VOL. 12, NO. 2, JANUARY 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

THE COST OF TRAFFIC ACCIDENT AND EQUIVALENT ACCIDENT NUMBER IN DEVELOPING COUNTRIES (CASE STUDY IN INDONESIA)

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ABSTRACT

Many developing countries like Indonesia have a serious road accident problem. Traffic accidents data in 2014 was recorded 95,906 cases that resulted in 28,297 people died, 26,840 people severe injury, and 109,741 people minor injuries. There are 108,883 unitmotorcyclists that involving in traffic accidents. Various attempts have been made to reduce the number of traffic accidents. One of the parameters to perform cost-benefit analysis of the program conducted the necessary value of the accidents cost. The aims of this study is to analysis traffic accidents cost using gross output method and determining the value of an equivalent accident number based on accident cost. The research location is in Purbalingga, Indonesia using accident data from 2010-2012. The accident cost analysis based on the casualty severity of accidents is fatal, severe injury, minor injury, and Property Damage Only (PDO). Components of accident costs include costs to repair vehicle, loss of productivity, medical expenses, administrative expenses, and cost of pain, grief and suffering as well as the costs incurred by family. Casualty accident costs by severity type fatal are IDR263,025,680.96; severe injury is IDR12,066,000; minor injury is IDR1,904,312.87, and PDO is IDR1,562,909.09. Total accident cost in Purbalingga from 2010-2012 was estimated IDR27,582,518,750 or 0.38% of the gross domestic product. Equivalent accident number using conversion accident cost fatal: severe injury: minor injury: PDO = 168:8:2:1.

Keywords:accident cost, traffic accidents, gross output method, equivalent accidents numbers.

INTRODUCTION

Many developing countries like Indonesia have a serious road accident problem. The traffic accident rate in Indonesia is still considerably high, as reported by the national police and Ministry of Transportation, in 2014 was recorded 95,906 cases that resulted in 28,297 people died, 26,840 people suffered severe injury, 109,741 people suffered minor injury. There are 108,883 motorcyclists that involving in traffic accidents [1]. Around the world, every year more than 500,000 people have died in road traffic accidents in worldwide. The majority of the victims who died, 70% of which occur in developing countries [2], 65% of the victims who died are pedestrians and 35% of the pedestrians who died were children [3]. Three factors that cause accidents are human factor, vehicle, and environment. The highest accident causal is the human error factor [4]. Rao, *et al*. states that 66% of accidents occur due to human error factor and 33% because of the interaction of a vehicle, other road users, and environmental factors [5].

Traffic accidents are basically unexpected events that could cause many types of losses, including material, physical, and human life losses. To estimate the economic impacts of accidents, the number of accident casualties and accident costs are the most needed data [6]. There are six methods that can be used to analyse the cost of accidents to estimate how much the losses caused by traffic accidents [7,8]. While Anh,*et al*. states there are seven methods to analyse the cost of accidents, namely: gross output method, human capital method, net output method, life insurance method, court award method, implicit public sector valuation, and willingness to pay [9].

Traffic accidents cause a very high cost. In Australia, the cost of accidents in 2003 approximately AUS$17 billion, this value is 2.3% of Gross National Income Australia [10]. While in Indonesia, by the Director of Land Transport Safety estimated the losses as a result of the accident in 2002 at IDR41.4 trillion [11]. Using the 2002 Indonesia nominal Gross Domestic Product (GDP) of IDR1,421 trillion, the total accident cost in Indonesia was estimated to be roughly IDR41 trillion (approximately US$4.5 billion) or 2.9% of the gross domestic product [6]. The total costs of traffic accident in Thailand for the year 2004 are estimated at 153,755 million baht (approximately US$3,460 million) [12]. In Singapore, the total cost of traffic accidents occurring in 2003 is S$610.3 million. The annual cost of traffic accidents is about 0.338% of the gross domestic product [13].

The aims of this study is to analysis the traffic accidents cost using gross output method and determining the value of an equivalent accidents number based on the amount of accidents cost.

LITERATURE REVIEW

Casualty severity and accident classification

This study classifies casualty severity based on Law 14, 1990 (Traffic and Land Transport) [14]. Road accidents are classified into three categories of severity: fatal or died, severe injury, and minor injury. These categories are defined below:

a. A fatal accident is one in which the victim dies, either on the spot or due to injuries sustained within 30 days of the accident.

b. A severe injury is one in which the casualty suffers serious injuries and is admitted to a hospital and receives treatment for over 30 days.
c. A minor injury is one in which the casualty requires medical treatment or is admitted to a hospital and receives treatment for less than 30 days.

Based on Law 22, 2009 (Traffic and Land Transport), traffic accident is classified in three categories, fatal accidents, serious accidents, and slightly accidents [15]. A damage-only accident or property damage only (PDO) is one in which no one is injured but damage to vehicles and or property is sustained [16].

Accident cost

Traffic accidents cost and evaluation of accident prevention in developing countries, Hills and Jones-Lee identified six different methods that have been proposed for placing a cost on road accidents [7]. All of the methods outlined were applicable to non-fatal as well as to fatal accidents but for reasons of clarity and simplicity, they concentrated on describing accidents involving one fatality only [16]. The six methods are The gross output (or human capital) approach, The net output approach, The life-insurance approach, The court award approach, The implicit public sector valuation approach, and The value of risk change or willingness to pay approach. Gross output method (well suited to the objective of maximizing the wealth of a country). Willingness to pay method especially for social welfare maximization and for use in cost benefit analyses [16].

Seven methods that can be used to analyse the cost of accidents [9]:

a) **Gross output method:** the basis of the gross output method is the idea that individual could produce cumulative output through their life. The costs of accident will represent accident-related cost (vehicle damage cost, hospital costs, and administration costs) and the costs of future lost output.
b) **Human capital method:** the cost of a road accident involving one fatality is treated as the sum of real resource costs (i.e. vehicle, medical, and police costs) plus the costs reflecting pain, grief, and suffering. The value of the prevented accident is correspondingly defined as the avoided costs.
c) **Net output method:** this differs from the gross output method in that the extent that the present value of the victim's future consumption is subtracted from the gross output figure.
d) **Life insurance method:** the cost of accident is defined as the amount for which individuals are willing to insure themselves.
e) **Court award method:** the sums awarded by the courts to the surviving dependents of those killed are treated as indicative of the cost that society associates with a fatality or the value that it would have placed on its prevention. Real resource costs are then added to this figure to obtain the cost of an accident.
f) **Implicit public sector valuation method:** these attempts to determine the costs and values that are implicitly on accident prevention or on investment programs that affect road safety.
g) **Willingness to pay method:** the method is to estimate the amount of money people affected would pay to avoid an accident. Individuals have their chance of being involved in a fatal accident reduced by a small margin if a road safety improvement is introduced. Thus the value of preventing one fatality in one accident is defined as the aggregate amount that all the affected individuals in society are willing to pay for these small risk reductions.

In gross output or human capital approach the cost of a traffic accident involving a fatality can be divided into two main categories. Firstly there are the costs that are due to a loss or diversion of current resources and secondly there are the costs that are due to a loss of future output. Included in the former will be the cost of vehicle damage, medical treatment, and police/administration costs and usually there is little disagreement as to what should be included here [16].

According to the Transport Research Laboratory (TRL), traffic accidents cost components are grouped into two categories, namely direct costs and indirect costs. Indirect costs are a percentage of direct costs. Component of direct costs of traffic accidents includes property damage, administrative costs, medical costs, and loss of productivity [16].

a) Property damage

In each accident, there is some amount of damage to vehicles and property damage on a side street. The largest portion of property damage is the things that relate to damage to the vehicle [17].

b) Administrative costs

Police costs included as administrative costs, although this cost component is very small compared to other cost components. Costs incurred for the funeral for the victims' family died included in administrative costs [17].

c) Medical costs

Medical expenses for injuries is the cost since the occurrence of the accident until the time of healing, or for deaths, including the cost of first aid, ambulance, hospital costs (food, room, surgery, and medicine) and the cost of healing or rehabilitation [17].

d) The loss of productivity (lost output)

Loss of productivity is often associated with a loss of economic value to work because of an accident. The amount of working time lost for the death of the victim was the time they spent into the future if they do not die multiplied with income if an accident victim [17]. For severely injured and slightly injured lost productivity is calculated as the length of time they cannot work multiplied by the income the casualty if they works.

METHODS

The study location

The study location is in Purbalingga Regency, Central Java Province, Indonesia. The location of study can be seen in Figure-1.

Figure-1. Location of study in Purbalingga regency [18].

Data collection and analysis

This study was conducted by analysing each component of the cost of traffic accidents by using human capital method according to Silcock and Transport Research Laboratory [17] and Asian Development Bank [6]. The traffic accident cost is analysed based on casualty cost by severity type. Component cost of accidents in this study were divided into two, namely direct costs and indirect costs. Direct costs include: costs of property damage, medical expenses, administrative expenses, and loss of productivity. The amount of direct costs based on the severity rate of casualties obtained based on interviews with 15 the casualties of PDO, 20 casualties of minor injury accidents, 20 casualties of severe injury accidents, and 15 families of casualties of fatal accidents. The total respondent is 70 peoples.

Identity data and address the casualties of traffic accidents obtained from Purbalingga Police sourced from Data Traffic Accidents in Purbalingga during 2010 to 2012 [19]. Having obtained the direct costs, the next step is to calculate the indirect costs. Indirect costs include: the cost of pain, grief, and suffering. The amount of indirect costs is the percentage of direct costs of 28% for fatal accidents, 50% of severe accidents, and 8% for the minor accidents of the total direct cost [17]. Based on the analysis results of direct costs and indirect costs then summed to determine casualty cost by the severity type.

RESULTS AND DISCUSSIONS

Traffic accident in Indonesia

Traffic injury severity is an important safety concern of the transportation system. The road traffic accident rate in Indonesia is still considerably high, as reported by national police and Ministry of Transportation, in 2014 was recorded 95,906 cases. There are 108,883 unit motorcyclists those involving in traffic accidents [1].Based on NHTSA, in the United States, there were 32,675 people killed in motor vehicle crashes in 2014, and the total economic losses are up to $836 billion [20]. Traffic accident cost is one of the externality costs which are forgotten by road users [21]. Road traffic accident in Indonesia from 2010-2014 can be seen in Table-1.

Table-1. Road traffic accident in Indonesia 2010-2014 [1].

Accident and injury	Unit	Year				
		2010	2011	2012	2013	2014
Traffic accident	cases	109,319	109,776	117,949	100,106	95,906
Motorcycles	unit	140,277	147,391	111,015	119,560	108,883
Passenger cars	unit	26,495	25,502	25,200	21,304	18,147
Trucks	unit	20,347	25,227	16,165	21,335	19,242
Bus	unit	6,099	5,272	8,375	4,893	4,808
Special vehicles	unit	2,050	3,109	2,132	1,092	1,050
Un-motorist	unit	4,000	4,200	N.A	N.A	N.A
Total vehicles involved	vehicles	199,268	210,701	162,887	168,184	152,130
Fatal/died	people	31,234	31,185	29,544	26,416	28,297
Severe injury	people	46,851	36,767	39,704	28,438	26,840
Minor injury	people	97,702	108,811	128,312	110,448	109,741
PDO	IDR billion	143.16	286.09	298.627	255.864	250

Traffic accident in Purbalingga

Characteristics of traffic accidents in Purbalingga

Based on the analysis of traffic accident data from Purbalingga Police during 2010-2012 occurred 869 accidents with the fatality of casualties is 92 fatal (27 in 2010, 23 in 2011, and 42 in 2012), 25 severe or serious injury, and 1599 minor injury or slightly injury (169 in 2010, 573 in 2011, and 857 in 2012). Severity rate of casualties in Purbalingga from 2010-2012 as shown in Figure-2. Manner and Wünsch-Ziegler stated that accidents during daylight and at interchanges or construction sites are less severe. Accidents caused by the collision with roadside objects, involving pedestrians and motorcycles, or caused by bad sight conditions tend to be more severe [22].

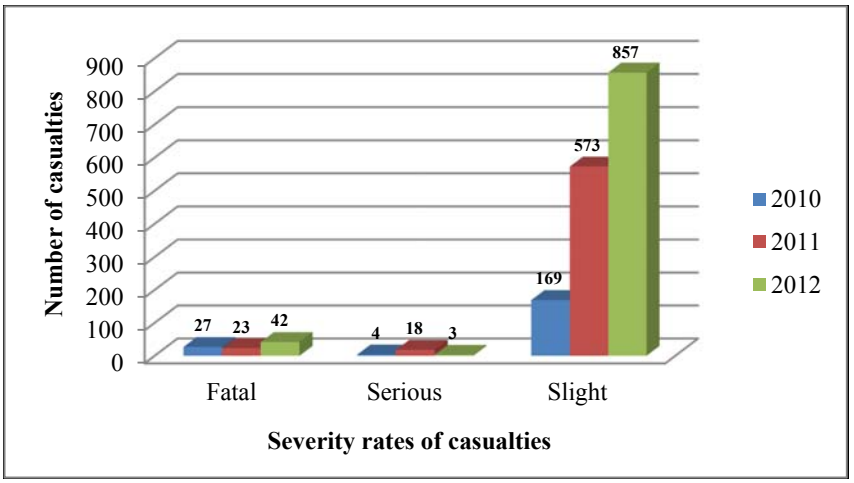

Figure-2. Severity rate of traffic accident casualties in Purbalingga [19].

Vehicles involved in traffic accident

As for the characteristics of the accident based on the types of vehicles involved in traffic accidents result 78.09% involved motorcycles; 6.19% involving passenger cars, 2.53% involve bus, 8.96% involved trucks, and only 3.41% involved un-motorized vehicles. There are 166 pedestrian that involved traffic accident in Purbalingga. Grouping types of vehicles involved in accidents by type of accident is presented in Table-2 below.

Based on Table-2 we know that number of accident in Purbalingga, Central Java, Indonesia from 2010 (93 accident) to 2012 (475 accident) is increasing by more than 410%. This condition is very different with the condition in Dhaka, Bangladesh. The number of accidents in Dhaka is reducing by more than 10% every year and 63% of the accidents took place where there was no traffic control [23]. Khorashadi, *et al.* studies the differences between accidents in rural and urban areas when trucks are involved and find significant differences for the two areas [24]. In order to increase traffic safety it is of central importanceto know the causing factors of accidents. Using data containingdetailed accident information the determinants of accident frequencyand severity can be analysed using statistical methods [22].

Table-2. Vehicle involved traffic accident year from 2010 to 2012 in Purbalingga [19].

Year	Number of accident	Vehicle involved traffic accident						Total vehicle
		Motor cycle	Car, Jeep	Bus	Truck	Un-motorist	Pedes-trian	
2010	93	103	15	18	19	6	15	161
2011	301	422	43	8	48	17	63	538
2012	475	712	40	14	75	31	88	872
Total	869	1237	98	40	142	54	166	1584

Accident cost using gross output method

a. Accident cost component

Traffic accidents cost components are grouped into two, namely direct costs and indirect costs. Indirect costs are a percentage of direct costs. Component of direct costs of traffic accidents includes property damage, administrative costs, medical costs, and loss of productivity [16].

b. Direct cost

Direct costs include: costs of property damage, medical costs or medical care, administrative costs, and

loss of productivity (lost output). The amount of direct costs based on the level of fatality rate of casualties obtained based on interviews with 15 casualties of PDO, 20 casualties of minor injury accidents, 20 casualties of severe injury accidents, and 15 families of casualties of fatal accidents. The loss of productivity is the result of an accident victim's loss of income is calculated based on the income the victim and the victim productive age. In the analysis of the victim's income is expected to rise by 5% per year [25]. For injuries, long lost productivity is calculated based on long concerned cannot work because of a traffic accident. For the casualties is died, long ago lost productivity is calculated based on the amount of productive age expectations set 60 (sixty) years. Results of the analysis of the direct costs of casualties based on fatality rates are shown in Table-3.

c. Indirect cost

Indirect costs are costs incurred by the family or relatives of the victims and the cost of pain, grief, and suffering or human cost. Human cost fee is a percentage of direct costs. According to Silcock and TRL [17] the amount of indirect costs is 28% for fatal, 50% for severe injury, and 8% for minor injury. In Indonesia, the percentage of human cost according to Pd.T-02-2005-B is 38% for fatal, 100% for severe injury, and 8% for minor injury [26]. The results of the analysis of indirect costs according to Silcock-TRL and Pd.T-02-2005-B are shown in Table-4.

Casualty cost by severity type

Casualty cost by severity type of accident is obtained by summing the cost of direct and indirect costs according to Silcock and TRL. Casualty accident costs by severity type: fatal (died) is IDR263,025,680.96; severe injury is IDR12,066,000; minor injury is IDR 1,904,312.87, and property damage only is IDR1,562,909.09. Result of the analysis of casualty cost by the severity type is presented in Table-5.

The result of this study is similar with research of Sugiyanto in Banyumas Regency, Central Java Province, Indonesia, the casualty cost by severity type for severe injury is IDR12,221,903.78, and for minor injury is IDR877,574.13. The value of casualty cost for fatal or died in Banyumas is smaller than in Purbalingga. The casualty cost for fatality in Banyumas Regency, Central Java is IDR89,873,969.68 [4, 27]. With the value of human cost according to Silcock and TRL [17], the casualty cost by severity type in Banyumas is IDR83,366,218.25 for fatal (died) and IDR9,492,999.33 for severe injury [27].

Table-3. Direct costs based on the fatality rate of casualties (IDR).

Component of accident cost	Severity rates of casualties			
	Fatal (died)	Severe injury	Minor injury	PDO
Property damage	1,478,313.25	875,000.00	827,127.66	1,390,909.09
Administrative cost	1,120,500.00	318,750.00	172,000.00	172,000.00
Medical care	2,625,000.00	5,765,750.00	387,250.00	0.00
Lost output	200,265,000.00	1,084,500.00	376,875.00	0.00
Total cost unit	205,488,813.25	8,044,000.00	1,763,252.66	1,562,909.09

Table-4. Indirect costs or human cost (IDR).

Human cost	Severity rates of casualties		
	Fatal (died)	Severe injury	Minor injury
Silcock and TRL	57,536,867.71	4,022,000.00	141,060.21
Pd.T-02-2005-B	78,085,749.04	8,044,000.00	141,060.21

Table-5. Casualty cost by severity type (IDR).

Cost component	Fatality rates of casualties			
	Fatal (died)	Severe injury	Minor injury	PDO
Direct cost	205,488,813.25	8,044,000.00	1,763,252.66	1,562,909.09
Indirect cost	57,536,867.71	4,022,000.00	141,060.21	0.00
Total cost unit	263,025,680.96	12,066,000.00	1,904,312.87	1,562,909.09

Accident cost by severity

a. Ratio of vehicles involved in traffic accident

To calculate the accident costs by severity type, it must first be calculated ratio of the vehicle involved in the traffic accident. Ratio of vehicles involved in traffic accident is classified by the accident type: fatal (1.952), severe (1.867), minor (1.807), and property damage only (1.333). The ratio of vehicles involved in traffic accident is presented in Table-6.

b. Average of casualties per cases and severity

In addition to the vehicle and accident ratios, to calculate the cost per accident or accident cost by severity type of the accident must be calculated the average casualties of a traffic accident. On any kind of accident casualties are separated according to the severity of the casualties, then the number of casualties based on the severity of accidents divided by the number of accidents based on accident severity rates. Total of fatal accident is 83 accidents, severe injury accident is 16 accidents, minor injury accident is 752 accidents, and property damage only is 18 accidents. Number of casualties in fatal accident is 92 fatal, 7 severe injury, and 92 minor injury. Number of casualties in severe accident is 18 severe injuries and 13 minor injuries. Results of the average calculation of traffic accidents casualties indicated by type of accident are shown in Table-7.

c. Direct cost, indirect cost, and accident cost

Calculation of the accidents cost per cases is done by calculating the direct costs and indirect costs. A result of calculation for the direct costs is shown in Table-8, while for the indirect costs per accident shown in Table-9.

Accident cost by severity type of accident is obtained by summing the direct cost and indirect costs according to Silcock and TRL [17]. Accident costs by severity type: fatal (died) is IDR 294,916,596.65; severe injury is IDR 15,723,214.18; minor injury is IDR 3,783,302.44, and property damage only is IDR 1,562,909.09. Result of the analysis of accident cost by severity type is presented in Table-10.

Table-6. Ratio of vehicles involved in traffic accident (per accident) in Purbalingga 2010-2012.

Accident type	Total accident	Total vehicles	Ratio of vehicles involved in traffic accident
Fatal (died)	83	158	1.903
Severe injury	16	30	1.875
Minor injury	752	1359	1.807
PDO	18	24	1.333
Total	869		

Table-7. Number and average of casualties' per-accident.

Accident type	Total accident	Number of casualties (people)			Average casualties/accident		
		Fatal	Severe	Minor	Fatal	Severe	Minor
Fatal (died)	83	92	7	92	1,108	0,084	1,108
Severe injury	16	-	18	13	-	1,125	0,812
Minor injury	752	-	-	1494	-	-	1,987
PDO	18	-	-	-	-	-	-
Total	869	92	25	1599			

Table-8. Direct costs per accidents (IDR).

Component of accident cost	Accident type			
	Fatal	Severe	Minor	PDO
Property damage	2,629,223.66	1,656,416.22	1,643,256.28	1,390,909.09
Administrative cost	1,459,533.13	498,343.75	341,712.77	172,000.00
Medical care	3,825,147.59	6,801,109.38	769,350.40	0.00
Lost output	222,489,686.75	1,526,273.44	748,738.36	0.00
Total cost unit	230,403,591.13	10,482,142.79	3,503,057.81	1,562,909.09

Table-9. Indirect costs per accident (IDR).

Human cost method	Accident severity type		
	Fatal (died)	Severe injury	Minor injury
Silcock and TRL	64,513,005.52	5,241,071.39	280,244.62
Pd.T-02-2005-B	87,553,364.63	10,482,142.79	280,244.62

Table-10. Accidents cost per cases (IDR).

Component cost	Accident cost by severity type per accident			
	Fatal	Severe	Minor	PDO
Direct cost	230,403,591.13	10,482,142.79	3,503,057.81	1,562,909.09
Indirect cost	64,513,005.52	5,241,071.39	280,244.62	0.00
Total cost unit	294,916,596.65	15,723,214.18	3,783,302.44	1,562,909.09

Purbalingga regency accident cost

The Purbalingga regency accident cost is obtained by multiplying the number of casualties and unit cost for each level of severity. Table-11 illustrates the total annual regency economic loss due to road accidents. Using the 2013 Purbalingga Regency nominal Gross Domestic Product IDR 7,298,610.75 million [28], the total accident cost in Purbalingga was estimated to be roughly IDR 27,582,518,750 or 0.38% of the gross domestic product. In Italy, in 2007 social costs due to road accidents were estimated at about 30.4 billion euros, corresponding to 2% of Italian GDP in the same year [29]. If using the GDP in 2015, the total accident cost in Purbalingga from 2010-2015 was estimated to be roughly IDR 236,517,103,652 or 1.27% of the gross domestic product [30].

One of the alternatives to reduce the accident cost is identification of black spots [31]. The determination of traffic accident location using weighted method: equivalent accident number [31] and Pd.T-09-2004-B [32]. Accident costs can be reduced by reducing accident frequency and reducing injury severity. Primary safety measures reduce accident frequency e.g. improved road geometry, relocation of poles, etc. Secondary safety measures reduce injury severity e.g. seat belts, energy-absorption systems [33].

Given the importance of roadway safety and the substantial economic losses caused by motor vehicle crashes, there has been increasing interest in developing crash prediction models to estimate motor vehicle crash counts, identify crash contributing factors, and implement effective safety strategies and countermeasures to improve traffic safety [34].

Table-11. Accident cost in Purbalingga regency, Central Java, Indonesia.

Severity	Number of casualties	Cost unit (IDR)	Total cost (IDR)
Fatal or died	92	263,025,680.96	24,198,362,649
Severe injury	25	12,066,000.00	301,650,000
Minor injury	1,599	1,904,312.87	3,044,996,283
Property Damage Only (PDO)	24	1,562,909.09	37,509,818
Total	1,740		27,582,518,750
Gross Domestic Product (GDP)	IDR 7,298,610.75 million [28]		
Percent of GDP	0.38%		

Equivalent accident number (EAN)

Equivalent accident number is numbers that are used to grade the weighting accident; this value is based on the value of an accident with damage or loss of material [32]. The ranking by weighting the accident rates using a conversion cost of accidents.

1. Using a comparison of the monetary value of the costs of accidents are:
   M: B: R: K = M/K: B/K: R/K: 1
   With:
   M is *meninggal dunia* or fatal (died).
   B is *luka berat* or severe injury.
   R is luka ringan or minor injury.
   K is *kerugian materi* or property damage only

2. Using the equivalent accidents number with the weighting system, which refers to the cost of the accident: M: B: R: K=12: 3: 3: 1 [32].

In this study, the equivalent accident number using a conversion from accident cost. Casualty accident costs by severity type: fatal or died is IDR 263,025,680.96; severe injury is IDR 12,066,000; minor injury is IDR 1,904,312.87, and property damage only is IDR 1,562,909.09. Giving the value M: B: R: K = 168: 8: 2: 1.

CONCLUSIONS

Based on the results, the following conclusion can be drawn:

a) Casualty accident costs by severity type: fatal (died) is IDR 263,025,680.96; severe injury is IDR 12,066,000; minor injury is IDR 1,904,312.87, and property damage only is IDR 1,562,909.09.
b) Road traffic accidents cost in Purbalingga by severity type: fatal (died) is IDR 294,916,596.65; severe injury is IDR15,723,214.18; minor injury is IDR 3,783,302.44, and property damage only is IDR 1,562,909.09.
c) The total accident cost in Purbalingga was estimated to be roughly IDR 27,582,518,750 or 0.38% of the gross domestic product.
d) Equivalent accident number using a conversion accident cost M: B: R: K = 168: 8: 2: 1.

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