

Clinical Article



Measuring Catastrophic Costs in Families Facing Traumatic Brain Injury in Iran

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ABSTRACT

Objectives: Traumatic brain injury (TBI) is preventable and expensive. The medical costs of TBI can be too high for some households and might lead to poverty, malnutrition, and loss of assets, which are called catastrophic expenditures. In this study, we investigated the incidence of catastrophic costs associated with TBI caused by road accidents in a province in northern Iran.

Methods: This prospective study involved a 1-year follow-up after the accident. Data of 220 patients were collected from the medical records of the Poursina Hospital, Rasht, Iran from March 2018 to February 2020. Direct and indirect costs faced by the households of patients with TBI and catastrophic costs related to TBI were calculated. Regression models were obtained and sensitivity analyses were performed at the end of the study.

Results: In total, the prevalence of households TBI-related catastrophic costs (TBICC) was 45.5%. Households of female patients (odds ratio [OR]: 0.289, $p=0.042$), households of retired patients (OR: 0.053, $p=0.005$), and households falling in the fifth quintile of wealth (OR: 0.370, $p=0.050$) faced lower TBICC compared to other groups. The Activities of Daily Living scores had a significant negative relationship with TBICC.

Conclusions: Political interventions such as implementation of insurance schemes, exemptions from payment for certain groups, identification of poor households, and coverage of assistance services can protect households from catastrophic health expenditures.

Keywords: Traumatic brain injury; Catastrophic; Income; Direct service costs; Iran

INTRODUCTION

According to the World Health Organization (WHO), road accidents result in the death of more than 1.2 million people and cause injury to 20–50 million people worldwide annually, with an incidence of more than 90% in low- and middle-income countries.¹⁰⁾ Road accidents in Iran result in the death of thousands of individuals every year, resulting in a huge cost to

Conflict of Interest

The authors have no financial conflicts of interest.

the country's economy. The number of road accidents in Iran is 20 times higher than that in the rest of the world. Every 19 minutes, one person in Iran dies from a road accident.¹⁷⁾ Road traffic accidents can be costly and tragic, especially when associated with traumatic brain injury (TBI). TBI is an unpredictable and costly condition. Medical costs of TBI can be too high for some households and may lead to poverty, malnutrition, and loss of assets, which are drivers of catastrophic expenditures.⁷⁾ Two types of catastrophic health expenditures were discussed by the WHO. Catastrophic expenditures related to general health, also called catastrophic expenditures regardless of the type of disease, occur when the direct expenditure for medical services (out-of-pocket payments) exceeds 40% of a household's ability to pay.³⁾ A study in Tehran showed that 2.4% of all households fell below the poverty line due to out-of-pocket payments for healthcare services, 6.7% had to pay out-of-pocket, and 3.8% faced catastrophic costs.⁴⁾

Another type of catastrophic health expenditure is that faced by households due to a specific chronic disease or injury. This type includes not only the out-of-pocket expenditures but also other expenditures such as travel costs for treatment, income loss due to absence from work, cost of nursing care, and cost of medical equipment.³⁾

TBI may have many side effects such as paralysis, disability, and loss of income.¹¹⁾ Patients' households also suffer from the stress of caring for the patients.^{2,15)} This may cause the caregivers to lose their jobs to care for the disabled person. The cost of treatment, surgery, and caregiving for a person with TBI may force a household to reduce the essential living expenses.¹⁾ In Iran, which is a developing country, the treatment for accidents is free in public hospitals. Hence, patients with TBI may not need to pay for the treatment. However, households of these patients have to bear many other costs after discharge from the hospital. Therefore, we investigated the incidence of catastrophic costs related to TBI caused by road accidents in a province in northern Iran.

MATERIALS AND METHODS

Study setting

This study included patients who suffered road traffic accidents and were referred to Poursina Hospital of Rasht, the capital of Guilan province in Iran. Poursina Hospital is a referral hospital for trauma patients and all cases of TBI in the Guilan Province are referred to this hospital. Guilan is a province in northern Iran near the Caspian Sea with a population of 2.7 million in 2021.

Design and samples

This prospective study involved a 1-year follow-up after the accident. Initial data were collected from the medical records of Poursina Hospital from March 2018 to February 2020. The inclusion criteria were International Classification of Diseases (ICD) (10th revision) codes S06.2 and S06.30, patients living in the Guilan province, and patients injured in traffic accidents. The inclusion criteria were patients alive at 1 year after the accident (at the follow-up time point), patients with other severe types of trauma that were not treated for more than 1 month after the accident, patients who did not answer the calls, and patients who refused to participate in the study. Data from 313 patients (all patients referred to the hospital between March 2018 and February 2020) were collected from the medical records of the hospital. Altogether, 54 patients died, and 39 patients did not answer the calls (response rate=84.9%).

Questionnaire

A panel of experts designed the questionnaire. This panel included 2 neurosurgeons, 2 health economists, 2 nurses, 2 hospital accountants, and 4 caregivers of TBI patients who were asked to discuss the expenses faced by the TBI patients. The questionnaire contained eight parts. The first part included pre-interview questions regarding data that could be collected from the patients' hospital medical records (out-of-pocket payments for treatment, costs for drugs and surgery as well as other hospital-based costs, time of injury, age, and sex). Medical expenses in Iran are low and all treatments for accidents are free for the first time at public hospitals. Therefore, out-of-pocket payments for treatment in public hospitals are zero in the majority of the cases. The second part of the questionnaire included questions about all non-hospital treatment expenses including psychiatric consultations, drugs, transportation, food, and nutrition plans related to TBI. Information about these expenses was obtained for 1 month. The third part included questions about expenses for long-term care including caregivers, nursing, physiotherapy, and other related expenses. Information about these expenses was obtained for 6 months. The fourth part of the questionnaire included questions about costs faced by the patients and their families due to loss of jobs including changes in the income of the patients and their families, absence from work due to TBI, changes in the time of work, and type of work (related to TBI). Information about these factors was collected for 1 year. The fifth part included questions about household income and household living assets including house ownership type (house owner or rental house); house surface area; and access to smartphones, washing machines, personal computers, and cars. The sixth part contained an activities of daily living (ADL) questionnaire. It is an eight-item questionnaire about personal hygiene, eating, clothing, mobility, walking, bathing, going to the toilet, and urinary and fecal control. The total ADL score ranges from 0 to 16, with higher scores indicating lower dependence on others. The questionnaire was confirmed psychometrically in Iran by Taheri et al. (2016).¹⁶⁾

Analysis

TBI-related catastrophic costs (TBICC) were calculated using the following equation:

$$T = \frac{\sum OOPM + OOPN + IN}{y}$$

In this equation, "OOPM" represents the monthly direct medical and non-medical TBI-related expenses paid by the patient and his/her family (both short-term and long-term), "OOPN" represents the monthly indirect medical and non-medical TBI-related expenses, "IN" is the loss of income faced by the patient and his/her family due to changes in job or absence from work (related to TBI), and "y" is the monthly household income. All cost-related data collected during the 6- and 12-month periods were converted to their 1-month equivalents. According to the WHO guidelines, if T exceeds 0.2, the household faces catastrophic costs. A logistic regression model was used to determine the relationship between different variables and catastrophic costs. Additionally, wealth status was calculated by applying a principal component analysis to household assets. The wealth status of households was categorized into five quintiles, ranging from the poorest to the richest.

Sensitivity analysis

A sensitivity analysis was performed by changing the threshold of catastrophic costs (T). Different new thresholds from 0.1 to 1 were added and changes in TBICC were assessed. Hence, household income might be estimated lower than its real amount, it was calculated indirectly from household assets. For this purpose, the 2016 Iranian household income and expenditure survey (HIES) was used, and a regression model was estimated as follows:

$$inc = \beta_1 + \beta_2 own_i + \beta_3 car_i + \beta_4 wash_i + \beta_5 smt_i + \beta_6 suf_i + \beta_7 comp_i + \varepsilon_i$$

In this equation, “inc” is the monthly income of each household (which was multiplied by the consumer price index between 2016 and 2020 (2.6) due to inflation during this period), “own” represents house ownership, “car” is access to a personal car, “wash” is access to a washing machine, “smt” is access to a smartphone, “suf” is the surface area of the house, and “comp” is access to a personal computer. The coefficients of the estimated model were used to indirectly estimate the income of TBI patients. New results for catastrophic costs were calculated using the estimated income.

All monetary values were presented in US dollars (USD) with an exchange rate of 185,000 USD-Iranian Rials. The Institutional Review Board (IRB) of the Guilan University of Medical Sciences (ethics code: IR.GUMS.REC.1400.272) approved the study (IRB approval code: 3434). Statistical analysis was performed using STATA SE version 14.1 (StataCorp LLC, College Station, TX, USA). All patients were informed about the project and verbal informed consent was taken from all cases.

RESULTS

Descriptive statistics are presented in **TABLE 1**. Among 220 patients, 190 (86.36%) were male, 38 (17.27%) did not have any insurance, 77 (35%) had social security insurance, 64 (29.09%) had rural insurance, and 21 (9.55%) had Iranian health insurance (**TABLE 1**). In addition, 25 (11.36%) were unemployed, 54 (24.55%) were out of the labor force (housekeepers and students), 119 (54.09%) worked in the private market, 8 (3.64%) worked for the government, and 14 (6.36%) were retired. Twenty-three (10.5%) patients were illiterate, 18 (8.22%) had completed primary school, 83 (37.9%) had completed secondary school, 75 (34.25%)

TABLE 1. Descriptive statistics

Variable	Frequency	Percentage
Insurance type		
Without insurance	38	17.27
Social security	77	35
Rural health insurance	64	29.09
Iranian health insurance	21	9.55
Others	20	9.09
Job before accident		
Unemployed	25	11.36
Out of labor market	54	24.55
Private market	119	54.09
Public sector	8	3.64
Retired	14	6.36
Complementary insurance		
Covered	24	10.9
Not covered	196	89.1
Educational status		
Illiterate	23	10.5
Primary school	18	8.22
Secondary school	83	37.9
High school	75	34.25
Academic degree	20	9.13
Sex		
Male	190	86.36
Female	30	13.64

had completed high school, and 20 (9.13%) had completed academic degrees. The mean (standard deviation; SD) age of the patients was 39.30 ± 1.36 years, mean (SD) monthly household income was 188.89 ± 7.37 USD, and mean (SD) ADL score was 11.28 ± 0.415 .

TABLE 2 shows the direct and indirect costs and income loss of TBI patients. The mean monthly direct expenses related to TBI were 11.86 ± 1.29 USD, mean monthly indirect expenses were 87 ± 18.96 USD, and monthly income loss was 73.59 ± 18.85 USD. The percentage of TBICC is also shown in the **TABLE 2**. Among 220 households, 100 (45.5%) experienced catastrophic costs, while 120 (54.5%) did not incur catastrophic costs.

FIGURE 1 shows the percentage of TBICC among different wealth groups. The percentage of catastrophic costs was highest in the first quintile (63%) (Poorest quintile) and lowest in the third quintile (37%).

TABLE 3 shows the results of logistic regression used to determine the relationship between different variables and TBICC. Households of female patients faced significantly lower TBICC (odds ratio [OR]: 0.289, $p=0.042$). Educational status of the patients did not have a significant relationship with TBICC. Households of retired patients (OR: 0.053, $p=0.005$) faced lower TBICC when compared with other job types. Households in the fifth quintile of wealth (OR: 0.370, $p=0.050$) faced lower TBICC compared to other wealth quintiles. ADL scores had a significant negative relationship with TBICC. Thus, households with patients having higher ADL scores faced lower TBICC (OR: 0.888, $p<0.026$). Access to health insurance did not have a significant relationship with TBICC, indicating that there was no significant difference in the risk of TBICC between insured and uninsured households.

TABLE 2. Direct and indirect costs, income loss, and catastrophic costs

Variable	Mean	Standard error	Lower limit	Upper limit
Direct costs (USD)	11.86	1.29	9.33	14.40
Indirect costs (USD)	87.00	18.96	49.62	124.38
Income loss (USD)	73.59	18.85	36.44	110.74
Incidence of catastrophic costs	45.45%	3.36%	38.82%	52.09%

USD: US dollars.

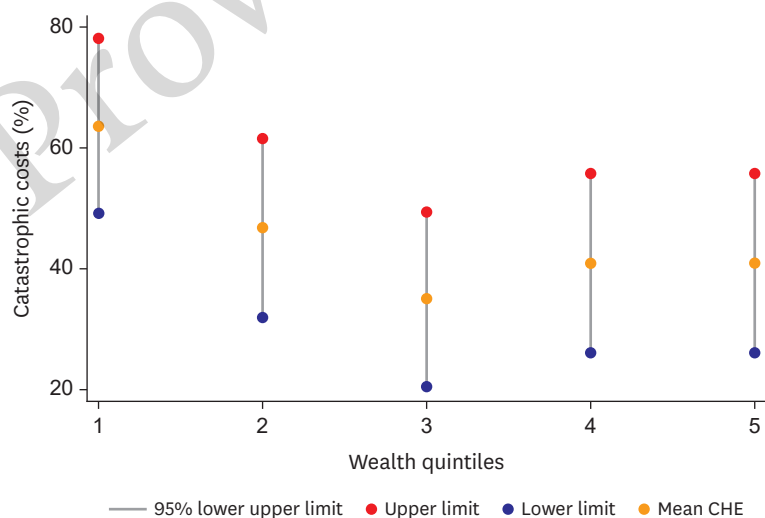


FIGURE 1. Traumatic brain injury-related catastrophic health costs in different wealth quintiles. CHE: Catastrophic Health Expenditures.

TABLE 3. Logistic regression model to assess the relationship between different variables and catastrophic costs related to traumatic brain injury

Variable	Odds ratio	Standard error	p-value	Lower limit	Upper limit
Sex (female)	0.289	0.177	0.042	0.087	0.958
Educational status of the patient			Illiterate (base)		
Primary	0.597	0.469	0.511	0.128	2.786
Secondary	0.400	0.238	0.123	0.125	1.283
High school	0.949	0.603	0.934	0.273	3.297
Academic degree	0.333	0.262	0.162	0.071	1.557
Insurance coverage	0.794	0.328	0.577	0.353	1.785
Job type of the patient			Unemployed (base)		
Out of labor force	0.614	0.362	0.408	0.193	1.949
Private market	0.749	0.412	0.599	0.255	2.201
Public sector	0.600	0.622	0.622	0.079	4.569
Retired	0.053	0.055	0.005	0.007	0.413
Age (years)	1.017	0.011	0.119	0.996	1.038
ADL score of the patient	0.888	0.026	0.000	0.838	0.941
Wealth quintile			First quintile (base)		
2	0.672	0.324	0.410	0.261	1.729
3	0.395	0.198	0.063	0.148	1.053
4	0.550	0.271	0.225	0.209	1.445
5	0.370	0.188	0.050	0.137	1.001
Constant variable	10.922	10.314	0.011	1.716	69.527

ADL: activities of daily living.

Sensitivity analysis

Changing the threshold of TBICC

FIGURE 2 shows the changes in TBICC according to different thresholds. Different thresholds ranging from 10% to 100% of the total income in the model were added to estimate TBICC. TBICC decreased with an increase in the threshold percentage. The changes were greater at lower thresholds. The incidence of TBICC was 55%, 40%, 37%, and 35% at the thresholds of 10%, 30%, 40%, and 50%, respectively.

Using estimated income instead of perceived income

The estimated income was calculated from a regression model using HIES from 2015. The estimated model was as follows:

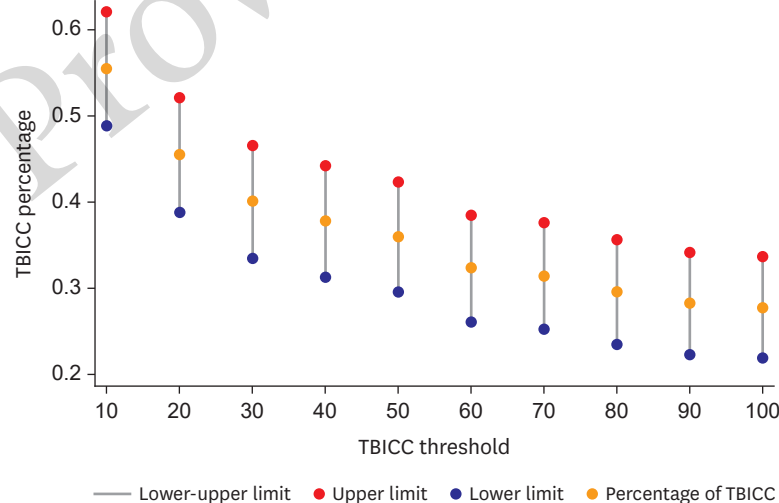


FIGURE 2. Sensitivity analysis of Traumatic Brain Injury-related catastrophic costs in different thresholds. TBICC: traumatic brain injury-related catastrophic costs.

$$inc = 2,565,886 - 1,464,099 own_i + 4,501,715 car_i + 10,100,000 wash_i + 5,219,014 smt_i + 27,977.55 suf_i + 4,721,994 comp_i + \epsilon_i$$

The estimated income was converted to USD and multiplied by the inflation rate between 2015 and 2020. Subsequently, it was used in the TBICC formula to calculate the incidence of TBICC. **TABLE 4** shows the incidence of TBICC according to the estimated incomes of households. The mean perceived monthly income was 188.89 ± 7.32 USD, while the mean estimated income was 166.64 ± 4.68 USD. Thus, 44.5% of the households faced TBICC when estimated income was used instead of perceived income for the calculation.

TABLE 5 shows the comparison of households facing TBICC and those not facing TBICC according to the perceived and estimated incomes. Altogether, 105 households did not incur TBICC, while 83 households faced TBICC according to both methods. Seventeen households faced TBICC according to the perceived income method, but not according to the estimated income method. Fifteen households incurred TBICC according to the estimated income method, but not according to the perceived income method.

DISCUSSION

In the present study, the incidence of TBICC was investigated while considering its effects on the families and households of the patients. Altogether, 45.4% of the households incurred TBICC. Our findings showed that a high percentage of TBI-related costs were indirect costs and costs due to income loss. According to the Iranian accident law, inpatient treatments for accidents are free in public hospitals. Therefore, the direct costs related to the treatment of TBI are very low in Iranian public hospitals. Furthermore, the Iranian Ministry of Health implemented the Health Evolution Plan in 2014. Diseases that might lead to catastrophic costs were identified to reduce the incidence of catastrophic costs to zero. As a part of this plan, hospital social workers had to identify low-income households to prevent the burden of catastrophic costs on these households.³⁾ The results of the present study showed that the Ministry of Health's efforts to decrease catastrophic costs were not too effective in patients with TBI, since these plans focused on direct costs and did not consider the indirect costs and costs due to income loss.

Our findings showed that families of retired patients and female patients had a lower risk of facing catastrophic costs. In Iran, females are not the main source of income for their families due to cultural considerations. Hence, their disabilities do not affect their family

TABLE 4. Catastrophic costs related to traumatic brain injury and perceived and estimated monthly incomes

Variable	Mean	Standard error	Lower limit	Upper limit
Facing TBICC (estimated income)	44.5%	3.4%	37.9%	51.2%
Household monthly income (perceived) (USD)	188.894	7.372	174.366	203.423
Household monthly income (estimated) (USD)	166.641	4.688	157.402	175.880

TBICC: traumatic brain injury-related catastrophic costs, USD: US dollars.

TABLE 5. Traumatic brain injury-related catastrophic costs based on perceived and estimated monthly incomes

Estimated income	Perceived income			
	Not facing	Facing	Total	
Not facing	105	17	122 (55.45%)	$\chi^2=109.747$ $p<0.001$
Facing	15	83	98 (44.54%)	
Total	120 (54.54%)	100 (45.45%)	220	

income. In addition, the income of retired individuals is not affected after being disabled or injured and the family does not face loss of income due to retirements. These 2 findings are very important in demonstrating the effects of income loss on TBICC.

We observed that insurance coverage did not influence the risk of catastrophic costs. This was because homecare and income loss are not supported by the health insurance plans in Iran. These findings are similar to those from a study in Vietnam involving severely injured patients.¹⁴⁾ A study in 2017 with a 5-year follow-up reported that the risk of catastrophic costs in trauma patients without insurance coverage was 70% in the United States. This risk was up to 93% in low-income groups.¹³⁾ Another study showed the effect of the Affordable Care Act services on reducing the out-of-pocket payments and catastrophic costs in trauma patients in the United States. These services helped reduce the risk of catastrophic costs from 12% to 8% in the total study population and from 29% to 20% in low-income groups.⁸⁾

In a study in Vietnam, the incidence of catastrophic health expenditure among patients with severe trauma and their caregivers or households was 3.1–11.7% and 1.4–6.1% in rural and urban areas, respectively.¹⁴⁾ Another study in Vietnam showed that 27% of the patients who had a high percentage of head trauma due to road traffic accidents experienced catastrophic costs.¹⁴⁾

According to the ADL index, the risk of TBICC in a household increases with an increase in the patient's disability (decrease in the ADL score). Disability has a direct impact on jobs and income sources.¹²⁾ Disabled individuals are a source of high burden on households and caregivers. This might result in other family members leaving their jobs for full-time care of the patient. At the same time, the costs of maintenance, purchase of medical equipment, physiotherapy, doctor visits, and home nursing services are much higher for patients with greater disability.^{6,9)} All these services result in considerable expenses, inevitably leading to TBICC.

The results of the present study showed that the risk of catastrophic costs was lower among high-income groups. Consistently, the incidence of catastrophic costs was 1.5 to 2.5 times higher in poor households with severely injured members compared to the rich ones.¹⁴⁾

Suggestions for policymakers

TBI often leads to severe injuries including complete paralysis. A high percentage of patients with TBI experience long-term disabilities, leading to a high socioeconomic burden. Since these patients and their caregivers often incur catastrophic health costs, they are forced to change their lifestyle, leading to deterioration of their quality of life. To overcome the high percentage of TBICC in Iran, the costs related to home care, physiotherapy, and other long-term care measures should be covered under health insurance. Universal health coverage is important for this purpose. Insurance services must cover new medical services, decrease out-of-pocket payments for the services, and include uncovered groups. In addition, poor families should be identified in hospitals and financial assistance should be considered. Poor families can be identified practically using the equation employed in the present study for calculating the wealth index and the outputs of the regression model to predict the risk of TBICC based on different socioeconomic variables.

The present study had some limitations such as recall bias, which means that many individuals might not have been able to remember the costs for their treatments. To overcome this bias, we asked the patients to consult their insurance payment records. Multiple traumatic injuries are inevitable in TBI patients which might affect the results

of income loss and indirect costs faced by the patients. However, we excluded cases with multiple severe traumatic injuries. Future studies should calculate the financial burden and catastrophic costs associated with other types of traumatic injuries.

CONCLUSION

A high percentage of households of TBI patients face catastrophic health expenditures. An increase in universal health coverage, identification of poor households, and social work to decrease the out-of-pocket payments can help decrease TBICC.

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