ORIGINAL PAPER

The Direct Costs of Patients with Traumatic Brain Injury in an Intensive Care Unit (ICU) in Cyprus

Despena Andrioti, PhD in Health Economics
Head, Ministry of Health and Social Solidarity, Athens, Greece

Photini Zenonos, RN, MSc in Health Management
Frederick University, Nicosia, Cyprus

Alexandra Skitsou, PhD in Health Services Research
Visiting Professor, Frederick University, Nicosia, Cyprus

Panayiota Kokkori, MD
Hippokration General Hospital, Athens, Greece

George Charalambous, MD, MSc, PhD
Hippokration General Hospital, Athens, Greece
Co-ordinator MSc in Health Management, Frederick University, Nicosia, Cyprus

Correspondence: Andrioti Despena, Paritsi 67, 15451, N. Psychiko Athens, Greece. dandrioti@gmail.com

Abstract

Background: The traumatic brain injuries are one of the leading causes of morbidity and mortality in our country. But studies that relate to the cost of hospitalization in the Unit are very limited.
Objectives: To microeconomically assess the direct costs of patients with traumatic brain injury in Nicosia Hospital.
Methodology: We got a convenience sample of all patients (7) who were hospitalized from July to September 2010. (a) The age, duration of stay, severity of incident and costs of all therapeutic procedures were surveyed using descriptive statistics (b) Pearson chi-square was used to investigate correlations between variables. (c) Multivariate Regression Analysis was employed for the investigation of factors affecting the cost of treatment. Age, duration of hospitalization and the cost of individual treatments were considered as independent variables for the direct cost. All tests were considered to be significant at a 5% level. Analysis was carried out using SPSS 20.0.
Results: The average cost of hospitalization of the patients with traumatic brain injury in the Unit was € 18,659.51 (€ 2,936.56-33,330.2) and SD € 11,191.11. The average number of days of hospitalization was 14.14 (4-34 days) and SD 10.81 days and the average age was 36 years (13-66 years) and SD 20.06 years. Older age was associated with a significant longer stay, $p < 0.01$ and furthermore age and disease severity had statistically significant correlation $p < 0.001$ with the total cost of hospitalization.
Conclusions: The cost of hospitalization in the Unit was influenced by age, duration of stay and severity of the patient's status (Glasgow Coma Scale)

Keywords: Direct cost, cost evaluation, Glasgow score

Introduction

Deaths from injuries are among the main causes of death in developed countries following cardiovascular diseases and malignant neoplasms. In addition they are the leading cause of death in the first four decades of life.

According to Faul et al. (2010), brain injury is the leading cause of death among 1-44 years and is responsible for 28 million hospital admissions and 150,000 deaths per year. Trauma has resulted in the loss of 4.3 million of potential life years each year, whereas for cancer and heart disease the loss is less than 3 million years (Ezzati et al., 2003).

This kind of injuries cost about 9 billion per year for medical operations and 13 billion spent on disability benefits (CDC 2010).

In Canada (Stiell et al., 2001; Maas et al., 2008), and in Greece (Andrioti, 2008), the traumatic brain injuries are the leading cause of death among 2-44 years.

In England and Wales half a million patients are admitted to hospitals from accidents each year and 18,000 of them die (Pandor et al., 2011), while in the U.S. is 1.4 million annually suffer a VTC 50,000 of whom annually die and 80-90,000 remain with severe disabilities (McGarry et al., 2002).

Definition of Traumatic Brain Injury

The traumatic brain injury (TBI) is an injury of the skull and brain. It can be closed, which means that the brain is not exposed or not in danger of being exposed to the outside environment, or open, when the brain is exposed to the outside environment. In the closed injury a fractured skull may coexist, while it is always present in the open ones. In traumatic brain injury a hematoma may coexist, which can be epidural, subdural the intracerebral (Badjatia et al., 2007).

Neurological evaluation

The first and most important feature that the neurosurgeon is required to assess is the level of consciousness of the injured with TBI.

It should be emphasized from the outset that the level of consciousness and its changes are the most important and decisive factors in the course of a patient with TBI (Saatman et al., 2008).

There are many ways to classify brain injury according to the criteria and how they were made. They are divided into closed and penetrating. Closed head injuries are caused after high-speed car accidents, falls or assaults. The perforating TBI are caused by weapons, biting and cutting instruments or deep impressions with the presence of a foreign body (Ruff et al., 2009).

The most popular classification for human head injury is the Glasgow Coma Scale that allows stratifying admitted patients into 3 major categories. This of mild (score 13-15/15), and it amounts to 80-90% of the total. Moderate (score in Glasgow Scale 9-13/15), amounts to 5-10% and severe TBI, characterized those with score 3-8/15, and accounts for 5-10% of the total (Carlson et al., 2011; Chesnut et al., 1993). The lowest level of consciousness is classified as Score 3. The person under this score does not open his eyes, does not react to painful stimuli and does not respond well to verbal stimuli, but retains his breath. The highest score is 15. The patient has eyes open, obeys commands and is fully oriented. Conservative treatment is offered to patients and in more severe cases surgical intervention (Seeling et al., 1984; Rose et al., 1977).

It has been estimated that 50% of sufferers of brain injury die before reaching the hospital (Pearson et al., 2012).

The increasing number of TBIs has created enormous social and economic problems, for this different countries have adopted measures such as the reduction in speed limit, mandatory application of the protective helmet (WHO, 2004; 2005), which are intended to, either to prevent the accident or diminish the number of accidents, with encouraging results so far after a reduction observed in traffic caused mortality in most Member States (WHO, 2012).

Although TBI is the leading cause of death in young ages, the economic data availability is limited in our country. The hospitalization of patients with TBI in the ICU of tertiary hospitals with highly qualified staff and appropriate equipment, contributes to the rise in health care costs and a higher burden on insurance providers.

The present study was undertaken to analyze and calculate the direct costs of TBI in the ICU, to investigate the factors that can contribute to the prediction of health care costs in the Unit as well as demonstrate the burden on the health system. Knowledge of the factors determining the total cost of hospitalization in ICU patients will help in selecting the most effective treatment.

Materials and Methods

The sample consisted of all the patients (7) with a diagnosis of TBI who had been hospitalized in the ICU, from June to September 2010.

The research got approval from the Bioethics Committee, the Scientific Committee and the executive management of the hospital. The data collection for consumables, health and pharmaceutical supplies and laboratory tests was done by personally contacting each patient, according to the hospitalization sheet and hospitalization records of the Unit under the respective protocols, on a daily basis. (A)

To calculate the cost of hospitalization, the treatment was recorded and the cost of consumables, the paraclinical examinations, culture, health and pharmaceutical material was calculated.

Excel tables were created on which all supplies, medications, tests, analyses, intravenous fluids which were administered to patients during their stay in the unit were recorded. Prices were collected from the accounting department of the hospital, the pharmacy, the storage depot supplies and the lab.

A distinction was made on health care costs per treatment and totally for each patient in the areas of respiratory, cardiovascular, nervous, and urinary systems, feeding, sugar monitoring, consumables required in hospitalization, examinations, cultures, intravenous fluids and medications.

Prices were collected from the accounting department of the hospital, the pharmacy, the storage depot supplies and the lab (Table1).

Descriptive Statistics were used and the Mean, Standard Deviation (SD), Minimum (Min) and Maximum (Max) of the above variables were presented (Table 2).

(B) Pearson correlation coefficient was used to investigate correlations between variables.

(C) Regression analysis was used to investigate the contribution of variables, patient age, duration of hospitalization, cost of food, cost of treating urinary tract, cost of consumables, cost of cultivation, cost of intravenous fluids and medications to the prediction of the total cost (Table 3).

Statistical analysis was performed with the SPSS 20.00.

The ICU of Nicosia General Hospital

The multipurpose ICU began operations in 2006 upon the completion of the hospital. It is the Reporting Unit for the entire Cyprus and accepts critically ill patients from public and private hospitals. Admissions are from all medical and surgical specialties of the Hospital (except pediatric patients under 12 years).

The model of operation is that of "closed ICU" where patients are hospitalized under the responsibility of Intensive-care specialists partnering with doctors of the referring Clinic and other specialties. It serves as the Unit for post-anesthesia care of cardiac surgery patients during the first 48 hours of post-surgery hospitalization.

It has 17 beds, 10 in a single open space and 7 in isolation rooms (here we refer to the closed ICU).

The ICU is organized in 2 nursing stations with 2 central remote monitoring subsystems (central monitoring stations). Staffed with 8 doctors (Six intensivists and two residents), eighty nurses entirely of higher education, eight support staff (assistants and cabin cleaners) while working with the team of physiotherapists, X-rays and nutritionists of the hospital for the needs of patients. In 2010, 417 (53.75%) thoracic surgery, 140 (18.5%) neurosurgery, 47 (5.6%) pathology, 42 (5.4%) surgery and 130 (16.75%) various other incidents were hospitalized (Nicosia Hospital, 2010).

The treatment of patients is based on the analogous international clinical protocols and new guidelines, on which continuing education to all staff is provided by the clinical instructor of the Unit.

Results

Table 1 presents the direct cost per system per patient.

Table 2 presents the Min and Max values, the Mean and Standard Deviation of the cost of the various areas of treatment for each type of treatment (respiratory, cardiovascular, nervous, urinary tract, blood glucose). Furthermore Table 2 includes also Min and Max values, the Mean and Standard Deviation of the cost for the supplies needed with regards to the hospitalization of seven patients with traumatic brain injury who participated in the survey, as well as examinations carried out, cultures, intravenous fluids, medication, feeding, depending on age and length of stay in the ICU.

The total direct cost of care of a patient with traumatic brain injury in the intensive care unit ranged from 2,936.56 € to 33,330.2 €.

The average health care cost in the intensive care unit was € 15,426.49 € with a standard deviation of € 11,191.11.

The average cost of treatment of the cardiovascular system was 50.34 €, respiratory 579.38 €, neurological system 303.43 €, urinary tract 10.53 €. The average cost of feeding was estimated at 94.39 €,

Table 1: Total cost per system with patients with traumatic brain injury in Intensive Care Unit

	Respiratory	Cardio-vascular	Neurology	Feeding	Urinary Tract	Consumables	Glucose	Exams	Cultures	NIB	Medications	Age	Duration	Total Cost
1	175.8	12.33	124.8	4.15	5.50	1655.23	0	249.45	666.38	26.47	265.90	22	3	2936.56
2	295.56	38.56	75.51	7.67	5.50	4013.12	0	550.00	1153.35	47.26	401.62	22	5	6038.15
3	244.63	39.76	100.68	28.25	5.50	3862.43	0	380.98	1750.69	73.35	817.55	13	7	6922.84
4	335.61	90.02	249.46	127.10	11.56	11055.24	19.07	1110.54	4501.46	199.38	4137.33	54	18	20726.23
5	1228.82	100.44	623.86	265.44	28.18	18272.59	0	1050.72	7562.32	339.80	4908.77	66	33	33330.22
6	1038.59	46.96	249.46	183.70	11.40	10996.87	11.17	326.33	4758.80	244.52	6978.75	49	22	24520.22
7	736.69	24.33	700.28	44.4	6.10	6640.33	0	997.80	2684.07	187.16	2487.85	26	11	13511.21

Table 2. Minimum, Maximum value, Mean and Standard Deviation of the costs of hospitalization of patients in ICU

FIELDS	N	MINIMUN PRICE	MAXIMUM PRICE	MEAN	STANDARD DEVIATION
Total Cost	7	2936.56	33330.22	15426.49	11191.11
Cardiovascular	7	12.33	100.44	50.34	32.83
Respiratory	7	175.80	1228.82	579.38	422.79
Neurology	7	75.51	700.28	303.43	255.26
Feeding	7	4.15	265.44	94.38	100.69
Urinary Tract	7	5.50	28.18	10.53	8.25
Consumables	7	1655.23	18272.59	8070.89	5757.98
Glucose	7	.00	19.07	4.32	7.72
Exams	7	249.45	1110.54	666.55	374.01
NIB	7	26.47	339.80	159.75	115.33
Cultures	7	666.38	7562.32	3296.72	2451.62
Medications	7	265.90	6978.75	2856.82	2577.98
Duration	7	3.00	33.00	14.14	10.81
Age	7	13.00	66.00	36.00	20.06

Table 3: Multiple Regression Analysis of Independent Variable The overall cost Hospitalization

FIELDS	R	R^2	R^2 Adjusted	β	p
Age	.944	.892	.870	.944	.001
Length of stay	.944	.988	.985	.984	.000
Urinary Tract	.885	.784	.740	.885	.008
Consumables	.988	.975	.970	.988	.000
Cultures	.992	.985	.982	.992	.000
NIB	.982	.965	.958	.982	.000
Medications	.892	.796	.756	.892	.007

Statistically significant level ($p \leq 0.05$)

consumables 8,070.83 €, examinations 666.54 €, cultures 3,296.72 €, drugs 2,856.82 €, NIB 159.70 €. The average length of stay ranged from 3-33 days with a mean of 14.14 days and standard deviation of 10.81 days. The age of patients ranged from 13-66 years with a mean of 36 years and a standard deviation of 20.06 years. If we add the staff payroll the charge amounts to € 2,694.19 per patient, while additional € 538.83 are incurred by ICU's 20% share of various costs for the hospital overheads, such as electricity, heating, and cleaning (Goula, 2007) raising the total direct cost of ICU at € 18,659.51.

(B) The results of the correlation analysis showed statistically significant correlation at a level of significance of $p \leq 0.001$ between the costs required for the treatment of respiratory and the intravenous fluids. The cost required for the treatment of cardiovascular system appears to have a statistically significant relationship with level of significance $p \leq 0.001$ with the cost of consumables. Intravenous fluids are correlated with the number of days in the unit and the total cost of care. The cost of treatment of urinary tract of patients hospitalized for traumatic brain injury seems to be associated ($p \leq 0.01$) with the cost of feeding, the cost of consumables, the cost of cultures, length of stay and overall cost of care. The cost of consumables required during hospitalization for traumatic brain injury was related ($p \leq 0.05$) with the cost of treatment of the cardiovascular system, the cost of feeding ($p \leq 0.001$) the cost of treatment of the urinary system ($p \leq 0.05$), the cost of cultures, the cost of intravenous fluids, the patient's age, duration of hospitalization and its total cost. The cost of culture needed during hospitalization was associated with traumatic brain injury ($p \leq 0.001$), the cost of feeding, the cost of treatment of the urinary system, the cost of consumables, the cost of intravenous fluids, the patient's age, duration of hospitalization and its total cost. The cost of intravenous fluids consumed during the treatment of patients with head injury related ($p \leq 0.001$) with the cost of feeding, consumable costs, the cost of cultures, the patient's age, duration of treatment and the total direct cost. The cost of medication for the treatment of patients with traumatic brain injury was associated ($p \leq 0.001$) only to the total cost of care. The age of patients being treated with traumatic brain injury was associated ($p \leq 0.001$) with the cost of feeding, the cost of cultures, the cost of intravenous fluids and length of hospitalization. The length of stay was associated ($p \leq 0.001$) with the cost of feeding, the cost of treatment of the urinary system, the cost of consumables, the cost of intravenous fluids, the cost of cultures, the patient's age and the overall cost. The total direct cost of hospitalization of patients with traumatic brain injury was associated ($p \leq 0.001$) with the cost of feeding, the cost of treatment of the urinary system, the cost of consumables, the cost of intravenous fluids, the cost of cultures, the cost of medication, the age of the patient and the length of stay.

In Table 3, the weighted coefficients "beta" β are shown for each independent variable, as well as the corresponding values of R, R square and the adjusted R square (R square Adjusted) are presented with the introduction of each independent variable at a ($p \leq 0.05$) significance level.

The results of multiple regression showed that direct costs of treating a patient with TBI in the ICU were influenced by patient age ($p <0.05$), length of stay in the hospital ($p <0.001$), the cost of consumables, cultures, NIB ($p <0.001$) and medications ($p<0.05$).

The cost of hospitalization was higher in patients with a low score on the Glasgow Coma Scale. The lower the score the more severe is the patient condition and the greater the cost of treatment in the ICU

Discussion

Despite the fact that road deaths have fallen in our country after 1995 and especially after the introduction of a package of measures from the central government and tighter controls on drivers regarding alcohol consumption, they are still higher than the average of EU countries (EU15) according to WHO (2012).

It is worth noting that traffic accidents affected mainly ages 15-34 and men more than women, so there are many years of life lost from this preventable cause (Ezzati et al., 2003). Leading cause of TBI are the traffic accidents and falls, leading sufferers to multi-day hospitalizations, surgeries and lengthy rehabilitation (Tennat, 2005). There are varying degrees of traumatic brain injuries, from mild to severe. A mild brain injury often results in a reversible brain damage and, thus, temporarily affecting the neurological functions of the patient, and a serious injury almost always causes neurological damage. The location and severity of the injury determines the nature and type of treatment.

In this study, all patients with TBI admitted to the ICU were included and although our sample was small, similar results emerged in terms of the direct cost of hospitalization of patients in the ICU, which amounted to € 18,659.51 in 2010. The amount is consistent with similar studies both low and high income such as Vietnam, the States, England and Wales (Hoang at al., 2008; Finkelstein et al., 2006; Morris et al., 2008) and is only part of the total cost in which the total duration of hospitalization, surgeries and all treatments offered have to be calculated. In addition one should also consider the cost of rehabilitation of the sufferer. So the size of the burden to the social security funds becomes very high. Under the current financial constrains, it is utmost important to point to and apply the most cost-effective treatments (Andrioti, 2008).

The direct cost of hospitalization in the ICU is associated with the age of the patient the duration of hospitalization, and costs of the individual treatments such as the urinary tract, the cost of consumables of intravenous fluids, the cost of cultivations and in particular the cost of medications ($p < 0.05$), since the medications are a large part of the treatment of patients with traumatic brain injury (Christensen et al., 2008).

The duration of hospitalization was associated with the cost of treatment of urinary tract ($p < 0.001$). The more a urethral catheter is used in a patient, the more prone they are to UTI (Rossi et al., 2006). Also it is related to the cost of cultures since the longer the stay in one patient unit, the easier it is to suffer from an infection, thus increasing the cost of cultures and intravenous fluids.

The age of patients treated with traumatic brain injury is related ($p < 0.05$) with the cost of consumables, investigations and medications and the duration of hospitalization, given that a young-age patient would be able to cope more easily with wounds and is clearly in a better physical condition than an older one. So the days spent in the unit are fewer.

Finally, as expected, the investigation of the factors that may predict the cost of treatment in the ICU showed that the patient's age, duration of hospitalization and the score of the Glasgow Coma Scale had a significant contribution in predicting the total direct cost of Care. The cost of hospitalization was higher in patients with a low score on the Glasgow Coma Scale. The lower the score the more severe is the condition of the patient and the greater the cost of the ICU

In this context, the burden of the health system is highlighted and there is an urgent need for preventive measures to reduce the accidents and in particular the road ones. The plan of similar ICU units which should be staffed with appropriately trained personnel and equipped with advanced technology for the treatment of patients, whose treatment should be based on best practices derived from the application of relevant clinical protocols, would be of help. Moreover, one should take care and provide appropriate rehabilitation services.

Towards the effective management of patients with TBI, better organization of acute care services and the operation of adequate ICU beds are, among other things, prerequisites. The factors that shape the costs should be taken into account by the administrators and managers of the ICU in order to reflect the real costs, to assess the economic consequences and to set the key priorities in their financial and operational planning.

References

Andrioti D (2008). An Epidemiological Approach of Women’s Health in Greece. In: Roumelioti A., Kyriopoulos J (eds). Health and Health Services for the Female population. Papazissis Editions. Athens (in Greek).

Badjatia N, Carney N, Crocco TJ (2007) Brain Trauma Foundation; BTF Center for Guidelines Management. Guidelines for prehospital management of traumatic brain injury 2nd edition. Prehosp Emerg Care. 12 Suppl 1:S1-S52.

Carlson KF, Kehle SM, Meis LA (2011). Prevalence, assessment, and treatment of mild traumatic brain injury and posttraumatic stress disorder: a systematic review of the evidence. J Head Trauma Rehabil. 26:103-115.

Centers for Disease Control and Prevention, National Center for Injury Prevention and Control (NCIPC). Concussion and mild TBI. August 2010. http://www.cdc.gov/ (accessed 19 July 2012).

Chesnut RM, Marshall LF, Klauber MR (1993). The role of secondary brain injury in determining outcome from severe head injury. J Trauma. 34:216-222.

Christensen M, Ridley S, Lecky F, Munro V, Morris S (2008). Outcomes and costs of blunt trauma in England and Wale. Critical Care (2003). 12:R23 (doi:10.1186/cc6797).

Ezzati M, Vander Hoorn S, Rodgers A (2003). Estimates of global and regional potential health gains from multiple major risk factors. The Lancet. 362:271-280.

Faul M, Xu L, Wald MM (2010). Traumatic brain injury in the United States: emergency department visits, hospitalizations, and deaths 2002-2006. GA Atlanta.

Finkelstein EA, Corso PS, Miller TR (2006). Associates Incidence and Economic Burden of Injuries in the United States. Oxford University Press. New York.

Goula A (2007). Hospital Management and Administration. Papazissis Editions. Athens (in Greek)

Hoang THM, Pham LT, Vo T, Nguyen P, Doran Ch, Hill P (2008). The cost of traumatic brain injury due to motorcycle accidents in Hanoi, Vietnam. Cost Eff Resour Alloc. 2008; 6: 17. doi: 10.1186/1478-7547-6-17

Maas AI, Stocchetti N, Bullock R (2008). Moderate and severe traumatic brain injury in adults. Lancet Neurol. 7:728-741.

McGarry LJ, Thompson D, Millham FH, Cowell L, Snyder PJ, Lenderking WR, Weinstein MC (2002). Outcomes and costs of acute treatment of traumatic brain injury. J Trauma. 53(6):1152-9.

Morris S, Rindley S, Lecky F, Munro V, Christensen M (2008). Determinants of hospital costs associated with traumatic brain injury in England and Wales. Anesthesia. 63:499-508.

Nicosia Hospital. Annual Report 2010 (in Greek)

Pandor A, Goodacre S, Harnan S (2011). Diagnostic management strategies for adults and children with minor head injury: a systematic review and an economic evaluation. Health Technol Assess. 15:1-202.

Pearson WS, Ovalle F, Faul M (2012). A review of traumatic brain injury trauma center visits meeting physiologic criteria from the American College of Surgeons Committee on trauma/centers for disease control and prevention field triage guidelines. Prehosp Emerg Care. 16:323-328.

Rose J, Valtonen S, Jennett B (1977). Avoidable factors contributing to death after head injury. BMJ. 2:615-618.

Rossi C, Simini B, Brazzi L, Rossi G, Radrizzani D, Lapichino G, Bertolini G (2006). Variable cost of ICU patients: a multicenter prospective study. Intensive Care Med. 32(4):545-52.

Ruff RM, Iverson GL, Barth JT (2009). NAN Policy and Planning Committee. Recommendations for diagnosing a mild traumatic brain injury: a National Academy of Neuropsychology education paper. Arch Clin Neuropsychol. 24:3-10.

Saatman KE, Duhaime AC, Bullock R (2008). Workshop Scientific Team and Advisory Panel Members. Classification of traumatic brain injury for targeted therapies. J Neurotrauma. 25:719-738.

Seeling JM, Marshall LF (1984). Traumatic acute epidural hematoma. Unrecognized high lethality in comatose patients. J Neurosurgery. 15:617-620.

Stiell IG, Wells GA, Vandemheen K (2001). The Canadian CT head rule for patients with minor head injury. Lancet. 357:1391-1396.

Tennant A (2005). Admission to hospital following head injury in England: incidence and socio-economic associations. BMC Public Health. 5:21.

World Health Organization (2004). A strategy to prevent chronic diseases in Europe: A focus on public health action. The CINDI vision. WHO. Copenhagen.

World Health Organization (2005). The European Health Report 2005. WHO. Geneva.

World Health Organization (2012). Health for All database. WHO. Copenhagen.