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Cost analysis and related factors in patients with traumatic hand injury

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Abstract
The aim of this study was to measure the direct and indirect costs and factors influencing these costs in patients presenting following traumatic hand injury. We assessed patients aged 18–65 years who were in work. Hand injury severity and functional status were assessed. Direct costs, including medical care expenses, and indirect costs, including lost productivity, were calculated. Seventy-nine patients of a mean age of 32 years were included. The mean direct cost for each patient was $1772 (47% of total cost), and the indirect cost was $1891 (53% of total cost). Injury severity, time to return to work, and hospitalization time were the main parameters of increased total cost in a linear regression analysis.

Keywords
Hand injuries, economics, accident, cost analysis

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Introduction

Traumatic hand injuries constitute 10% of emergency department visits and 6.6–28.6% of all injuries. Such injuries are more frequent among males; the average age at injury is within the active working age (Anakwe et al., 2011; Eser et al., 2009; Kouyoumdjian, 2006; Özdemir et al., 2004; Rosenfield and Paksima, 2001; Vordemvenne et al., 2007). There is a wide spectrum of injury types that range from soft tissue injuries and simple lacerations to complicated lacerations (tendon and/or nerve injuries), burns, fractures, and amputations. The severity of injury is usually classified as minor, moderate, severe, and major. About 50% of injuries are soft tissue injuries and simple lacerations, which are classified as minor (O'Sullivan and Colville, 1993; Rosberg et al., 2005a). The duration of sick leave is 10-times longer for major than minor injuries, while total expenditures are also 10-times greater for major than minor injuries (Rosberg et al, 2005a; Rosenberg et al., 2005).

Health economics is considered an important part of modern medicine and provides detailed information about expenses associated with certain diseases and relative cost-effectiveness of different health care programmes (Rosberg et al., 2003). The majority of patients with a hand injury are working men. Because they may require a long period of recovery and rehabilitation and potential long-term disability, the economic burden of these injuries is substantial (Rosberg et al., 2005b). The costs following an injury include direct and indirect costs. Direct costs include surgical interventions, laboratory tests, investigations, drugs, outpatient visits, rehabilitation, and physio- and occupational therapy and their ancillary costs. Indirect costs include time away from work, income loss, and compensation fees provided by social security institutions (Dias and Garcia-Elias, 2011). It is estimated that loss of production accounts for 67% and 72% of the total expenditure in major and minor injuries, respectively (Rosberg et al., 2005a).

The purpose of this study was to determine the direct and indirect costs of traumatic hand injuries in patients in Turkey.

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Methods

The study was performed by assessing the costs in patients with traumatic hand injuries admitted to a hand rehabilitation unit between October 2009 and October 2011. Exclusion were patients not in paid employment; who were treated for burns, had previous multiple operations for hand injuries, and had inappropriate rehabilitation after hand trauma; and those initially treated elsewhere. The study endpoint was the date when the patient returned to full-time work or date of a disablement report.

Demographic data, nature of the injury and surgical treatment, and functional status of patients were collected from medical records. Patients with missing data were invited for assessment and their data were completed.

The medical records of 501 patients were reviewed. Of patients who were excluded from the study, 43 were age < 18 years or > 65 years, 68 were housewives, 23 were retired, 27 were students, 14 were unemployed, 87 had time away from work without sick leave, 34 had no follow-up records, 28 were continuing a physiotherapy programme, one was on sick leave, 16 had an etiologic factor other than trauma, 25 had multiple trauma that included the wrist, forearm, elbow, and arm fractures, 33 had suffered a complication before admission to our clinic, 10 had sequelae of burns, and 11 had no accessible record. As a result, the study was performed with 79 patients.

The severity of injury was classified using the Hand Injury Severity Scale (HISS) (Campbell and Kay, 1996). HISS is an evaluation system which consists of separate evaluations of skin, skeletal, motor, and neural tissues of the hand and carpal regions. Each category was recorded for the overall injury pattern and each specific injury scored according to their relative importance. Each X-ray should be examined separately. According to HISS, a minor injury score is < 20, a moderate injury 20–50, a severe injury 50–100, and a major injury > 100. The scores of the Quick form of Disabilities of the Arm, Shoulder, and Hand (Q-DASH) questionnaire and Duruoz Hand Index (DHI) were recorded for the functional assessment.

The Q-DASH is a self-administered questionnaire that measures the physical function and symptoms in patients with upper extremity problems. The validity and reliability of the Turkish version of questionnaire have been established (Gummesson et al., 2006; Öksüz et al., 2006). The questionnaire includes 11 items extracted from the DASH questionnaire. To calculate the Q-DASH score, at least 10 of 11 items should be answered. Each item includes five options. The total score is calculated as the sum of the scores on each item (from 0 [no disability] to 100 [the most severe disability]).

The DHI was first developed in 1996 to assess the limitations of activities associated with hand problems in patients with rheumatoid arthritis. The index is a self-assessment tool and includes 18 items of hand function in kitchen work, dressing, personal hygiene, employment, and other general activities. The scores range from 0 to 40 for kitchen work, 0 to 10 for dressing and hygiene, and 0 to 20 for "other activities". Patients score their abilities from 0 (no difficulty) to 5 (impossible to do). The questionnaire takes 3 minutes to complete and total score ranges from 0 to 90. Higher scores represent more activity restriction and greater difficulty in activities of daily living (Duruöz et al., 1996). The validity and reliability of the Turkish version of the questionnaire were established in patients with traumatic hand injury (Erçalık et al., 2011).

Collection of cost data

The total cost of injuries were calculated for direct and indirect costs. Direct medical costs were the costs incurred by the individual, insurance agencies, or government for the care and treatment of the injury. Indirect costs were measured using the human-capital approach (Hodgson, 1994). The principle of this approach is to estimate lost income and earnings from compensation payment during time away from work. The costs that are recorded or estimated include the cost of short-term production loss due to the injury to the individual and cost of any long-term production loss due to permanent disability resulting from the injury.

Medical expenses of patients were calculated using the hospital information-management system (HIMS): the invoiced costs of surgical treatments, anaesthesia, laboratory tests, and radiological examinations; duration and cost of hospital stay; Physical Medicine and Rehabilitation (PMR) outpatient visits, including physical therapy and rehabilitation sessions and orthotics/splints; and type, number, and cost of complications (surgery, laboratory tests, radiologic imaging, medications, splints, etc., separately).

Because follow-up visits were planned as once a week for the first month, every 15 days for the following 2 months, and every 3 months thereafter, as required, the visits at these time points were considered as routine examinations of our hand rehabilitation unit, while visits outside these routine examinations were recorded as visits for complications.

In addition, drug costs for the inpatient treatment period were calculated from the HIMS, while those

Table 1. Demographic characteristics of patients

	n	(%)
Gender		
Male	72	(91.1)
Female	7	(8.9)
Education level		
İlliterate	1	(1.3)
Primary school	54	(68.4)
High school	22	(27.8)
University	2	(2.5)
Occupation		
Technician	1	(1.3)
Deskwork profession	6	(7.6)
Farmer	1	(1.3)
Labourer	69	(87.3)
Other	2	(2.5)
Dominant hand		
Right	71	(89.9)
Left	8	(10.1)
Injury of dominant hand	39	(49.4)

Table 2. Data about the injury

	n	(%)
Cause of injury		
Accident	76	96.2
Work	57	72.1
Home	15	19
Hobby	1	1.3
Traffic	3	3.8
Other	3	3.8
Assault	1	1.3
Punching glass	2	2.5
Injury object		
Knife	20	25.3
Machine	19	24.1
Heavy object	13	16.5
Spiral saw	12	15.2
Other	15	19
Type of injury		
Fracture	20	25.3
Extensor tendon injury	12	15.2
Fracture + tendon injury	12	15.2
Flexor tendon injury	8	10.1
Flexor tendon + nerve	7	8.9
Extensor tendon + nerve	1	1.3
Nerve injury	2	2.5
Other	17	21.5

after the discharge from hospital were calculated from the database of the Social Security Institution (SSI). Direct patient costs were considered the sum of these fees.

Central Bank exchange rates were used for the cost analysis, and the Turkish lira was converted to US dollars using the exchange rate at the time of each intervention.

The monthly payment made by the SSI for the duration of sick leave, cost of work loss (salary the patient did not earn in the period of time away from work), costs of social welfare other than SSI that the patient received, and costs of compensation paid for both injury and failure of health and safety by the employer, were calculated for indirect costs. In addition to duration of sick leave, time away from work and time of return to full-time work were recorded.

Results

We assessed 79 patients: 72 male (91%) and 7 female. Mean age was 32 (SD 7.6) years; 87% of patients (n = 69) were labourers. Demographic characteristics are presented in Table 1. In total, 76 of 79 patients (96.2%) were injured as a result of an accident, 3 of 79 patients (3.8%) were not. Of these accidents, 72.1% (n = 57) were industrial accidents. The most common mechanism of injury was by a knife or machine. Injuries are recorded in Table 2.

The mean duration of hospitalization was 2.9 (SD 4.2) days. The average number of surgical and PMR outpatient visits were 5.9 (SD 3.5) and 3.8 (SD 2.14), respectively. All patients received physiotherapy for a mean of 11.8 (SD 9.1) sessions. The mean duration of sick leave was 109 (SD 81.8) days, and patients returned to work after an average of 114.7 (SD 98.5) days. The average number of days the SSI made payments to a patient was 107.4 (SD 83) days. While 56 patients (70.9%) returned to their previous work, 23 (29.1%) patients had to leave their job.

The average direct and indirect costs are shown in Table 3. The average direct cost was $1771.8 (SD 1446.2) (37.1% of the total cost), the average indirect cost was $3370 (SD 2623.3) (62.9% of the total cost), and the average total cost was $5141.9 (SD 3417.3). Six patients suffered complications requiring further surgery (three required tenolysis, one tenolysis and neurolysis, one suffered an implant fracture, and one replantation necrosis). Complex regional pain syndrome occurred in two patients, which was treated nonoperatively. There were no other complications. The extra direct cost of treating these complications was $604 (SD 754.9) (range $72–2510).

Cost was not associated with age, gender, education level, type of injury, time between accident and surgery, or Q-DASH and DHI scores ($p > 0.05$). The

Table 3. Detailed direct, indirect, and total costs

Direct medical costs, USD	Cost, USD $		
	Minimum	Maximum	Mean ± SD
Ward cost	0	630	45.2 ± 99.2
Operation cost	0	3456	651 ± 730.5
Operation material cost	0	2204	129.9 ± 297.7
Anaesthesia cost	0	304	44.6 ± 61.1
Radiological examination cost	0	503	33.8 ± 66.8
Laboratory cost	0	210	23.6 ± 35.8
Drug cost in hospitalized patients	0	725	56 ± 153.7
Drug cost in outpatient	0	131	15.8 ± 24.2
Outpatient visit cost of surgery	16	360	112.5 ± 71.2
Outpatient visit cost of rehabilitation	10	214	56 ± 38.2
Physiotherapy cost	0	2051	504.3 ± 543.5
Splint cost	0	96	29.3 ± 33.1
Complication cost	72	2510	604 ± 754
Sum of direct costs	99	6275	1771.8 ± 1446.2
Indirect costs, USD			
Loss of salary	0	8423	2061.8 ± 1625.5
Payment from social insurance	0	5790	1308.3 ± 1059
Sum of indirect costs	0	14 213	3370 ± 2623.3
Total costs, USD	231	20 478	5141.9 ± 3417.3

Table 4. Linear regression analysis for total, direct, and indirect costs

	B	SE	Beta	*p*
Total costs (R^2 = 0.784) (linear regression model I)				
Duration of sick leaves, days	18.3	7.9	0.44	**0.024**
Duration of hospitalization, days	157.4	46.7	0.19	**0.001**
Direct costs (R^2 = 0.499) (linear regression model II)				
Duration of hospitalization, days	158.6	30.3	0.465	**0.001**
Duration of return to work, days	3.7	1.3	0.251	**0.006**
Hand Injury Severity Score	20.2	6.9	0.252	**0.005**
Indirect costs (R^2 = 0.782) (linear regression model III)				
Duration of sick leaves, days	28.3	1.7	0.88	**0.001**

Linear regression model I: Dependent variable: total cost. Independent variables: age, gender, education level, type of injury, severity scores of injury, Q-DASH and DHI scores, duration of return to work, duration of sick leave, duration of hospitalization, time between accident and surgery, time between surgery and first PMR examination. **Linear regression model II:** Dependent variable: direct cost. Independent variables: age, gender, education level, type of injury, severity scores of injury, Q-DASH and DHI scores, duration of return to work, duration of sick leave, duration of hospitalization, time between accident and surgery, time between surgery and first PMR examination. **Linear regression model III:** Dependent variable: indirect cost. Independent variables: age, gender, education level, type of injury, severity scores of injury, Q-DASH and DHI scores, duration of return to work, duration of sick leave, duration of hospitalization, time between accident and surgery, time between surgery and first PMR examination.

HISS (r = 0.37), time to return to work (r = 0.70), duration of sick leave (r = 0.68), duration of hospitalization (r = 0.48), and time between surgery and first PMR examination (r = 0.49) were significantly correlated with the total cost. The significant results for total, direct, and indirect costs are presented in Table 4.

According to the HISS classification, 44 patients (55.7%) had mild, 28 (35.4%) had moderate, six (7.6%) had severe, and one (1.3%) had major injuries. The direct, indirect, and total costs, duration of sick leave, and mean Q-DASH and DHI scores with respect to HISS classification are presented in Table 5. It is

Table 5. Characteristics of functional status and duration of sick leave and costs according to Hand Injury Severity Score

	Minor injury (n = 44)		Moderate injury (n = 28)		Severe injury (n = 6)		Major injury (n = 1)	
	Cost, $	%	Cost, $	%	Cost, $	%	Cost, $	%
Direct costs	1209.34 ± 925.6	33.8	2245 ± 1669	40	3723.7 ± 1259	46	1534	52
Indirect costs	2930 ± 2083	66.2	3599 ± 2807	60	5856 ± 4156	54	1392	48
Total cost	4139 ± 2417		5845 ± 3755		9580 ± 4417		2926	
	Mean ± SD		Mean ± SD		Mean ± SD		Mean	
Duration of sick leaves, days	88.5 ± 48.3		123.3 ± 93.8		201.7 ± 145		52	
Q-DASH score	17.3 ± 18.1		14.63 ± 18.1		31.8 ± 21.3		61	
DHI score	10.7 ± 15		10.9 ± 14.4		30 ± 27.8		55	

Table 6. Correlations between Hand Injury Severity Score (HISS) and costs, functional status, duration of sick leave, and duration of return to work

	r	*p*
HISS – Total cost	**0.340**	**0.002**
HISS – Direct cost	**0.425**	**0.001**
HISS – Indirect cost	0.209	0.065
HISS – Q-DASH	**0.266**	**0.020**
HISS – DHI	**0.359**	**0.001**
HISS – Duration of sick leaves, days	**0.270**	**0.016**
HISS – Duration of return to work, days	**0.239**	**0.035**

r = Pearson correlation coefficient; $p < 0.05$ was considered significant
DHI: Duruöz Hand Index; Q-DASH: Quick Disabilities of Arm, Shoulder and Hand

noteworthy that indirect costs contributed to total cost more than direct costs in all severity groups except major injury, which had just one patient. Costs and number of days of sick leave increased with increasing severity, except for major injuries. Q-DASH scores were slightly higher in patients with minor injury compared with those with moderate injury (Table 5).

The relationship of HISS with the costs, functional status, time to return to work, and duration of sick leave are presented in Table 6. Because there was only one patient in the major injury group, we calculated the HISS as scores for correlation analysis not classifications. The costs (direct and total), Q-DASH, DHI scores, time to return to work, and duration of sick leave significantly increased with increasing HISS scores. Only indirect costs did not correlate with HISS.

Discussion

In this study the patient demographics are very similar to those reported in the literature. Work-related hand injuries are usually seen in men (80%) aged 28–39 years old (Rosberg et al., 2003; 2005a; Trybus et al., 2006). The mean duration of hospitalization was 3 days, which is also comparable with previous studies which reported the length of hospital stay from 1.5 to 3 days. The mean number of physiotherapy sessions was slightly higher in our study compared with previous studies (12 vs. 5–7 sessions) (Eriksson et al., 2011; Rosberg et al., 2003).

The time away from work after a traumatic injury is affected by several medical factors, such as the site and severity of the injury. The average time away from work was reported to be 73 days for flexor tendon injuries (Rosberg et al., 2003) and 30–64 days for saw injuries (Eriksson et al., 2011; Hoxie et al., 2009). In a study from India on industrial hand injuries, although 56% of patients had a minor injury the mean time away from work was 35 days and time away from work exceeded 12 weeks in the presence of neurovascular or tendon injury (Mathur and Sharma, 1988). In contrast with other studies, time away from work as long as 10 months has been reported over a follow-up period of 3 years (Matsuzaki et al., 2009).

In this study the mean duration of sick leave was 109 days. The longer duration of sick leave compared with other studies may be because 40% of our patients had a fracture with or without tendon injury. This combination of injuries may also explain the high number of physiotherapy sessions. Another explanation may be that 72% of our patients were injured at work. Previous studies have reported that accidents occurring at work result in a longer time away from work than those occurring elsewhere. The authors suggested that these results could be because accidents at work predominantly occur in workers who use hand tools (carpenters, mechanics, fitters, etc.), there is a need for advanced manual skills for these individuals to continue to their job, and there is no light work for them when they return to work (O'Sullivan and Colville, 1993). Return to work is obviously important to patients. Rosberg et al. (2005b) and Bruyns et al. (2003) reported return to work rates of 69% and 59%, respectively, 1 year from injury. Of our patients, 71% returned to their previous work, whilst 29% of patients had to quit or changed their job.

Severity of the injury is another important variable affecting return to work. In a study examining the 3-year results of 82 patients, all those with mild–moderate injury returned to work, but only 74% of those with severe injury and 29% of those with major injuries did so (Matsuzaki et al., 2009). Another study of 140 patients followed for 12 months reported an average sick leave of 269, 106, 84, and 30 days in patients with major, severe, moderate, and mild injuries, respectively (Rosberg et al., 2005a). We noted time away from work of 202, 123, and 86 days, respectively, in patients with severe, moderate, and mild injuries, which is comparable with previous reports.

It may be impossible to compare the cost data for hand injuries from studies conducted in different countries because of differences in currency and individual business-labour policies and health-economic management methods in each country, as well as many other factors. The costs of medical services, and economic and political aspects, such as compensation, sickness benefits, and disability pensions after injury, are important in these assessments. Moreover, there are often a different range of injuries or parameters used to assess cost. The studies discussed below must be considered in light of these differences. In an analysis of patients (45% with mild and 30% with moderate injuries) from Poland between 1987 and 2000, the total cost for each patient was $6162, with $247 (4%) going on direct costs and $5916 (96%) on indirect costs (Trybus et al., 2006). In a Swedish study, the average total cost was €45820, with 13% (€6015) as direct costs and 87% as indirect costs (Rosberg et al., 2005b). A US study reported on 134 patients with electric saw injuries. The estimated total, direct, and indirect costs were $30754, $22086 (71.8%), and $8668 (28.2%), respectively (Hoxie et al., 2009). In a study from Ireland of 156 patients with predominantly minor injuries (50%), mean total cost was only IR£475 (O'Sullivan and Colville, 1993). A study from The Netherlands estimated that hand injuries cost $740 million annually, of which 56% was due to indirect costs (de Putter et al., 2012).

In this study the human capital method for estimation of indirect costs was used as in some studies in the literature in order to compare results. However, indirect costs might be exaggerated by using the human capital method. Lower indirect cost could be estimated by using the more recently developed friction cost method. Because the friction cost method is believed by some economists to be based on implausible assumptions according to neoclassical economic theory, we chose to use the human capital method (Johannesson and Karlsson, 1997; Koopmanschap, et al., 1995).

Although direct comparison of costs seems impossible, cost-related factors can be examined. The HISS score, duration of hospitalization, time to return to work, and also duration of sick leave were the variables which independently affected costs in our study. Severity of injury has been correlated with costs in almost all studies (Eriksson et al., 2011; Rosber at al., 2005a; 2005b). In a cost analysis of patients with median and ulnar nerve injury, direct costs were found to be 34% higher in patients with combined (median and ulnar nerve) injuries than those with a single nerve injury, 48% higher in patients with four or more tendon injuries than those with fewer than four tendon injuries, and 27% higher in patients who had to change their jobs due to disability than those who did not (Rosberg et al., 2005b). Although the health care costs were €2500 for minor injuries, they increased to €11 500 for major injuries in The Netherlands, and the total costs were 10-times greater for major than minor injuries (Mink van der Molen et al., 2003). Only a one-point increase in HISS score has been reported to cause a 2% increase in health expenditures and 1% increase in lost production. Moreover, that study also reported that the severity of the injury correlates with the number of days of sick leave and that a one-point increase in HISS score increases sick leave by 3% (Rosberg et al., 2005a). Using a linear regression analysis we found that the direct cost was influenced by time away from work, duration of hospitalization, and severity of injury, whilst indirect cost was only influenced by time away from work.

When evaluating the outcome of an injury, both the costs and functional outcome should be assessed. In the 2–7 years of follow-up, evaluation of a patient group in which 61% of patients had severe or major injuries, HISS and DASH scores were found to be correlated. It has been reported that, whereas severe and major injuries had the highest DASH values, minor injuries were also associated with substantial costs and remaining functional limitations in DASH scores (Eriksson et al., 2011). In another study with a follow-up duration of 6 months, DASH scores were not found to be associated with severity of injury (Mink van der Molen et al., 2003). On the other hand, in a study that evaluated patients at 3, 6, and 12 months following admission to an emergency department, the authors concluded that DASH scores can be used to monitor the recovery period, but did not include all indicators related to costs and severity score (Rosberg et al., 2005a). In the present study, the severity of injuries correlated with the DASH and DHI scores.

The major limitation of this study is that, in an attempt to include all indirect costs, we only evaluated patients who were actively working and returned to work or had a disability report. These strict inclusion criteria resulted in a small number of patients.

Information about costs is one of the most important determinants of health economics. This study is the first from Turkey reporting the costs of traumatic hand injuries. Publicizing the costs of traumatic hand injuries may prompt governments and the public to take greater precautions. Further studies are needed to determine the costs of specific types of traumatic hand injuries.

Conflict of interests

None declared.

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Ethical approval

The study was approved by Pamukkale University local ethical committee, September 27, 2011, no. 17.

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