtaining a death certificate, and funeral expenses. While, direct medical costs cover all medical expenses related to consultations, diagnostics, medications, surgeries, hospital stays, autopsies, rehabilitation/physiotherapy, and even post-discharge care. Medical costs alone comprise a huge percentage of the road accident cost (Sugiyanto and Santi, 2011; Alrukaibi, Alotaibi and Almutairi, 2015).

Medical studies in India on RTAs related to catastrophic effects on families, the severity of victims, classification of injuries based on the Abbreviated Injury Scale (AIS) scale, medical costs in case of fatality, etc., are minimal and require more research. These

medical expenditures dig deep into the pockets of the families and are commonly associated with distress financing, which points toward a bleak future for the family. Research and studies have been carried out in great depth regarding medical expenditures and the burden it has on families, but this has not been translated to the national scale and covers only a small sample size, thereby not substantiating the magnitude of the problem (Mofadal and Kanitpong, 2016).

Even though there are standard estimation techniques for health care costs that are used to calculate the overall social costs associated with road safety, the specific "things" that contribute to the list of costs vary by country and can include everything from first aid and recovery expenses to burial costs in some cases. However, scientific and grey literature shows that even when concentrating on the four main essential expenditures, there are variances in the average values as well as the units of measurement or assessment criteria (First aid and emergency room, Ambulance, Recovery, and Rehabilitation) (Corazza *et al.*, 2017)

The medical cost was generated using the following equations by each injury type, as shown in Equations 4 to 6.

Medical cost due to Fatalities (brought dead or in-hospital death) = Number of cases x Average Total hospitalization cost per person (4)

Medical cost due to Grievous injury accidents = Number of cases x Average hospitalization days x Average hospitalization cost/person/day (5)

Medical cost due to Minor injury accidents = Number of cases x Average hospitalization days x Average hospitalization cost/person/day (6)

2.2.3 Human Cost

The human cost is the cost associated with the pain, suffering, or grief associated with the loss of life. It is an intangible cost and is the highest cost component as the cost of life is above all for ethical reasons. The human cost is based on the calculation of the Value of Statistical Life (VSL). VSL is the amount individuals are ready to pay to reduce the risk of death. There are two methods to calculate the Human cost using the VSL. The first one, adopted in this study, is the Transport Research Laboratory method which is an addition to the result of the HC approach, where a certain percentage of the loss of productivity cost is the Human Cost in each severity.

According to Silcock and Transport Research Laboratory (2003), for Fatal accidents - 28 % of loss of productivity of fatalities; for Grievous injuries - 50 % of loss of productivity of grievous injuries; for Minor injuries - 8 % of loss of productivity of minor injuries.

The second one is the Willingness to Pay (WTP) method. In this approach, individuals are directly or indirectly asked how much money they would be willing to pay on a risk reduction in order to establish the VSL.

2.2.4 Administration Cost

It covers the price of paying for insurance, legal fees, and the expense of paying for police and other emergency services. Due to the difficulty in estimating this cost, the Silcock and Transport Research Laboratory (2003) equation is used in the study to obtain this figure.

According to Silcock and Transport Research Laboratory (2003), for Fatal accidents - 0.2% of Human cost and Vehicle damage cost categories; for Grievous injuries - 4% of Human cost and Vehicle damage cost categories; for Minor injuries - 14% of the Human cost and Vehicle damage cost categories; and for PDO - 10% of Vehicle damage cost category.

2.2.5 Vehicle Damage Cost

Vehicle damage is generally a definite outcome of RTAs that may or may not necessarily have a fatal or injured victim. Vehicle damage is calculated using the severity of the accident, the count of involved vehicles per accident, and the average damage for each vehicle. The vehicle damage cost was estimated using the following equation for each injury type, as shown in Equation 7.

Vehicle damage cost = Number of vehicles x Average vehicle damage costs (7)

Due to the insufficiency of data, other property damages, including infrastructural damage, are not considered. It was well recognized that this damage pales in comparison to vehicle damage.

3. Data Collection

On the basis of the proposed cost framework, data on traffic accidents were collected from the DCRB, Ernakulam. The primary data was collected from a follow-up telephone survey of the victims, while the secondary data used to calculate the productivity loss was taken primarily from the websites of several Kerala government agencies. The average retirement age, growth rate of GDP, per capita GDP, and discount rate/ interest rate are included in these statistics. Data required for estimates of vehicle damage costs were obtained from authorized and unauthorized garages through questionnaires and personal interaction. In contrast, the data for medical costs, were obtained from private hospitals through questionnaires and direct interaction. The data from private hospitals gave a real picture of medical costs than government hospitals, where the medical expenses are subsidized.

In order to understand the direct costs and the indirect costs of road traffic accidents, three sets of questionnaires were designed and issued.

A total of 7,919 First Investigation Reports (FIRs) related to RTAs were collected from DCRB in 9 circles covering the entire Ernakulam city. All the FIRs were downloaded, and required data was collected from each FIR, like the vehicle details, injury details, age, occupation, and contact number. Twelve hospitals were listed for collecting the data regarding medical costs, of which only four agreed to give the data, and those included hospitals of different levels of facilities and expenditure. Details like hospitalization days and hospitalization costs were collected based on injury type. Bill samples were collected for each vehicle type from authorized and unauthorized vehicle garages to estimate the vehicle damage cost.

The number of samples to be surveyed for the follow-up survey of victims was obtained using the Modified Cochran formula, i.e., 366 out of 7,919. These samples have been selected such that all the occupation types are covered, and gender bias is avoided. Details regarding their accident, like the number of days of rest at home and the amount they

spent at hospitals and other departments due to the accident, were collected through the follow-up telephonic survey.

Three sets of questionnaires were created and then distributed to the respondents. The questionnaire is for a follow-up survey of the victims to collect data regarding the lost productivity cost component. Questionnaire II is for selected Vehicle Garages (Authorized and Unauthorized) to determine the vehicle damage cost. Questionnaire III is for selected hospitals to find the medical cost component.

A pilot test was conducted on some prospective respondents to ensure the effectiveness of the survey. During the pilot test, the time required to answer the questionnaires was recorded, and any ambiguous areas found in the questions were identified. Based on the comments of the respondents, all the questionnaires were fine-tuned after the pilot test.

4. Results and discussion

The HC approach is used to assess the total cost of RTAs based on cost components and each injury severity level. The results obtained are discussed in the following sections in detail.

4.1 Lost productivity cost

The secondary data regarding the estimation of lost productivity cost is obtained from the state government websites, as shown in Table 2. From the follow-up survey of victims, the average wage per day and the number of hospitalization days (days spent at the hospital, and days spent at home, are included in deriving the average) are obtained, as shown in Table 3. The amount of productive age, or the age gap between the victim and the typical retirement age, is used to determine lost production for fatalities. The victim's earnings are predicted to increase by 6.8% (Kerala Budget, 2022) annually. Equation 1 is used to quantify the cost of lost productivity due to the fatalities. The amount of time a person is out of work due to a traffic accident is multiplied by their income to determine lost productivity in the case of injuries. The total lost productivity cost of the RTAs by injury severity level is shown in Table 4.

This cost component is more in the years 2018 and 2019 due to a greater number of accident cases. Even though there are a smaller number of grievous and minor injury cases in 2021, this cost is significantly high due to greater number of deaths in the year.

Table 2: Secondary data for estimating lost productivity cost

Description	*Value*	*Source*
GDP per capita	251104 INR	(Kerala Budget, 2022)
GDP growth rate	6.8%	(Kerala Budget, 2022)
Discount rate	5%	(Treasuries, 2022)
Average Retirement Age	56 years	(Jose and ekher, 2021)

Table 3: Primary data for estimating lost productivity cost

Description	*Grievous*
Average wage per day	827 INR
The average number of days hospitalized	67 days

Table 4: Total Lost Productivity cost of all the years (INR)

Injury Severity	*2018*	*2019*	*2020*	*2021*	*Average*	*% of total Productivity cost*
Fatal	399760765	437894388	275452690	364023914	369282939.25	81.69
Grievous	91056363	89181187	58847450	71091249	77544062.25	17.15
Minor	7058648	6103464	3156964	4565456	5221133.00	1.15
Total	497875776	533179039	337457104	439680619	452048134.50	100

4.2 Medical cost

Medical cost includes various costs like ICU charge, cost of surgery, medicines cost, room rent, nursing and admission cost, death care (in case of a fatality), etc. For injuries, medical cost is calculated by multiplying the average medical cost obtained from the hospitals and the number of respective injury cases. Table 5 shows the average medical cost for injured victims (both grievous and minor).

The average medical cost of injuries has been calculated from the data obtained from the private hospitals and the telephonic survey results, as shown in Table 6. The medical expenditures are usually underestimated because most studies only considered the costs associated with public hospitals, according to the literature. The medical cost is anticipated to be closer to the exact value in this study since it considers medical costs from different private hospitals depending on their spatial distribution in the city. For fatalities, the average medical cost is calculated by multiplying the average medical cost obtained from the hospitals and the number of fatalities. Table 7 shows the average medical cost for fatalities.

Table 5: Average Medical cost for injured victims (INR)

Description	*Average amount*	
	Minor Injury	Grievous Injury
ICU Charge	6175	12273
Cost of Surgery	17950	56818
Cost of Medicine	9041	45209
Room Rent	2900	12663
Nursing Charge	1375	8188
Admission Cost	100	118
Total	32996	125472

Table 6: Average Medical cost for injured victims (INR) based on accident severity

Injury Severity	*Average amount*			
	Private Hospital 1	*Private Hospital 2*	*Private Hospital 3*	*Telephonic Survey*
Grievous	125472	107654	242631	101431
Minor	32996	10785	31479	26039

Table 7: Average Medical cost for fatality (INR)

Description	*MLC charge*	*Clinical support care*	*EM Service charge*	*ECG portable*	*ECG Electrodes*	*Death care*	*Cost of Medicine*	*Total Cost*
Average amount	250	75	120	140	100	360	380	1625

Table 8 displays the total medical costs for RTAs by injury severity level. This cost component increased in 2018 and 2019, perhaps due to an increase in accident cases. As a result of the Covid-19 lockdown, there were fewer accident cases in succeeding years, which led to lower costs.

Table 8: Total medical cost for all the years (INR)

Year Injury Severity	*2018*	*2019*	*2020*	*2021*	*Average*	*% of total medical cost*
Fatal	212875	234000	159250	217750	205968.75	0.09
Grievous	238234501	233328400	153964998	185998953	211704406.75	96.56
Minor	11041559	9547403	4938312	7141559	7342541.25	3.35
Total	249488935	243109803	159062560	193358262	219252916.75	100

4.3 Vehicle damage cost

The average vehicle damage cost due to RTAs has been calculated for various types of vehicles based on information provided by authorized and unauthorized garages from the study area, taking the type of collision into consideration, which is found to be rarely addressed in the literature, as shown in Table 9. Considering the type of collision, there is a significant difference in the vehicle damage cost involving cars and autorickshaws. The number of vehicles involved in the RTAs for the year 2021 based on the type of vehicle and injury severity is shown in Table 10. Both scooters and motorcycles together have a share of more than half of the total number of vehicles involved (62.75%). Cars have a share of 25.29%, while other vehicles have a significant share of 11.96% of the total vehicles involved in the RTAs.

Table 9: Average vehicle damage cost by collision type (INR)

Vehicle Type	*Collision Type***	*Damage Cost*
Scooter/Motorcycle	Front/Rear/Side	15835
Car	Front	200187
	Rear	37775
	Side	41725
Autorickshaw	Front	55600
	Rear	25150
	Side	42750
Bus/Truck	Front	28605
	Rear	28605
	Side	28605

** Average is taken,s if the type of collision is not mentioned in First Investigation Report (FIR)

The total vehicle damage cost of the RTAs by injury severity level is shown in Table 11. This cost component is more in the years 2018 and 2019 due to a greater number of accident cases. At the same time, fewer costs in the later years are due to the smaller number of accident cases because of the Covid-19 lockdown.

Table 10: Number of vehicles involved in accidents in 2021

Vehicle type	*Injury Severity*			
	Fatal	*Grievous*	*Minor*	*Non-Injury*
Scooter	33	460	87	5
Motorcycle	52	633	127	10
Car	22	397	95	53
Autorickshaw	6	126	28	0
Bus/Truck	9	70	16	13
Total	122	1686	353	81

Table 11: Total vehicle damage cost for all the years (INR)

Injury Severity	*2018*	*2019*	*2020*	*2021*
Fatal	4107478	4610016	3021426	4063372
Grievous	72976805	71301984	45393543	59008134
Minor	25139008	17435034	8841112	12316005
Non-Injury	13025229	10221943	4181416	4611762
Total	115248521	103568976	61437496	79999273

4.4 Human cost

According to Silcock and Transport Research Laboratory (2003), human costs are the indirect costs incurred by the victims' families or other close relatives, i.e., the cost of pain, grief, and suffering, which is calculated as a percentage of lost productivity cost. Table 12 displays the findings of the analysis of human expenses in 2021 as per Silcock and TRL. The total human cost of the RTAs by injury severity level is shown in Table 13. This cost component is more in the years 2018 and 2019 due to a greater number of accident cases. While the less costs in the later years are due to fewer accident cases because of the Covid-19 lockdown.

Table 12: Human cost by severity level in the year 2021

Injury Severity	*As per Silcock and TRL (%)*	*Human cost (INR)*
Fatal	28% of Lost productivity of fatality	101926696
Grievous	50% of Lost productivity of grievous injury	35545625
Minor	8% of Lost productivity of minor injury	365236
Total		137837557

4.5 Administrative cost

The administrative cost includes police service, court service, and insurance administration costs. The study adopts the equation suggested by Silcock and TRL (2003) to compute administrative cost.. Table 14 displays the findings of the analysis of administrative expenses in 2021, according to Silcock and TRL.

Table 13: Total human cost for all the years (INR**)**

Injury Severity	*2018*	*2019*	*2020*	*2021*
Fatal	111933014	122610429	77126753	101926696
Grievous	45528182	44590594	29423725	35545625
Minor	564692	488277	252557	365236
Total	158025888	167689299	106803035	137837557

Table 14: Administrative cost by severity level in the year 2021

Injury Severity	As per Silcock and TRL (%)	Human cost (INR)
Fatal	0.2% of human cost + vehicle damage cost	211980
Grievous	4% of human cost + vehicle damage cost	3782150
Minor	14% of human cost + vehicle damage cost	1775374
Non-injury	10% of vehicle damage cost	461176
Total		6230680

The total administrative cost of the RTAs by injury severity level is shown in Table 15. This cost component is more in the years 2018 and 2019 due to a greater number of accident cases. While the less costs in the later years are due to the smaller number of accident cases because of the Covid-19 lockdown.

Table 15: Total administrative cost for all the years (INR)

Injury Severity	*2018*	*2019*	*2020*	*2021*
Fatal	232081	254441	160296	211980
Grievous	4740199	4635703	2992691	3782150
Minor	3598518	2509264	1273114	1775374
Non-Injury	1302523	1022194	418142	461176
Total	9873321	8421602	4844242	6230680

4.6 Total estimated road traffic accidents cost

For 2018 to 2021, the overall accident costs in the city of Ernakulam are estimated and analyzed using the HC approach outlined in the methodology. The anticipated cost of all traffic accidents in 2021 is INR 85,71,06,391. The estimated lost productivity costs was INR 43,96,80,619, which is, 51.30 percent of total expenditures, as shown in Figure 4.

Medical cost was the second most significant cost component, which was 22.56 % of the total estimated costs and was INR 19,33,58,262. The grievous injury accidents take hold of the major share of medical cost as medical procedures, hospital care, and medicines are intensively required to bring the victim back to normal life. Vehicle damage cost and human cost have a significant share of 9.33% and 16.08% of the total costs,

respectively. The administrative cost is a relatively small cost component accounting for 0.73 % of the total costs. The total estimated costs are given in Table 16 based on the cost component and severity level in 2021. More than half of the total costs (54.89%) are related to fatalities. Grievous injuries account for 41.47% of the total costs, minor injuries account for 3.05%, and non-injuries account for 0.59% of the total costs. The analysis results are shown in Table 17 and Figure 4.

The total costs of road traffic accidents in 2021 are estimated at INR 85,71,06,391, corresponding to 0.57% of Ernakulam's GDP.

Tables 18 and 19 show that the RTAs are posing a considerable socio-economic burden in Ernakulam, corresponding to 0.44% to 0.7% of the GDP of the city from the years 2018 to 2021.

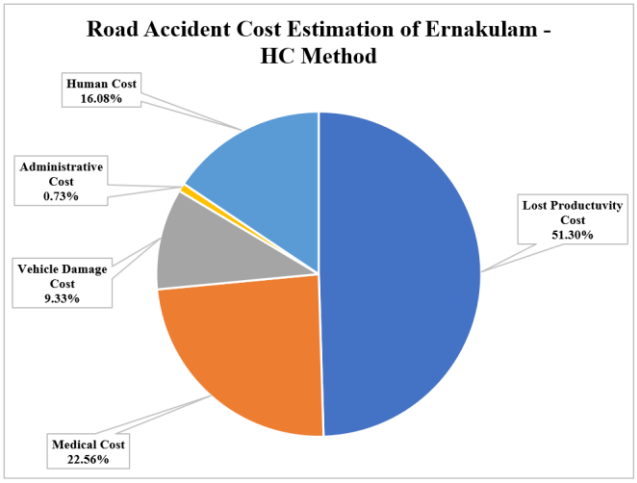

Figure 4: Total estimated cost expressed as a percentage of total cost

Table 16: Estimated RTA cost in Ernakulam city in 2021 given in INR

Cost Component	*Severity Level*	*Amount (INR)*
Lost Productivity Cost	Fatalities	364023914
	Grievous injuries	71091249
	Minor injuries	4565456
Total		439680619
Medical Cost	Fatalities	217750
	Grievous injuries	185998953
	Minor injuries	7141559
Total		193358262
Vehicle Damage Cost	Fatalities	4063372
	Grievous injuries	59008134
	Minor injuries	12316005
	Non-injuries	4611762
Total		79999273
Administrative Cost	Fatalities	211980
	Grievous injuries	3782150
	Minor injuries	1775374
	Non-injuries	461176
Total		6230680
Human Cost	Fatalities	101926696
	Grievous injuries	35545625
	Minor injuries	365236
Total		137837557

Total Cost	857106391

Table 17: Estimated RTA cost by severity level in 2021

Severity Level	*Amount (INR)*	*Percentage of total costs (%)*
Fatalities	47,04,43,712	54.89
Grievous injuries	35,54,26,111	41.47
Minor injuries	2,61,63,630	3.05
Non-injuries	50,72,938	0.59
Total Cost	85,71,06,391	100

Table 18: Estimated RTAs cost component for the years 2018 to 2021 INR

Cost Component	2018	2019	2020	2021
Lost Productivity Cost	497875776	533179039	337457104	439680619
Medical Cost	249488935	243109803	159062560	193358262
Vehicle Damage Cost	115248520	103568977	61437497	79999273
Administrative Cost	9873321	8421602	4844242	6230680
Human Cost	158025888	167689299	106803035	137837557
Total Cost	1030512440	1055968720	669604438	857106391

Table 19: Economic loss due to RTAs in comparison with GDP

Year	Estimated Accident Cost (INR)	GDP %
2018	103,05,12,440	0.68
2019	105,59,68,720	0.7
2020	66,96,04,438	0.44
2021	85,71,06,391	0.57

However, as the analysis focused on the most significant cost items and has not considered several other cost categories, such as infrastructure damage and traffic congestion charges, even though they are minimal, the computed estimate for the city might be viewed as a lower limit of the expenses.

Furthermore, the costs are probably understated because only the recorded fatalities and injuries were included in the computations. Due to underreporting, the actual number of recorded fatalities and injuries is anticipated to be greater.

5. Conclusions

This study concentrated on estimating the RTA cost using the Human Capital approach, a widely used costing approach across many developed countries. Based on the accident analysis of the Kerala state, the study area selected was Ernakulam, since it is having the highest number of crashes among all the districts in Kerala according to the data from NATPAC.

The total costs of road traffic accidents in 2021 are estimated at INR 85,71,06,391, corresponding to 0.57% of Ernakulam's GDP. Lost productivity cost was estimated at INR 43,96,80,619, which accounts for a large proportion of total costs (51.30%). The medical cost was the significant cost component (as the private hospital data was accounted for) next to the lost productivity cost, which accounts for 22.56% of the total costs and is estimated at INR 19,33,58,262. Vehicle damage cost (considering the collision types) and human cost have a significant share of 9.33% and 16.08% of the total costs, respectively. Scooters and motorcycles altogether make up more than half of all

vehicles (62.75%). Cars account for about 25.29% of all the vehicles in RTA, while, other vehicles account for sizeable 11.96%. Administrative cost is a comparatively small, accounting for 0.73% of the total estimated costs.

The cost of fatalities amounts to over 50% of the overall expenses (54.89%). Grievous injuries comprise 41.47% of the total costs, whereas minor injuries account for 3.05%, followed by non-injuries (0.59%). The amount of data needed for an accurate estimation of the RTAs cost is quite onerous. The analysis demonstrates the necessity for a wide range of data, including information on insurance, economics, medicine, and emergency services. The findings from the study shed light on the necessity of the implementation of facilities in order to collect detailed data on road crashes, which can make the cost estimation more realistic. The resource allocation toward the safety infrastructure should concentrate more on two-wheeler traffic, considering their involvement in the crashes.

According to the estimations, the RTAs in Ernakulam are expected to contribute between 0.44% and 0.7% of the city's GDP between 2018 and 2021. However, as the analysis focused on the most significant cost items and left out several other cost categories, such as infrastructure damage and traffic congestion charges, even though they are minimal, the computed estimate for the city might be viewed as a lower limit of the expenses. The cost lost due to road fatalities must be minimized for the overall development of the nation. Furthermore, the costs are probably understated as only the recorded fatalities and injuries were included in the computations. Due to underreporting, the actual number of fatalities and injuries is anticipated to be greater.

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