Trauma Mon. 2017 March; 22(2):e35997. doi: 10.5812/traumamon.35997.
Published online 2016 August 10. **Research Article**

# Medical Costs and Economic Burden Caused by Road Traffic Injuries in Iran

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**Received** 2016 January 23; **Revised** 2016 April 18; **Accepted** 2016 July 31.

**Abstract**

**Background:** Road traffic injuries (RTIs) impose a significant social and economic burden.
**Objectives:** The objective of this study was to estimate the medical costs and economic burden caused by RTI in Iran
**Methods:** The major components included in this study were medical costs, lost output, and indirect costs. Cost components and their values in 2011 were obtained using previous data collected during the study. A general approach that included a consideration of capital was used to calculate the cost of RTIs.
**Results:** The economic burden of RTIs was estimated to be more than 111,000 billion Iranian rials (IRR) ($4.44 billion USD) in 2011. This cost relates only to the health sector and does not include components such as vehicle damage, lost time in accidents, and the administrative costs of insurance and police services. The estimated cost of RTIs to the health sector was about 2.18% of Iran's total GDP in 2011.
**Conclusions:** The medical costs and economic burden caused by RTIs in Iran clearly indicate that injuries should be a significant concern for health policymakers and medical planners.

*Keywords:* Road Traffic Injuries, Economic Cost, Medical Costs, Lost Output, Indirect Costs

## 1. Background

Approximately 1.24 million people die every year on the world's roads, and another 20 - 50 million sustain nonfatal injuries as a result of road traffic injuries (1). Injuries resulting from traffic accidents have various economic, social, and health aspects, and therefore, this burden should be carefully examined to allow for a complete understanding of these injuries and for the efficient allocation of resources.

The outcomes of such a study may be used directly in macroeconomic decision-making and resource allocation. The World Health Organization (WHO) has emphasized importance of the estimation of the economic costs and burden of road traffic injuries (RTIs) on societies and their role in the cost-efficiency analysis of road safety measures. The estimation of the indirect costs of RTIs in addition to their direct costs was an issue of concern for the WHO (2).

A general approach that included a consideration of human capital (HC) has been used for the calculation of road traffic accident costs in different countries. Comprehensive costs, which include lost quality of life, obtained on the basis of the willingness to pay method, have been introduced in the US's calculation of the cost of RTIs (3). In Australia, new methods were introduced against the traditional HC method, and life value was estimated using the willingness to pay method (4, 5). Additionally, a hybrid approach that combined HC with lost wages and a national value based on life lost due to premature death was employed (6). The long-term impacts of RTIs as a result of the social and economic outcome of such injuries were investigated in European countries (7). In low- and middle-income countries, use of the HC approach to calculate the cost of RTIs has been recommended. In these countries, higher shares of gross domestic product (GDP) have been observed for the cost of road accidents. In most cases, the share exceeds 1% of the GDP of one of these countries (8-10).

Studies have been estimating the costs of RTIs, and the cost estimates of these injuries have been updated in several different phases. In a comprehensive survey conducted in 2004, the total cost of rural road crashes in Iran was estimated to be more than 25,000 billion Iranian rials (IRR), which was a significant amount (as much as 5% of Iran's GDP in that year) which shows that RTIs and their related economic burden on society have a tremendous impact (11). The cost of traffic injuries among Iranian drivers of public vehicles constituted 1.25% of the gross national income in 2013 (12). The costs of traffic injuries in Iran in

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2013, which was calculated using the willingness to pay method, accounted for 6.46% of the gross national income (13).

The objective of this study was to estimate the medical costs and economic production losses caused by RTIs in Iran.

## 2. Objectives

This study reviewed estimations of the economic cost of healthcare and losses due to urban and rural traffic injuries throughout Iran. Therefore, all levels of injuries, including minor injuries (outpatient and nonhospital treatments), severe injuries (inpatient), fatalities, and physical disabilities and the lasting effects of these injuries were examined in this study. In general, these costs included all those incurred by society, including the victims, their families, and the state.

## 3. Methods

The major components, according to the recommendation by the ADB (14), included medical costs, output (production) loss, and human costs (pain, grief, and suffering). The casualty-related cost components of RTIs were the issues of concern in this study.

Medical costs were a major part of the direct costs imposed by RTIs. Medical costs included all treatment expenses concerning a victim who was receiving services regardless of whether the victim died or survived. All related data, including hospital treatment costs, inpatient duration, and emergency medical service (EMS) stations and missions, were adopted from the Iranian ministry of health and medical education (MOHME).

The components considered part of medical costs were prehospital costs, hospital treatment costs, posthospital costs, nonhospital costs, lost output, and indirect costs.

Prehospital costs included the total expenses related to dispatch, at-scene treatment, splinting, control of bleeding, patient transfer, and other actions that were completed through the whole procedure from the moment of the announcement of the accident, to the emergency room, to the transfer patients to the hospital. This cost included the fixed costs of EMS stations and the variable costs of urban, rural, or air EMS missions. To estimate the fixed costs of emergency rooms, the total cost of each kind of station should be multiplied by the number of stations. EMS stations could be separated into three categories: urban, rural, and air (helicopter) stations. Thus, regarding the share of each kind of station by traffic missions, the total fixed cost of emergency rooms was calculated using the following Equation 1:

$$C_{EMS,F} = \sum_{i=1}^{3} r_{S,i} \times C_{S,i} \times N_{S,i} \quad (1)$$

Where:

$C_{EMS,F}$ = *the fixed costs of EMS in association with traffic injuries.*

$r_{S,i}$ = *the share of stations type i in traffic accident missions.*

$C_{S,i}$ = *the cost related to EMS station type i.*

$N_{S,i}$ = *the number of stations with type i.*

The costs related to fire services, Red Crescent rescue services, and private clients transferred by private vehicles were considered part of the prehospital costs. To estimate the costs associated with private clients, two categories of information, including the number of private clients and their transfer costs, were estimated. Among the data received from the treatment deputy of the health ministry about the specifications of over 320,000 traffic casualties in 2011, the information associated with how casualties were transferred to hospital was inserted, and the number of private clients was estimated by adding this information to the total number of traffic casualties.

The cost of hospital treatment holds a large share of the direct expenses of traffic injuries. These costs included all expenses paid by RTI victims or the government, the total costs related to outpatients' treatment in emergency rooms, and posthospital costs for all levels of injuries. The careful analysis of hospital treatment cost data related to traffic injuries required a classification system for injuries. Therefore, a system was provided that suitably matches the six-level Abbreviated Injury Scale (AIS). Explanatory measures, including minor, medium, serious, severe, critical, and fatal, were assigned to the severity levels of the six scales. Using the AIS, the following measures were estimated: (1) the cost data clustered in all six groups, (2) the data clustering for the hospitalization period in all six groups, and (3) the cost per night and total hospital treatment cost in each injury severity group. The outpatients' treatment costs were considered for the group of RTI victims who stayed in the hospital for less than one night and whose injuries did not result in death. The unit cost of outpatients was considered to be 1/4 of the cost of a nightly hospital visit, as recommended by the ADB (14).

Posthospital costs were calculated for victims who left the hospital after a full or relative recovery or those who personally wished to leave after visiting to the hospital and being supplied with services as either an outpatient or an inpatient. After discharge, costs were generally related to items such as physiotherapy and orthopedics, subsequent surgeries, prostheses and artificial limbs, drugs, nursing and at-home care, and further medical visits and treatments. The best way to find out posthospital costs was through a previously designed telephone survey, part of which was related to posthospital costs. The number of discharged victims was extracted from MOHME treatment data.

Nonhospital treatment costs were estimated for outpatients who accomplished their treatments at home or nonhospital treatment centers. Since there were no exact statistics about the number of casualties in this group, calculations were carried out on the basis of previous studies (15) on multiple health and population indices. Since all the data from the studies used in this analysis originated in the year in which the RTIs analyzed by the present study occurred (2011), no discount was needed to estimate the present value.

Lost output is used as a criterion in the HC approach, which was based on GDP. Lost output consists of costs that are related to the loss of national production or lost income from death, hospitalization, or physical disabilities. This cost refers to the amount of economic loss and wage cut that is forced on families and society because of a victim's inactivity in the years during which they are affected by the accident.

To calculate the total lost output due to death or disability, determining the years of life lost to death of disability was necessary. The determination of the difference between life expectancy and the average age of a person who was killed or disabled due to a traffic accident was the simplest but somehow unconvincing method for this purpose. In recent years, the disability-adjusted life years (DALY) index has been used as an appropriate method for measuring the mortality and disability burden of different diseases. The DALY index is a method used to measure health gaps in society that combines time lost due to premature death and time related to a nonfatal condition (16). The DALY index for a definite disease was defined as the total years of life lost due to a premature death (YLL) and the years lost due to disability (YLD) for the disease:

$$DALY = YLL + YLD \tag{2}$$

Determining the loss of healthy life due to nonfatal status requires an estimation of the incidence of a disease within a distinct period. YLL is a function of mortality rate and the duration of life lost due to death at each age. In this study, the YLL and YLD indices were calculated using the instructions addressed in the practice guide for national burden of disease studies (16). The relationship that was used for the calculation of YLL for each age interval is defined as follows:

$$YLL = 6.4766Ne^{(0.12)}\left[e^{-0.16(L+a)}\left[-0.16\left(L+a\right)-1\right] - e^{-0.16a}\left[-0.16\times a-1\right]\right] \tag{3}$$

Where:

N = the number of people killed in each age range.

L = years of life lost due to premature death or disability.

a = the average age of victims for each age interval.

The number of effective years of lost life was obtained for each age interval using this equation. The calculation for lost output due to disability was similar to the calculation for YLL; however, this loss was measured based on the weight of each disability due to occurrence of a particular disease. Accordingly, the equation for estimating YLD for all age intervals is defined as follows:

$$YLD = 6.47661\times DWe^{(ra)}\left[e^{-0.16(L+a)}\left[-.016\left(L+a\right)\right] - e^{-0.16a}\left[-0.16\times a-1\right]\right] \tag{4}$$

Where DW represents the disability weight. By using the aggregation values of the YLD indices for each age interval, the average years of life lost can be calculated for each age interval (17).

The indirect costs of RTIs include the elements of costs for which no equal market price was found. This cost item covers cases that have a qualitative nature and require quantification through specific methods.

In case of death or disability of a family member in an accident, the social and economic foundation of the family was threatened, which can lead to profound social and cultural damage, such as the loss of the possibility for a victim's children's education or the possibility of improper upbringing of these children. The cost of pain, grief, and suffering (PGS) was a proportion of the total RTI cost. The guidelines for RTI cost estimation in low- and middle-income countries (18) recommend the use of proportions of the share of the total costs of death and injury: 28% of total costs for a fatal crash, 50% of total costs for a serious crash, and 8% of total costs for a slight crash.

The same ratios have been used in low- and middle-income countries in many studies (9, 19, 20), so the total HC cost due to RTIs could be obtained by accumulating the effect of reduced quality of life on economic loss due to medical expenses and loss of output production. To extract the proportion of total PGS costs from total costs, the cost per death and injury was calculated for each RTI victim.

The other cost component of indirect costs was lowered functional capacity due to RTIs. The functional capacity index (FCI) is a quantity scale related to the consequences of traffic injuries that was introduced by Mackenzie et al. (21). The FCI divides the normal functional abilities of one person into ten major sections and assigns a coefficient between zero and one for each section in order to represent a quantified sign of the anticipated reduction in the person's functional capacity. A coefficient of zero is evidence that no reduction in functional capacity was created, while a coefficient of one represents a complete loss of capacity in every part of the considered ten sectors. In order to quantify the effect of lowered functional capacity, information necessary for estimating the costs related to lowered functional capacity was taken into account, including injury severity, the FCI of each group of injury severity, the length of treatment period, the total time of lowered functional capacity, and the GDP per capita as the unit cost measure.

## 4. Results

Tables 1 and 2 show the estimation of total costs for traffic victims in the Iran, which has been divided into three classifications: the main classification, cost components, and details of costs.

The total RTI cost, which was calculated using the HC method (medical cost, lost output, and lowered quality of life), was 111,342 billion IRR (US $4.5 billion) (Table 1). Figure 1 shows the medical expenses divided into the three main categories, the lost production according to the cost elements, and the details of posthospital costs, which were the largest proportion of traffic injury costs. Table 2 shows the estimated cost per road traffic fatality and physical disability in 2011; the total cost per road traffic fatality and physical disability was 1688.318 and 1063.206 million IRR (US $67,500 and $42,500), respectively (Table 3). Figure 2 compares the cost components per fatality and disability. Table 3 shows estimates of the medical cost per casualty in 2011; the total medical cost was 1276.854 million IRR (US $51,000) (Table 4). Finally, taking the total cost of items using the HC method, the economic burden of traffic injuries was estimated to be more than 111,000 billion IRR (US $4.4 billion) in 2011, which was 2.18% of Iran's total GDP in 2011. Notably, this cost was related only to the health sector and did not include elements such as vehicle damage, time lost in accidents, and the administrative costs of insurance and police.

## 5. Discussion

The total cost of traffic injuries was estimated to be more than 111,000 billion IRR (US $4.4 billion) in 2011. By counting Iran's GDP, which was equal to 5,100,000 billion IRR (US $204 billion) in 2011, the estimated cost of RTIs to the health sector was about 2.18% of Iran's 2011 GDP. This cost has a value equivalent to 75% of the total funds allocated to Iran's health sector in 2011. The last studies conducted on comprehensive crash costs in Iran showed that 7% of Iran's GDP was lost to road traffic crashes in 2007 (12).

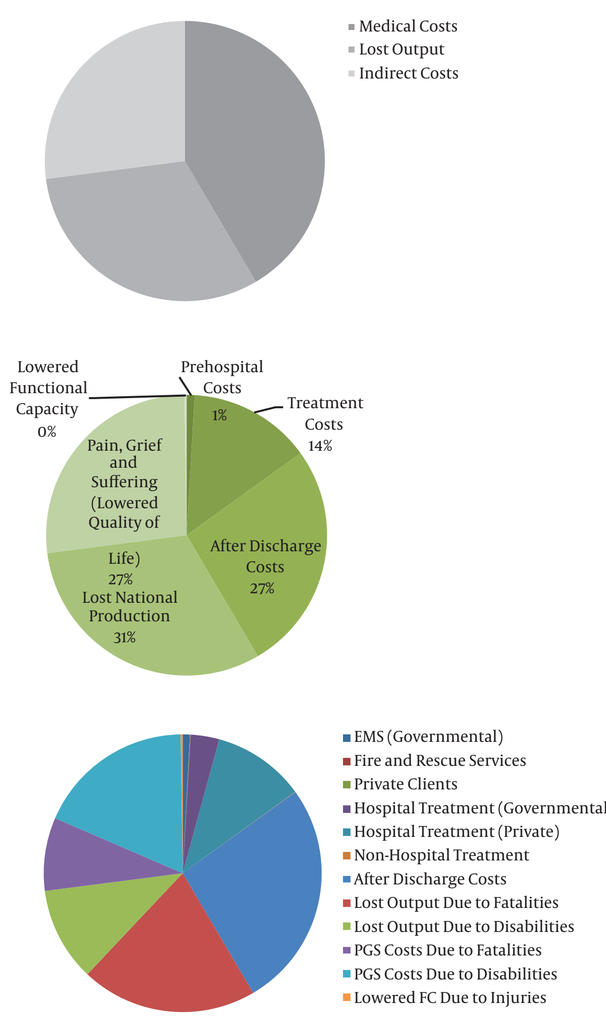


**Figure 1.** Estimated RTI Cost Components in Iran in 2011

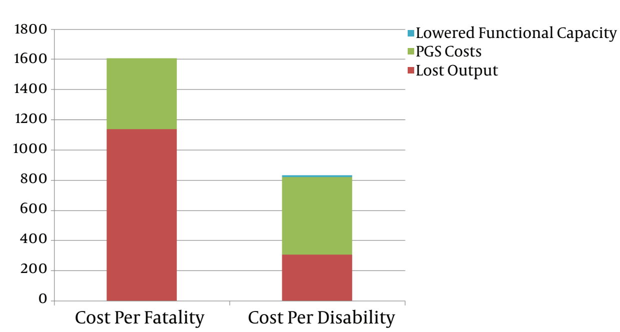


**Figure 2.** Comparison of cost Components Per Fatality and Disability

The results of Van Beeck et al.'s study on medical costs and economic production losses showed that the cost of RTIs was a key source of production loss. More than 80%

**Table 1.** Total Road Traffic Injury Costs in Iran in 2011

| Main Categories | | | | Cost Components | | | |
|---|---|---|---|---|---|---|---|
| **Title** | **Cost (Billion IRR)** | **Cost (Billion US Dollars)** | **Cost Rate (%)** | **Title** | **Cost (Billion IRR)** | **Cost (Million US Dollars)** | **Cost Rate (%)** |
| **Medical costs** | 52508.794 | 2.1 | 43.92 | Prehospital costs | 1022.692 | 40.907 | 0.919 |
| | | | | Treatment costs | 15738.828 | 629.553 | 14.136 |
| | | | | Posthospital costs | 29476.000 | 1179.040 | 26.473 |
| **Lost output** | 34997.172 | 1.4 | 29.23 | Lost national production | 34997.172 | 1399.887 | 31.432 |
| **Indirect costs** | 32152.757 | 1.29 | 26.85 | Pain, grief, and suffering (lowered quality of life) | 29846.740 | 1195.387 | 26.806 |
| | | | | Lowered functional capacity | 260.987 | 10.439 | 0.234 |

**Table 2.** Details of the Total Road Traffic Injury Costs in Iran in 2011

| Title | Title | Cost (Billion IRR) | Cost (Million US Dollars) | Cost Rate (%) |
|---|---|---|---|---|
| **Medical costs** | EMS (governmental) | 917.445 | 36.7 | 0.82 |
| | Fire and rescue services | 55.508 | 2.22 | 0.05 |
| | Private clients | 49.739 | 1.49 | 0.04 |
| | Hospital treatment (governmental) | 3713.220 | 148.53 | 3.33 |
| | Hospital treatment (private) | 11987.000 | 479.48 | 10.77 |
| | Nonhospital treatment | 38.608 | 1.54 | 0.03 |
| | Posthospital costs | 29476.000 | 1179.04 | 26.47 |
| **Lost output** | Due to fatalities | 0.05 | 0.002 | 20.50 |
| | Due to disabilities | 0.04 | 0.001 | 10.93 |
| **Indirect costs** | Due to fatalities | 3.33 | 0.13 | 8.53 |
| | Due to disabilities | 10.77 | 0.43 | 18.28 |
| | Due to injuries | 260.987 | 10.4 | 0.23 |

**Table 3.** Estimated Cost Per road Traffic Fatality and Physical Disability in 2011

| Cost component | Cost Of Road Traffic Physical Disability | | Cost Of Road Traffic Fatality | |
|---|---|---|---|---|
| | **Million IRR** | **US Dollars** | **Million IRR** | **US Dollars** |
| **Medical costs** | 228.536 | 9,141 | 79.568 | 3,183 |
| **Lost output** | 307.13 | 12,285 | 1136.05 | 45,442 |
| **Pain, grief, and suffering** | 513.35 | 20,534 | 472.7 | 18,908 |
| **Decrease in functional capacity** | 14.19 | 568 | - | - |
| **Total** | 1063.206 | 42,528 | 1688.318 | 67,533 |

of indirect costs belonged to young males (22). Connelly et al. (23) showed that the annual cost of RTCs in Australia in 2003 was approximately $17 billion, which was approximately 2.3% of the GDP. There was a noticeable variation in

**Table 4.** Estimated Medical Cost Per Casualty in 2011

| Injury Severity | Hospital Treatment (Governmental) | Hospital Treatment (Private) | After Follow-Up | Prehospital Cost | Lowered Functional Capacity | Total Medical Costs | |
|---|---|---|---|---|---|---|---|
| | | | | | | Million IRR | US Dollars |
| **Nonhospital treatment** | 0.000 | 0.246 | 0.000 | 0.000 | 0.000 | 0.246 | 10 |
| **Outpatient injuries** | 0.246 | 0.246 | 0.000 | 1.105 | 0.000 | 1.351 | 54 |
| **1** | 6.216 | 12.828 | 31.300 | 1.105 | 0.005 | 51.454 | 2,058 |
| **2** | 48.094 | 24.460 | 59.400 | 1.105 | 0.143 | 133.202 | 5,328 |
| **3** | 147.875 | 28.926 | 81.700 | 1.105 | 1.269 | 260.875 | 10,435 |
| **4** | 316.412 | 47.000 | 149.500 | 1.105 | 6.960 | 520.978 | 20,839 |
| **5** | 573.393 | 39.400 | 343.300 | 1.105 | 30.503 | 987.701 | 39,508 |
| **6** | 813.317 | 20.000 | 310.000 | 1.105 | 132.423 | 1276.845 | 51,194 |

incidence of RTCs by region, and the costs of RTIs ranged from 0.62% to 3.63% of the gross state product in Australia. The present study's findings are in line with Van Beeck et al.'s and Connelly et al.'s studies.

Trawen et al. (24) conducted a study intended to assemble information about RTI costs adopted by authorities in 19 countries. Great Britain, New Zealand, Sweden, and the US conduct their own willingness to pay surveys, while in Finland; the cost of RTIs is calculated using the value of lost productivity and the cost of care for an institutionalized disabled person. In Australia, Austria, Germany, and Switzerland, the cost of RTIs is calculated using the HC method and insurance payments. Trawen's study showed that choosing a RTI cost estimation method was a challenging issue.

Haghparast-Bidgoli et al. (25) showed that the hospital charges of RTIs were related to the age, gender, socioeconomic and insurance status, injury specifics, and health outcomes of an injured person. Estimations of individual costs need to consider the components of the effective cost of each category of injury severity. In other words, the cost that was imposed on society because of each death, disability, or injury of any severity level should be clear. For this purpose, all items described in the process of cost calculation for estimating the individual costs of death, disability and injury have been used in the study. The PGS cost for a disability was higher than the PGS cost for a fatality, which resulted in higher values of medical costs and longer duration of treatments while still losing production of the disabled victim.

### *5.1. Conclusion*

The casualty-related cost components of RTIs were the issue of concern in this study. Cost components and their values in 2011 were obtained. The economic burden of RTIs was estimated to be more than 111,000 billion IRR in 2011. The estimated cost to the health sector was about 2.18% of Iran's total GDP in 2011. This cost has a value equivalent to 75% of the total funds allocated to Iran's health sector in 2011.

## Acknowledgments

This article is the result of a project funded by the WHO's Eastern Mediterranean regional Office as a subprogram for governing the economic, health, and social impact of RTIs in a road safety plan in Iran. The authors thank all colleagues in the ministry of health and medical education who provided data for the different sections of this project. The authors especially thank Professor Ayati for his contribution of sharing copies of previous research of the base national experiences that were used in this study.

## Footnote

**Authors' Contribution:** Study concept and design: Hamid Reza Behnood; acquisition of data: Mashyaneh Haddadi and Reza Rezaei; analysis and interpretation of data: Hamid Reza Behnood; drafting of the manuscript: Hamid Reza Behnood; critical revision of the manuscript for important intellectual content: Elaheh Ainy; statistical analysis: Hamid Reza Behnood; administrative, technical, and material support: Shadrokh Sirous and Mashyaneh Haddadi; study supervision: Shadrokh Sirous.

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