

Calculating the cost of time loss in traffic accidents by different types of roads and vehicles(Case Study: Khorasan Razavi rural roads)

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ABSTRACT

In cost-benefit analysis and prioritization of safety countermeasure, it is necessary to estimate the social costs of accidents. One of the crash costs is the cost of users' time loss due to delays caused by accidents. In most studies, this factor has been ignored or considered only as a general estimate and no specific method has been considered for it. In this research, an analytical method has been proposed to calculate the cost of the delay caused by the accident and the factors affecting it have been investigated. Another objective of this paper is to investigate and compare the cost of time loss to road users in different types of accidents according to type of vehicles and roads. In a case study, total time loss of users in various accidents is calculated. The results show that accidents on freeways-highways and especially heavy vehicle accidents, cause the most wasted time for users. Total time loss in each injury or fatal accident on the freeway-highway, major road and secondary road is 2039.65, 700.39 and 95.90, respectively. Also, it is found that the share of freeway-highway, major and secondary roads from the total time lost in rural accidents is 43.69, 54.92 and 1.39 percent, respectively. The average time lost in each rural accident is 869 people - hour and its cost in 2016 is equal to 27.3 million Rials, which is about 0.6% of the total cost of rural accidents. The results show that although the cost of time lost in accidents on low-traffic roads can be neglected, it is still significant in on expressways and highways.

KEYWORDS

Rural accident, traffic safety, crash cost, traffic delay, time loss of accident

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Introduction

Calculating the cost of road accidents creates a more appropriate view of its impact on the economy and social welfare, and also justifies investing in safety. One of the crash costs is the cost of time lost in traffic congestion due to accidents. In a study on traffic congestion costs, Kim [1] mentioned accidents as one of the factors affecting traffic congestion. Also, Bardal and Jørgensen [2] in their research on the importance of delay costs and seasonal changes in road accidents have shown that the cost of delay is about 10% of the social costs of accidents, and especially this cost is higher in winter.

The purpose of this study is to investigate and calculate the cost of delay due to the accident and the factors affecting it. Also, the cost of delay for road users in different types of accidents (separately for heavy and light vehicles) and different types of roads (freeway-highway, main road and side road) are compared and evaluated using a case study.

Methodology

After the accident, occurs a blockage or disruption in traffic flow. This creates a delay for vehicles arriving at the scene of the accident. The number of vehicles in the queue increases with the rate g_i and after the handling time, the queue of vehicles decreases with the rate g_f and disappears. Handling time means when the vehicles and effects of the accident are removed from the lanes, which is the function of "arrival speed of rescue equipment and time to eliminate the effects of the accident. The model defined by Custer and Wright [3] is used to calculate the loss time and the maximum queue length. According to this model, the total time loss for all vehicles (TTL_v) is equal to:

$$TTL_v = \frac{1}{2} \times g_i \times HT^2 \times \left(1 + \frac{g_i}{g_f}\right) \quad (1)$$

The total time loss of users (vehicle occupants) can also be calculated as follows:

$$TTL_p = TTL_v \times \frac{\sum_{i=1}^n n_i \times p_i}{\sum_{i=1}^n n_i} = TTL_v \times \bar{P} \quad (2)$$

Where \bar{P} is the average number of vehicles occupants and p_i and n_i are the average number of occupants and the number of vehicles of the i -th type, respectively.

The total cost of time loss due to the accident is calculated as follows:

$$TC = \left[\sum_{j=1}^m C_j \times R_j\right] \times TTL_p \quad (3)$$

Where R_j and C_j are the share and cost of the trip with goal j , respectively, of the total trips.

Case study

In this section, using a case study in the roads of Khorasan Razavi province, Iran, the amount of time lost and its average cost are analyzed separately by road and accident types. Information on fatality and injury accidents [4,5] has been considered and the road blockage situation has been obtained by examining 207 accident reports that have a more detailed description. The handling times are also estimated based on interviews with experts who are present at the scene to investigate the accident.

Figure 1 show the total time loss in accidents by road and accident types. These values are calculated using Equation (1). The weighted average of the lost time is obtained according to the ratio share of each type of accident in these roads.

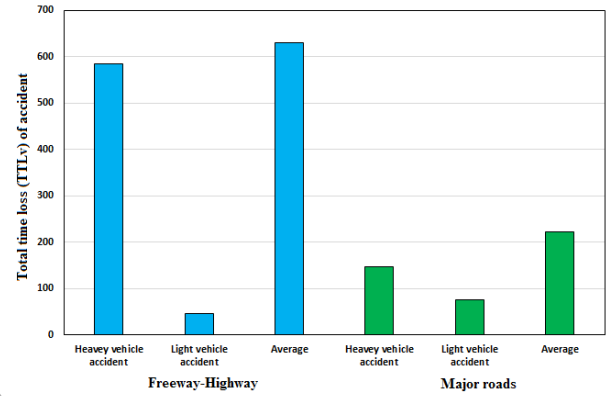


Figure 1. Total time loss in various types of road accidents and the share of light and heavy vehicle accidents (fatal or injury accidents)

The average occupant of each vehicle is equal to 3.13 people [6] and using Equation (2) the total time loss of users (TTL_p) can be calculated. Based on household income and household size and number of working hours per month [7], the average per capita income is 40,278 Rials per hour. On the roads of Khorasan province, business trips make up 56% of trips and non-working trips 44% of the trips [6].

Based on purpose, 56% of trips are work trips and 44% are non-work trips. Therefore, according to equation (3) and assuming that the value of non-working hours is 50% of the value of working hours, the value of lost time is calculated as 31417 Rials per hour. Depending on the road type, the value of time lost in each accident on major roads and freeways is 2.2 and 6.4 million Rials, respectively.

Results and discussion

Equation (1) shows that there is a quadratic relationship between total time loss and accident handling time.

Table 1. Cost of time loss in injury or fatal rural accident

	Freeway-highway	Major roads	Secondary roads	Weighted average for rural road
Accident share (percent)	18.6	68.1	13.3	100
Time loss (person-hours)	2039.65	700.39	95.90	869.1
Cost (Rials)	64079648	22004153	2855805	27283465

Therefore, a small reduction in the handling time and elimination of the accident bottleneck will have a greater effect on reducing the TTL.

The results of Table 1 show that despite the smaller handling time on freeways compared to the major roads, due to the high volume of traffic and the higher share of the heavy vehicle accidents on freeways, the amount of time lost on this type of roads is higher. By considering the share of accidents in each type of road, the weighted average of time loss for a rural accident is equal to 2.7 million Rials. Ayati [8] has calculated the total cost of a rural accident in 2007 equal to 987.2million Rials. Taking into account the inflation coefficient in the years 2007 to 2016, the cost of each rural accident in 2016 is estimated at 4.6 billion Rials. It can be concluded that the share of time loss in accidents is about 0.6% of the total cost of rural accidents.

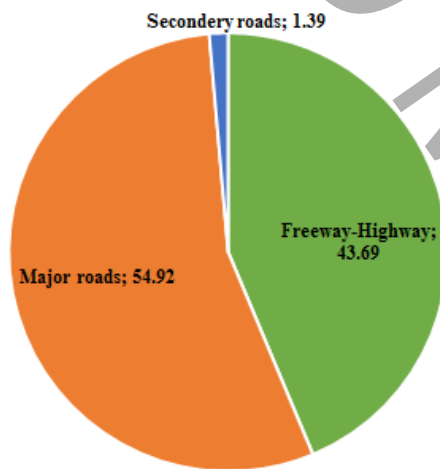


Figure2. Contribution of various roads from the cost of time loss in rural injury or fatal accidents

Conclusion

In this paper, first, the degree of dependence of the total lost time with the time of elimination of the effects of the accident was determined. Also, in order to investigate the importance and magnitude of this time, by separating rural accidents in terms of type of road and vehicle types involved in the accident, it was found that heavy vehicle accidents on freeways creates the most time loss for users

arriving at the crash site. The shares of time loss in rural accidents for freeways, major roads and secondary roads are 43.69, 54.92 and 1.39 percent, respectively. The average TTL_P in each fatal or injury rural accident is 869 people-hours and its cost in 2016 is equal to 27.2 million Rials. Accurate calculation of this cost can be useful in analyzing economic returns and cost-benefit analysis of all safety projects, especially projects that reduce handling time of accident. In future research, uncertainty along with some factors can be corrected. Considering the effect of traffic flow fluctuations in day hours and accident time (peak or non-peak) are some of these cases.

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