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Research Article

Direct, indirect, and intangible costs after severe trauma up to occupational reintegration – an empirical analysis of 113 seriously injured patients

Direkte, indirekte und intangible Kosten nach einem schweren Trauma bis zur beruflichen Wiedereingliederung – eine empirische Analyse von 113 schwer verletzten Patienten

Abstract

Aim: Although seriously injured patients account for a high medical as well as socioeconomic burden of disease in the German health care system, there are only very few data describing the costs that arise between the days of accident and occupational reintegration. With this study, a comprehensive cost model is developed that describes the direct, indirect and intangible costs of an accident and their relationship with socioeconomic background of the patients.
Methods: This study included 113 patients who each had at least two injuries and a total Abbreviated Injury Scale (AIS) greater than or equal to five. We calculated the direct, indirect and intangible costs that arose between the day of the accident and occupational reintegration. Direct costs were the treatment costs at hospitals and rehabilitation centers. Indirect costs were calculated using the human capital approach on the basis of the work days lost due to injury, including sickness allowance benefits. Intangible costs were assessed using the Short Form Survey (SF-36) and represented in non-monetary form. Following univariate analysis, a bivariate analysis of the above costs and the patients' sociodemographic and socioeconomic characteristics was performed.
Results: At an average Injury Severity Score (ISS) of 19.2, the average direct cost per patient were €35,661. An average of 185.2 work days were lost, resulting in indirect costs of €17,205. The resulting total costs per patient were €50,431. A bivariate analysis showed that the costs for hospital treatment were 58% higher in patients who graduated from lower secondary school [Hauptschule] (ISS 19.5) than in patients with qualification for university admission [Abitur] (ISS 19.4).
Conclusions: The direct costs of treating trauma patients at the hospital appear to be lower in patients with a higher level of education than in the comparison group with a lower educational level. Because of missing data, the calculated indirect costs can merely represent a general trend, so that the bivariate analysis can only be seen as a starting point for further studies.

Keywords: direct costs, indirect costs, intangible costs, trauma, socio-economic status

Zusammenfassung

Zielsetzung: Die vorliegende Arbeit untersucht die Kosten, welche bei der Behandlung und Rehabilitation polytraumatisierter Patienten nach einem schweren Unfall entstehen, und zwar von der Aufnahme ins Akutkrankenhaus bis zur Wiederaufnahme der prätraumatisch ausgeübten oder posttraumatisch erlernten Arbeit. Dabei wird zwischen direkten, indirekten und intangiblen Kosten unterschieden.

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Methodik: In die Studie eingeschlossen wurden 113 Patienten mit mindestens zwei Verletzungen und einem Gesamt-AIS größer gleich fünf. Es wurden direkte, indirekte und intangible Kosten ermittelt, die zwischen dem Tag des Unfalls und der Wiedereingliederung in den Beruf entstehen. Die Behandlungskosten im Akutkrankenhaus und der Rehabilitationsklinik werden dabei als direkte Kosten bezeichnet. Als indirekte Kosten werden zum einen Krankengeldleistungen erfasst, zum anderen wird der Wertschöpfungsverlust durch den krankheitsbedingten Arbeitsausfall mittels Humankapitalansatz berechnet. Die intangiblen Kosten wurden in der vorliegenden Analyse mit dem SF-36 erfasst und in nicht monetärer Form dargestellt. Im Anschluss an einer univariaten Auswertung erfolgt ein bivariater Vergleich zwischen den genannten Kosten und den soziodemographischen sowie -ökonomischen Eigenschaften der Patienten.
Ergebnisse: Bei einer Verletzungsschwere von im Mittel 19,2 Punkten nach ISS betragen die direkten Kosten pro Patient im Durchschnitt 35.661 €. Bei einer gemittelten Arbeitsausfallzeit von 185,2 Tagen entstehen indirekte Kosten in Höhe von 17.205 €. Somit ergeben sich Gesamtkosten von 50.431 € pro Patient. Eine bivariate Analyse ergab, dass die Kosten für die Behandlung im Akutkrankenhaus bei den Patienten mit Hauptschulabschluss (ISS 19,5) um 58% höher sind als bei Patienten mit Abitur (ISS 19,4).
Fazit: Die direkten Kosten, welche bei der Behandlung traumatisierter Patienten im Akutkrankenhaus entstehen, scheinen bei Patienten mit höheren Bildungsgraden geringer auszufallen als in der Vergleichsgruppe mit niedrigerem Bildungsstand. Die aufgeführten indirekten Kosten sind aufgrund der fehlenden Datenlage nur als Tendenz zu betrachten, so dass der bivariate Vergleich nur ein erster Anhaltspunkt darstellen kann.

Schlüsselwörter: direkte Kosten, indirekte Kosten, intangible Kosten, Trauma, sozio-ökonomischer Status

Introduction

Seven to eight million accidents occur every year in Germany, injuring about 580,000 individuals [1]. Between 33,000 and 38,000 of the injured suffer from severe trauma as measured by the Injury Severity Score (ISS) (≥16) [2]. The affected individuals are predominantly (65–80%) males [3] between 20 and 30 years of age. This is an age group with high occupational activity [4], which means that the national economy bears significant costs associated with the patients' recovery, but even more so in the form of lost revenue as a result of their reduced total working life [5]. It is important to consider that in case of occupational accidents, in particular, a high proportion of the costs actually arise through the occupational activity of this patient group. The German Federal Statistical Office [Statistisches Bundesamt] determined that injuries and poisoning caused a loss of 870,000 work years in 2006, which represents 21.9% of the total work years lost annually due to illness. The costs of these types of illnesses represent 4.9% (€11.5 billion) of the total health care budget, which is estimated at about €236 billion [6]. Beyond the costs to the health care budget, the loss of working years results in additional costs for social insurances and in some cases to the respective employers.

Traffic accidents are the most common cause of polytrauma [7]. While the number of individuals killed in traffic is continuously decreasing [1], the number of the severely injured is, according to a study by the German Federal Highway Research Institute (BAST) in collaboration with the German Society for Trauma Surgery (DGU) [8], not dropping simultaneously. Improved availability and increased use of medical services will additionally result in a continued rise in health care costs [9]. For patients with polytrauma, however, this also means higher survival rates and potentially improved outcomes, which are now understood to mean not only survival but also the quality of life after surviving a serious accident [10]. In individuals below 40 years of age, trauma is the most common cause of death at 44.9% [11], and the fact that 30–40% of patients still suffer from full or partial occupational incapacity four to six years after a serious accident [12] indicates that improvements are still needed in this area.
This paper examines the costs that arise in the treatment and rehabilitation of patients with polytrauma after a serious accident, from admission to a hospital until the return to work either in the previous occupation or in an occupation for which patients received training posttraumatically. Direct, indirect and intangible costs are differentiated.

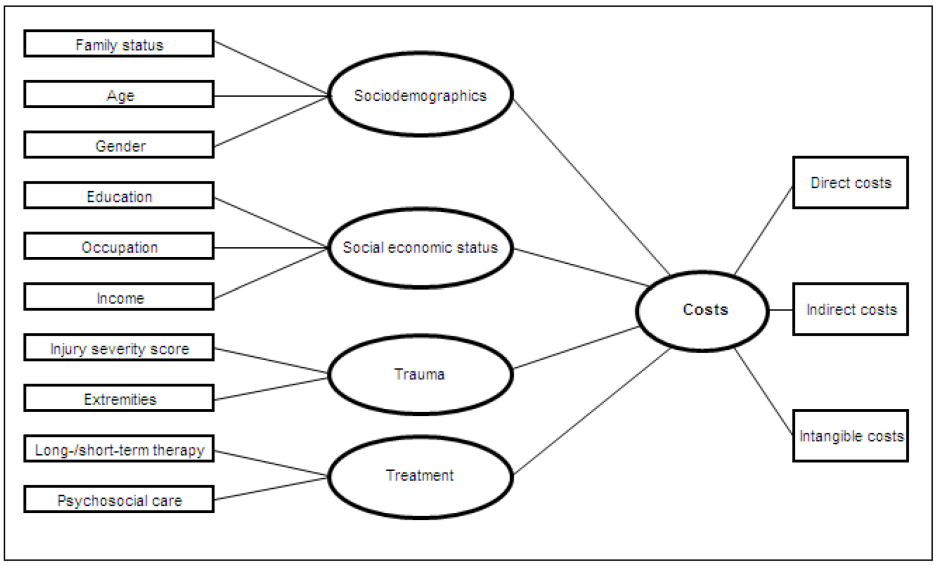

Figure 1: Overview of patient characteristics and costs

Direct costs are those associated with the medical recovery of the patient. In business economics, the term "costs" is defined as the consumption of goods and services of a certain value as a result of the company's output [13], [14]. Direct costs can therefore be understood as the additional use of resources of a certain value that is directly associated with providing the treatment [15]. The costs incurred at hospitals and rehabilitation centers belong in this category. For hospitals, the costs of treatment in the trauma room, any fluid replacement therapy, surgeries, and treatment at the intensive care unit (ICU) and on the ward are distinguished. For this purpose, this study uses the cost estimates from the Trauma Registry of the DGU. Direct costs also include the costs of treatment at the rehabilitation center, which are calculated as daily flat rates but actually represent revenues to the rehabilitation centers. The identified costs are financed through revenues of the social security funds. Hospital treatment is covered by health insurance, while the rehabilitation costs are covered by the statutory pension insurance or the health insurance, depending on whether the patient is able to return to work. In case of occupational accidents, the employers' liability insurance association [Berufsgenossenschaft] bears the costs [16].

Indirect costs are defined as an economy's lost potential productivity resulting from illness-related absences or impaired performance at the workplace [15]. The calculation assumes that the wages correspond to the marginal product of labor. In this work, indirect costs not only consist of the gross income and non-wage labor costs but also include sickness benefits. The later often are not conceived to be indirect costs in related studies and are itemized separately instead. Indirect costs therefore comprise payments in the form of sick pay or sickness benefits that employees who are incapable of working receive during illness and rehabilitation, either from the employer or from the health insurance or employers' liability insurance association. These represent patient-associated monetary costs. In addition, non-wage labor costs must continue to be paid to the social insurances during this time.

To facilitate quantifying the benefit of certain medical treatments and measures, studies in the field of health care economics also consider intangible costs that cannot be directly measured in monetary form. Intangible effects, such as pain, joy, or physical limitations, are assessed using the patient's biopsychosocial quality of life after the accident; quality of life in this context includes physical health as well as social contacts and emotional health [17]. Two parts of the Polytrauma Outcome Chart (POLO-Chart) were used for this purpose, namely the Short Form Survey (SF-36) and Glasgow Outcome Score (GOS) [18]. This paper also compares the calculated costs with sociodemographic characteristics, socioeconomic status, and factors related to the trauma and treatment (see Figure 1). Sociodemographic data include age, gender, and family status. The socioeconomic status involves education, occupation and income. Data on trauma represent the severity of injury as measured by the ISS, and treatment-related factors are largely psychosocial care factors, which depend on whether the patient was in the long-term or short-term therapy group for psychotherapeutic interventions. In the context of the analysis, we looked for correlations between these patient characteristics and the identified costs.

According to current knowledge, this paper is the first comprehensive survey of all costs associated with severely injured patients calculated on the basis of individual data that takes into account the hospital and rehabilitation center costs as well as the costs of lost work time and intangible costs, and that furthermore includes a bivariate comparison between the types of cost and sociodemographic characteristics or socioeconomic status. Studies that have already been published on this topic largely focus on the direct hospital costs [19], [20], [21], [22], [23], [24], [25], [26], [27] or on the intangible costs in the form of the patients' posttraumatic quality of life [17], [28], [29]. Other studies included expenses

for insurance services or vehicular damage in the direct costs [30], which complicates the comparison of results.

Methods

In the context of the study on "effects of the quality of psychosocial care, socioeconomic level, and care-related patient attitudes on the quality of life of severely injured patients" [Effekte psychosozialer Versorgungsqualität, sozialer Schicht und versorgungsbezogener Patienteneinstellungen auf die Lebensqualität schwerverletzter Patienten], a survey was conducted by the institute of medical sociology, health services research, and rehabilitation science (IMVR) of the University of Cologne from November 2001 to May 2007. The original question of this study supported by the German Research Foundation (DFG) was whether medicine can contribute to improving the situation of the seriously injured not only through competent medical treatment but also through good psychosocial care. For this purpose, a total of 862 seriously injured patients were screened at the trauma surgery departments of the University Medical Centers of Aachen, Bonn, Cologne-Lindenthal and of the Witten-Herdecke Campus Cologne-Merheim. Of these patients, 732 did not meet the inclusion criteria, so that 130 patients were originally included in the study (not included patients: transfer/discharge (n=78), denial (n=49), age not between 18 and 65 (n=126), mental disorder (n=58), suicide attempt (n=58), deceased (n=48), inadequate pattern of injury (n=105), insufficient German language skills (n=23), residence more then 70 km away from hospital (n=62), disoriented (n=12), miscellaneous (n=34)). The following inclusion criteria were applied: 18 to 65 years of age, two injuries with a total Abbreviated Injury Scale (AIS) value equal to or greater than five, and craniocerebral trauma with an AIS value equal to or less than three. To evaluate the effect of psychosocial interventions, the study population was divided into two groups, one receiving short-term psychosocial therapy and the other long-term psychosocial therapy. Both groups were assessed regarding quality of care and quality of life using valid socioepidemiological evaluation tools at five points in time (on the ward, at discharge, and six, twelve, and 18 months after traumatic event) [31].

This retrospective study examines the direct, indirect, and intangible costs arising during the recovery of the study participants in the period from the traumatic event to occupational reintegration. Seventeen additional patients had to be excluded from the original study because of insufficient data on their socioeconomic status, so that the analysis represents the data of 113 patients. The data were processed using Microsoft Excel 2000, and statistical analysis was performed using the program SPSS (Version 17.0).

Sociodemographic information

The previously mentioned relevant patient information, such as family status, age, and gender, were copied from the patient files.

Socioeconomic status

Information on education (educational degree and training) and occupation (most recent occupation before the accident) was collected from the patients using a questionnaire. The monthly gross income of 65 patients is known. For patients who did not share income information (n=48), we estimated the income on the basis of their occupation immediately before the traumatic event: For this purpose, we used the 2006 Structure of Earnings Survey [Verdiensttrukturerhebung] by the German Federal Statistical Office, which lists information on income by age and gender [32]. If patients were registered as job seekers at the German Federal Employment Agency (n=5), their previous earnings [Bemessungsentgelt] was calculated on the basis of their most recent occupation. The flat-rate social insurance contribution, income tax, and the solidarity surcharge were subtracted from this amount to establish the daily assessment base [Leistungsentgelt], from which the monthly unemployment benefit was calculated using the replacement rate [Leistungssatz] (67% for job seekers with children and 60% for those without children) [33]. If the patients were still in vocational training at the time of the accident (n=7), the average trainee income was calculated using the incomes in different stages of vocational training.

The monthly income of a total of 97 patients was indicated or estimated; these amounts represent gross monthly incomes except in the case of job seekers, for whom the net monthly benefit was used. For the remaining study participants, no income information was available because they were students, either at secondary schools or universities, or homemakers without regular employment, so that no costs for potential lost work days apply when using the human capital approach.

Since the income of only 57% of the study population is known, please note that the data on indirect costs are to be considered with caution and that they at best serve to indicate a general trend. They are not statistically valid.

Trauma

The ISS was used to assess the overall severity of the injuries, a score system assigning 0 to 75 points depending on the degree of anatomic injury. This value is calculated on the basis of individual injuries, and they in turn are assessed according to the AIS, a simplified injury scale. The ISS system is based on the degree of injury and the assignment of the injury to a certain body as assessed by the AIS injury scale. The ISS distinguishes between six body regions (head, face, thorax, abdomen, extremities and external soft tissue), and its final value is equal to the sum of the squares of the AIS scores of

the three most injured body regions [34]. For the present study, the ISS of 106 patients in the analyzed sample was established using the Trauma Registry of the DGU [35].

Treatment

At the beginning of the study on which these data are based, the patients were randomly assigned to a long-term or short-term therapy group. The long-term therapy patients received psychological care during their stay at the hospital (maximum of eight sessions) and on an outpatient basis after their stay at the rehabilitation center (maximum of six sessions), while patients in the short-term therapy group only received psychological care at the hospital, with a maximum of eight sessions.

Direct costs – hospital

Using the cost estimator discussed below, DGU has generated a trauma registry containing the data of 42,248 patients [36]. For 61 of our patients, we were able to find the treatment costs incurred at the hospital in this registry. For all other patients, the cost was calculated using the formulas of this cost estimator. It lists an average cost of €405.40 per patient for blood transfusions. Fluid replacement therapy is listed at a cost of €16.77 and treatment at the trauma room at a flat rate of €1,105.17. Due to the high level of standardization, trauma room care is assumed to be a lump sum, already including radiological examinations as well as monetary efforts for obligatorily monitored laboratory parameters. According to DGU, this lump sum comprises expenses for the depreciation on instruments and the calculated rent depending on the annual number of patients. However, if an adequate trauma room care can only be achieved through assistance of further medical specialists, additional costs for the consultation have to be added to the lump sum mentioned above. Treatment at the ICU was assessed using the Therapeutic Intervention Scoring System (TISS-28). TISS is an intensive care scoring system designed to evaluate resource use in intensive care medicine [37]. In this system, each patient is assigned 20.7 points per day, and this value is then multiplied by €35. Intubated patients receive 16.9 additional points per day. If the duration of intubation was unknown, 10.6 points were added to the 20.7 points. This represents an average intubation time of 7.5 days (63% of the average length of stay of 11.9 days). As a result, one day of treatment at the ICU is estimated to cost €1,095.50. The cost estimator lists €197.94 for one day on the ward. The cost of one surgical procedure is estimated at €1,801.67. If the exact number of surgeries was unknown, their number was estimated with the aid of DGU data on the basis of the patient's length of stay (n surgeries = 1.8 + (length of stay *0.05)). Excluded are anesthesia, radiological and analytical services associated with surgeries [38].
As mentioned above, the listed amounts are estimates obtained from the DGU Trauma Registry. Therefore, we did not take into account the actual reimbursements by the health insurances or employers' liability insurance associations as well as the treatment costs for each patient incurred by the health care facilities. Moreover, the available data do not allow a comparison with Diagnosis Related Groups evaluated by the “Institut für das Entgeltsystem im Krankenhaus”.

Direct costs – rehabilitation center

The daily flat rates that were individually negotiated between the rehabilitation centers and the health insurances, pension funds, or employers’ liability insurance associations were used as the basis for calculating the costs at these treatment facilities. On average, a daily rate of €190.36 (standard deviation (SD): €35.21) is charged for a patient in rehabilitation phase C (early rehabilitation; n=3). For patients in rehabilitation phase D (general rehabilitation; n=29), an average daily rate of €123.17 (SD: €17.11) is billed at the surveyed facilities, and €115.51 (SD: €5.72) per day is charged for patients in orthopedic rehabilitation (n=2). If the daily rate for a patient could not be determined, we used the weighted average of the above data, which equals €128.38.
The length of rehabilitation treatment was known for 65 patients, with an average length of stay of 38.8 days (SD: 19.7 days). If the number of treatment days was unknown, we used this average. When calculating the costs for the rehabilitation centers, factors other than the daily rates were disregarded. Possible additional costs, such as for the use of a single-occupancy room, were therefore not taken into account.

Indirect costs

Indirect costs are incurred through lost productivity that results from illness-related absences. The human capital approach was used as the basis for this calculation. In this approach, the value of life is first estimated on the basis of its expected productivity [39] and then used to calculate lost production. The latter is the sum of the patients’ gross monthly income and the employers’ non-wage labor costs, which depend on the lost work days, that is on the time interval between the accident and the first work day. In this study, indirect costs are explicitly supposed to include these efforts, which are considered as sickness allowance benefits in related surveys. This comprises the sickness benefit itself, as well as payments of the health insurance for annuity, nursing and unemployment insurances. Moreover, the missing contributions of the patient have to be taken into account to calculate the total health insurance’s expenses [40].
After converting the gross monthly income to gross daily income (by dividing by thirty days), the non-wage labor costs of 33%, which also must be paid by the employer, were added. Of this percentage, 20% represent legally mandated employer contributions to social insurance, 6% represent social insurance expenses that are voluntary or based on a collective agreement or contract, and 7%

represent other non-wage labor costs [41]. For six weeks, employees who are unable to work receive sick pay from the employer [42]. After six weeks, employees receive sickness or injury benefits equaling at least 70% of their previous income from the health insurance or employers' liability insurance association [43]. Employees must continue to pay their portion of social insurance contributions (statutory pension insurance, unemployment insurance, and long-term care insurance). However, these amounts will be reduced, since the employees receive only 70% of their original income. The above social insurances do not collect the employers' contribution during the time employees receive sickness benefits, and the employee contributions also drop, as mentioned above, resulting in a shortfall that we will identify as "lost revenue of social insurances." Patients receive free health insurance coverage while entitled to sickness benefits, so that the missed contributions from the insured also represent cost-relevant factors to the health insurances [44]; we took these into account under "lost revenue of health insurances."

Registered job seekers who have an accident continue to receive unemployment benefits while injured. In this case, there is no difference between sick pay and sickness or injury benefits, and the patient receives the full amount from the health insurance. No contributions to social insurances are made. Lost work day data was available for 57 patients, averaging 185.2 days (SD: 113.7). If the number of lost work days was unknown, this value was used.

Intangible costs

Pirente et al. (2002) developed the so-called POLO-Chart to enable the quantification of pain and social and psychological limitations in addition to the reduced physical functioning from which patients suffer following severe trauma [45]. This paper uses two instruments of the POLO Chart to quantify the relevant aspects of health-related quality of life. The GOS is used to describe the recovery status of patients after the treatment and therapy of the injuries that resulted from the accident. Eighteen months after the accident, the treating physician classifies the patient into one of five categories: "good recovery/able to work" (1); "moderate disability/independent" (2); "severe disability/dependent" (3); "persistent vegetative state" (4), and "dead" (5).

The subjectively experienced psychological effects of the accident are often unrelated to the objective severity of injuries [17] and to the recovery status of the patient. Therefore, we used the SF-36 as a second assessment instrument that includes the concept of quality of life and therefore reflects the patient's personal perception of his or her own physical and psychological well-being [46]. In the SF-36 quality-of-life index, the patient completes a questionnaire with 36 items. These are combined into subscales after transforming the raw scale scores. Statements regarding the patient's quality of life can then be made using the resulting eight subscales: "physical functioning" (1); "role physical" (2); "bodily pain" (3); "general health perception" (4); "vitality" (5); "social functioning" (6); "role emotional" (7); "mental health" (8). The established values were then compared with the data of a normative sample of the German population to reveal illness-specific changes [47].

Results

Sociodemographic and socioeconomic status

Table 1 shows the sociodemographic characteristics and the socioeconomic status of the 113 study patients.

Types of accidents and their effects

In the present group of patients (n=113), traffic accidents were the major cause of trauma at 62.8% of cases (n=71, of which n=25 were motorcycle accidents). According to Wick, traffic accidents cause 56 to 71% of multiple injuries [4]. In 12.4% of the study patients (n=14), the injuries were caused by a fall (other causes 5.3%, unknown 20.4%). For 87 patients, survey data on the effects of the accident after 18 months are available. For ten patients (11.5%) the trauma resulted in loss of their workplace. It remains unclear whether these patients are unable to work and if so, how long their disability will last. Nine patients (10.3%) received occupational retraining, and 14 patients (16.1%) had to change employers. Thus, 62 patients (71.3%) were able to return to their original job within 18 months. The accident was reported to have resulted in financial disadvantages by 41 patients (47.1%), and 22 individuals (25.3%) indicated difficulties with government agencies as a result of the trauma.

Trauma

In the literature, polytrauma is defined as injuries of 16 points or more according to the ISS [48]. Using the data of 106 patients, the average severity of injuries as measured by ISS is 19.2 points (SD:12.0). It should be noted, however, that the ISS was below the defined value for polytrauma in 48 patients. When comparing the ISS values with the direct costs arising from treatment at the hospital, a correlation was found that is illustrated in Figure 2.

In addition to considering patients' ISS, we noted whether their extremities were injured. Extremities were affected in 94.2% of patients, potentially causing additional psychological stress since such injuries often result in permanent disability or functional limitations [49].

Psychotherapeutic interventions

Among the study population, 56 patients (49.6%) were in short-term therapy, and 46 patients (40.7%) received long-term therapy as defined above. For eleven patients,

Table 1: Sociodemographic and socioeconomic status

	n
Gender	
Male	86 (76.1%)
Female	27 (23.9%)
Age	
< 20 years	11 (9.7%)
20 - 30 years	31 (27.4%)
30 - 40 years	27 (23.9%)
40 - 50 years	33 (29.2%)
50 - 60 years	10 (8.8%)
> 60 years	1 (0.9%)
Average	34.9
Family status	
Married, living together	38 (33.6%)
Married, living separately	4 (3.5%)
Unmarried	57 (50.4%)
Divorced	13 (11.5%)
Widowed	1 (0.9%)
Level of education	
Did not graduate from Hauptschule	2 (1.8%)
Graduation from Hauptschule/Volksschule (lower-level secondary school)	40 (35.4%)
Realschule / Mittlere Reife (intermediate secondary school graduate)	36 (31.9%)
General/subject-specific university entrance qualification	35 (31.0%)
Vocational training	
No completed occupational training	24 (21.2%)
Completed occupational training	63 (55.8%)
Fach-, Meister-, Technikerschule (vocational special training school, master craftsman school, technical school)	5 (4.4%)
University graduate	15 (13.3%)
Completed other occupational training	1 (0.9%)
No information available	5 (4.4%)
Occupation	
Blue-collar worker	22 (19.5%)
White-collar worker	51 (45.1%)
Civil servant	4 (3.5%)
Self-employed	8 (7.1%)
Secondary school student	6 (5.3%)
Trainee	7 (6.2%)
University student	6 (5.3%)
Retiree	1 (0.9%)
Unemployed	5 (4.4%)
Conscientious objector performing community service	1 (0.9%)
housewive/househusband	2 (1.8%)
Gross monthly income	
< 1,000 €	26 (23.0%)
1,001 – 2,000 €	16 (14.2%)
2,001 – 3,000 €	39 (34.5%)
3,001 – 4,000 €	20 (17.7%)
4,001 – 5,000 €	7 (6.2%)
5,001 – 6,000 €	3 (2.7%)
6,001 – 7,000 €	1 (0.9%)
No information available	1 (0.9%)

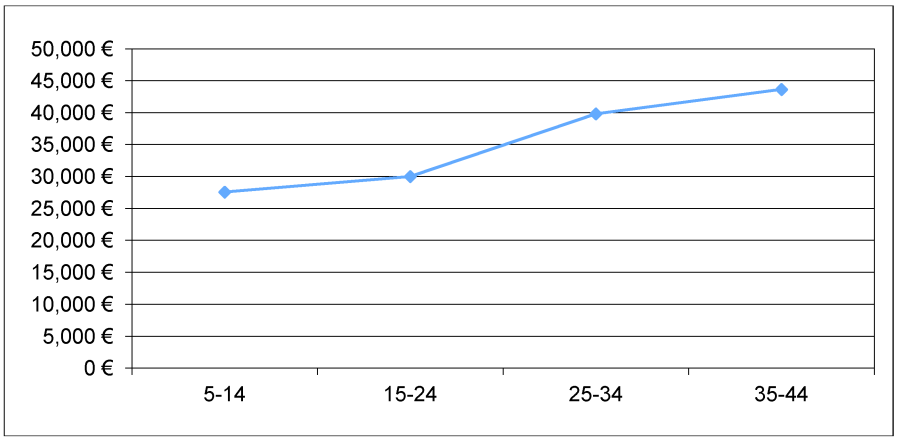

Figure 2: Correlation between ISS values and direct hospital costs

the type of therapy is unknown. No relevant differences were found between the individual cost items when comparing long-term and short-term therapy. The average total cost were €47,784 (SD: €23,648) for the short-term therapy group and €49,375 (SD: €22,381) for the long-term therapy group.

Direct costs – hospital

The average cost per patient for hospital treatment were €31,478 (SD: €18,591) (n=113). This includes the expenses for blood transfusions at €670 (2.1%) and for fluid replacement at €17 (0.1%). In addition, this figure includes trauma room costs of €1,173 (3.7%) and average surgery costs of €10,995 (34.9%). Treatment at the ICU was calculated to have cost €11,456 (36.4%), and treatment on the ward were €7,166 (22.8%) per patient. On average, the patients stayed at the hospital for 49.2 days (SD: 40.5), of which 11.0 days (22.3%) were spent at the ICU and 39.0 days (79.3%) on the ward (see Table 2).

Table 2: Direct costs and length of hospital stay

Direct costs – hospital		
Blood transfusion	669.70 €	2.1%
Fluid replacement therapy	17.22 €	0.1%
Trauma room	1,173.19 €	3.7%
Surgeries	10,994.89 €	34.9%
ICU	11,456.40 €	36.4%
Ward	7,166.13 €	22.8%
Total	31,477.53 €	
Length of stay – hospital		
ICU (n=105)	10.97 days	22.3%
Ward (n=113)	39.04 days	79.3%
Total	49.23 days	

Direct costs – rehabilitation center

Patients who visited a rehabilitation center stayed an average of 38.8 days (SD: 19.7) and incurred an average cost of €4,874 (SD: €1,963) per patient. Patients in rehabilitation phase C (n=3) cost the insurers an average of €3,019 with a mean treatment length of 17.3 days. For study participants in phase D (n=29), the average costs were €4,218 with a treatment length of 35.6 days; the costs for patients in orthopedic rehabilitation (n=3) were an average of €5,239 with 45.3 days of treatment.

Indirect costs

The average cost of lost work time is €17,205 (SD: €10,721) (n=97), based on an average of 185.2 lost work days (SD: 113.7). The employer must pay €3,367 (SD: €1,617) of this amount in the form of sick pay for a duration of six weeks; this amount already includes non-wage labor costs at a rate of 33%. Employees who were incapable of working received an average amount of €9,488 (SD: €6,733) in the form of sickness or injury benefits. These amounts are paid by the health insurances or employers' liability insurance associations as soon as the patients no longer receive sick pay from their employers; the benefits amount to at least 70% of gross income. To the social insurances other than the health insurances, an average deficit of €2,448 (SD: €1,731) arises for each patient, and the health insurances lose contributions of €1,903 (SD: €1,375).

Estimating indirect costs using the appropriate formula of the human capital approach results in €13,788.52 per patient. This value results from the days of lost work multiplied by the per capita gross domestic product of 2005, divided by 365 days [38], [50]. The amount described shall enable a comparison with other methods of calculation, this formula was not used for this work.

As some income information and data on lost work days are missing, as mentioned above, please note that the calculated indirect costs merely represent a vague trend.

Intangible costs

Data on the GOS are available for 58 patients. They show that at the time of classification, 34 patients were assessed as "good recovery/capable to resume occupational activities" (58.6%), 22 patients as "moderately dis-

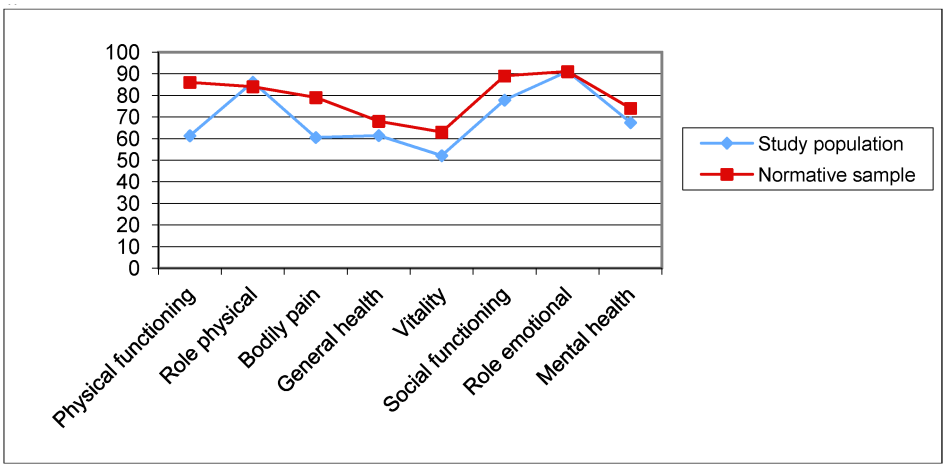

Figure 3: SF-36 of the study population compared with the normative sample

abled/independent" (37.9%), and two patients as "severely disabled/dependent" (3.5%). Because of the study design, no patients were in the categories "vegetative state" or "dead."

Eighteen months after the traumatic event, the quality of life of 89 study patients was assessed using the SF-36. Comparing these values with the scale values of the normative German sample [45] reveals that the patients' subjective assessment of their physical and mental health is more negative than that of the healthy control population, as may be expected, except for the items "role physical" and "role emotional" (see Figure 3).

Total costs

The direct costs include the cost estimates for the hospital and the treatment at the rehabilitation clinic and amount to a total of €35,661 (SD: €19,341). Adding the indirect cost of the lost work time, the total cost for each patient is €50,431 (SD: €23,748) (n=113).

Bivariate comparison

No relationships between the family status of the study patients and the cost parameters are apparent. While the group of individuals who are "married living separately" shows higher total costs than the group of patients who are "married and living together", the former have a higher ISS value; with four patients, the small size of this group also precludes a reliable and statistically valid comparison. No relationships between the patient's age groups at the time of the accident and the total costs were found. When comparing male (n=86) and female (n=27) patients, however, the male participants' hospital stay (51.8 days (SD: 43.4)) was almost ten days longer on average than the female participants' stay (41.0 days (SD: 28.3 days)). Therefore, the male patients caused higher direct costs at the hospital (men: €33,446 (SD: €19.650), women: €25,207 (SD: €13,153)). However, it must be noted that the average ISS value for men (20.0 (SD: 12.5)) was 3.9 points higher than the ISS value for women (16.1 (SD: 9.6)). When additionally considering the SF-36 results, we found that the male patients have a higher average point value in all eight subscales despite suffering from more severe injuries. While the differences are minimal overall, male participants appear to have a more positive perception of their physical and mental health status than the female patients (see Table 3). If the severity of injuries were equal, the group of female patients should create higher costs according to Michaels, because this group shows more symptoms of fear and depression and therefore requires more time to return to a productive work life [51].

Obvious correlations were also found when analyzing the educational levels of the study participants. From the day of the accident until the return to work, the average total costs per patient for the group with general or subject-specific university entrance qualification (n=35) were €41,124 (SD: €21,617), for graduates of Realschule (n=36) €47,698 (SD: €19,653), and for graduates of Hauptschule (n=40) €61,209 (SD: €25,708). This represents 48.8% higher costs in the last group than the first group, although the average severity of injuries was almost identical (ISS of those with Abitur: 19.4 (SD: 9.8), ISS of Hauptschule graduates: 19.5 (SD: 14.1)). The same results are found if indirect costs are disregarded because of the previously mentioned problems with data, and only the direct costs for each educational group are analyzed. The direct costs for the Hauptschule graduates are actually 54.8% higher than for those with Abitur. Clear results are still obtained when distinguishing between accident types, that is, traffic accident and fall, in the comparison of these subgroups' direct costs for hospital treatment. After a traffic accident, the hospital costs for patients with Abitur were on average €26,732 (SD: €12,590) at an ISS of 19.1 points, while the group of Hauptschule graduates incurred average costs of €40,592 (SD: €21,615) at an ISS of 18.2 points.

The analysis of the individual items shows that all cost-relevant parameters reflect this increasing trend, being lowest for those with Abitur, higher for Realschule graduates, and highest for Hauptschule graduates. Indirect costs represent the only exception, as they result from lost work days and therefore depend on the monthly in-

Table 3: List of cost parameters in selected groups

Averages		Gender		Level of education			Occupational category	
	Total	Male	Female	Abitur	Realschule	Hauptschule	Blue-collar worker	White-collar worker
N	113	86	27	35	36	40	22	51
Age	34.9	34.4	36.3	35.1	30.1	39.4	39.2	36.6
Length of stay at ICU	10.9	11.3	6.6	8.9	7.2	14.3	13.5	9.0
Length of hospital stay	49.2	51.8	41.0	45.7	48.7	51.7	53.5	45.8
Hospital costs	31,478 €	33,446 €	25,207 €	24,585 €	29,903 €	38,865 €	37,685 €	30,464 €
Days at rehabilitation	38.8	37.2	43.1	29.5	38.2	45.2	43.6	41.5
Rehabilitation costs	4,874 €	4,774 €	5,215 €	4,235 €	4,813 €	5,428 €	5,383 €	5,064 €
Direct costs (n=113)	35,661 €	37,610 €	29,456 €	28,094 €	34,181 €	43,479 €	42,335 €	34,733 €
*Lost work days**	*185.2*	*183.7*	*189.5*	*151.9*	*165.5*	*228.4*	*231.8*	*164.3*
Indirect costs (n=97)*	*17,205 €*	*16,980 €*	*18,022 €*	*18,242 €*	*15,697 €*	*18,184 €*	*18,038 €*	*17,990 €*
*Total costs**	*50,431 €*	*52,615 €*	*43,473 €*	*41,124 €*	*47,698 €*	*61,209 €*	*60,373 €*	*52,018 €*
ISS	19.2	20.0	16.1	19.4	18.3	19.5	20.4	21.5
SF-36								
Physical functioning	61	62	59	71	64	52	53	62
Role physical	86	87	83	87	80	96	69	87
Bodily pain	61	61	60	69	62	52	51	62
General health	61	62	60	65	64	55	59	61
Vitality	52	53	48	52	54	49	52	50
Social functioning	78	78	77	82	80	72	72	78
Role emotional	91	93	85	96	93	85	92	86
Mental health	68	69	63	70	66	66	65	66

*: The italicized information merely represents a vague trend and should be critically examined

come, which is lower on average in the group of Hauptschule graduates (average gross monthly income: those with Abitur: €3,120 (SD: €1,399), Hauptschule graduates: €2,375 (SD: €927)). Although the lost work days also increase with decreasing education level (Abitur: 151.9 days (SD: 111.1); Realschule graduates: 165.5 days (SD: 108.7), Hauptschule graduates: 228.4 days (SD: 110.3)), the differences in indirect costs between the groups are very small. A closer look at the average SF-36 values of the educational groups reveals that they clearly drop, being highest in those with Abitur, lower in Realschule graduates, and lowest in Hauptschule graduates. On average, the values of those with Abitur are slightly higher than the other two groups', meaning that the former group's subjective perception of well-being is somewhat more positive.

A comparison between blue-collar and white-collar workers regarding the individual cost items yields that all cost parameters are higher for blue-collar workers (n=22) than for white-collar workers (n=51), although the average ISS value of blue-collar workers is slightly lower (total cost: white-collar workers: €52,018 (SD: €19,573) (ISS: 21.5); blue-collar workers: €60,373 (SD: €24,780) (ISS: 20.4); difference of 16.1%). Again, the results are the same when comparing only the direct costs (21.9% cost difference between groups).

Discussion

We achieved the primary goal of the present study, that is, calculating the direct, indirect and intangible costs arising from the treatment of a seriously injured patient between the traumatic event and the return to work; the calculated indirect costs, however, must be viewed as a general trend only.

The direct costs of treatment at the hospital and the rehabilitation center represent costs as defined in the field of business administration; direct costs were analyzed in various ways. The hospital costs were calculated based on DGU estimates, regardless of the actual costs incurred at the respective hospital and without consideration of the reimbursements made by the health insurances or employers' liability insurance associations. The literature lists costs between €24,000 and €107,000 for hospital treatment (costs were compared using an accumulation factor of five percent [52]). However, the range of injury severity was quite large, with ISS values between 23 and 38, which complicates comparative analysis [18], [19], [20], [21], [22], [23], [24], [25], [26]. The design of the original study excluded patients with craniocerebral trauma of an AIS greater than three. Since comparable studies also included patients with more severe injuries, they are likely to result in higher costs.

The direct costs at the rehabilitation centers correspond to the daily rates that are reimbursed by the insurance companies. This analysis cannot determine whether the reimbursements to the centers are excessive or insufficient. In a study by the Hannover University Medical Center, patients stayed at the rehabilitation centers for an average of 114.7 days, but the study also included 36 cases with craniocerebral trauma of grade 2 or 3 [53]. As mentioned above, the present study does not include such patients; these major differences between the studies may in turn lead to significantly underestimated total costs.

The costs for emergency rescue services were not included in the calculations. While these services are always charged at flat rates regardless of the severity of injuries and the measures taken, they can vary in the individual rescue service regions. The city of Cologne, for example, charges €491 for deploying an ambulance and an emergency physician vehicle within the city limits [54]. Since no data were available regarding these costs in this study design and since these and similar costs would have little effect on the total costs, we did not calculate the cost for emergency rescue services. According to Brunner and Stollenwerk, every actual use of resources incurs direct costs [39]. The latter would therefore also include non-medical expenses, such as those for child care during treatments or hospital stays. In this analysis, however, only medical costs were considered in the calculation of direct costs. Monetary efforts, accumulating either after discharge from the primary hospital or after completion of the required medical treatment, i. e., further consultations of physicians (including specialists) and physical therapy, remain untended as well.

As defined in the field of business administration, indirect costs are the costs of goods or services that were not produced; in this study, these were assessed using the human capital approach. In addition, indirect costs can also include costs incurred by the reduced use of potential leisure activities [39]; these were not calculated in the present study. Another approach discussed in the literature for assessing indirect costs is the friction-cost method, which calculates the costs of productivity that is actually lost [40]. Given the available data, however, only the human capital approach could be used in the present study. A main criticism of the human capital approach is that the calculation of indirect costs shows a value of zero for retirees and others who are not employed or incapable of working, as these groups cause no loss in potential productivity [15], [55]. Since we used the human capital approach, the assessment does not include some costs employers may incur in addition to sick pay, such as any contractual penalties when specific delivery deadlines are not met or the expenses associated with hiring replacement staff during the employee's absence. Any re-training costs would also need to be considered, but we were unable to do so as the necessary data are not available. For the same reason, we could not take the Hamburg Model into consideration, in which employees are offered incremental reintegration into their previous occupation, initially with reduced weekly working hours. Since employment law still considers employees unable to work during the occupational reintegration phase, the insurances incur additional costs in the form of sickness benefits until employees return to 100% of their workload [56].

It should be emphasized, that this work regards sickness allowance benefits as indirect costs, implying these efforts to be regarded from a different perspectives. Though, the human capital approach represents the employer's expenses, whereas sickness allowance benefits are regarded as completely cost-relevant for the health insurances only. Both parties can consider these expenses to be afforded by different agencies to reintegrate a heavily injured person into his job. Thus, the term "indirect costs" cannot be defined in a very precise manner in this work, which may accounts for other studies on this subject and already led to the conclusion, this term to be often used in a irregular and mistakable context [15]. The present analysis is likely to significantly underestimate indirect costs, as income information is only available for 56% of patients, and potential disability after the last interview is not taken into account.

When assessing intangible costs, the "costs" hardly be indicated in monetary units. However, the internationally recognized SF-36 adequately assesses the subjective perception of quality of life as a form of intangible cost [57]. As expected, the SF-36 values of the study population are below the values of the German normative sample; this likely results in additional costs, which were also not calculated. Such costs may include expenses for the treatment of posttraumatic stress symptoms or other symptoms of depression, which may continue for months or years after the accident [58], [59]. The relevant literature suggests that four years after a traumatic event, the average scale values are still lower than the values of the control group [60]. As mentioned above, no correlation has been found between the presence of psychological symptoms and the patients' degree of injury [17]; instead, the availability of trauma-relevant coping strategies and social resources plays a major role [61]. It would be interesting to compare the available SF-36 values of the different subgroups (e.g., white-collar or blue-collar workers) to the respective values of the normative sample. However, we have not yet found such data.

If the above potential costs that were not included in this study were added to the average total cost of €50,431 per patient, the final cost of treating seriously injured patients and reintegrating them into work and everyday life would certainly be much higher.

This study also aimed to perform a bivariate comparison of social factors that may influence illness-related costs. The patient's age apparently does not affect costs, a finding that is supported in the literature [18], [21]. However, the comparison showed that between the day of the accident and the return to work, the costs of recovery of seriously injured patients significantly differ between groups of different socioeconomic status. The biggest differences were found in the direct hospital costs;

they result from differences in the length of stay and treatment but cannot be explained by greater severity of injuries according to ISS. This may be explained by individuals with a higher socioeconomic status having a more extensive social network that helps them to better and more quickly cope with difficulties resulting from a severe traumatic event [62]. This would permit earlier discharge from inpatient care. MacKenzie also believes that patients with a low socioeconomic status have a poorer prognosis in terms of the medical and social outcome [63]. The differences in direct costs incurred at the rehabilitation centers are not very large, but the data show that the group of Hauptschule graduates on average stays 15.7 more days at the rehabilitation center than the group of individuals with Abitur. The educational level or the original occupation may therefore affect the length of treatment. According to a study by Badura, blue-collar workers tend to have less resources than white-collar workers to cope with work-related strains and negative occupational effects of illnesses, a fact that affects their rehabilitation [64].

In principal, the relationship between the level of education and the health constellation could be proved. The context is reasoned by the possible influence of health relevant lifestyle factors, such as nutrition as well as the capability to utilize problem-solving techniques [65]. Results of the research group Health Behaviour in School-aged Children (HBSC) of the World Health Organization (WHO) already revealed a much higher ability of young A-level students ("Gymnasiasten") to self-assess their personal medical condition compared to those students of lower level schools [66]. This, at least personal experienced, inequality on the own health status seems to manifest itself already in adolescents and is either changing in an insufficient way or not at all later. Based on data of the Bundes-Gesundheitssurvey from 1998, individuals with a low-level high school diploma ("Hauptschulabschluss") have a 1.89fold higher risk for a worse overall constitution then those graduated from A-level schools ("Abitur") [67]. It could not be ruled out, whether an increased number of individuals among the investigated group of patients with a lower level of education had already been suffering from pre-existing diseases, which perhaps were responsible for longer stationary stays, or whether the reported health status resulted from a personally worse recognition of the patient's own condition.

From the comprehensive survey of the socio-economic characteristics of the patients collective it can be concluded, that individuals with both a lower educational level as well as a less qualified vocational certificate cause higher direct costs in the acute hospital for their recovery. Apparently, patients with a higher level of education rather have the personal competences for overcoming a disease, which include knowledge and information about the illness itself and the awareness about support oppurtunities. Treating physicians in acute hospitals seem to suppose patients revealing a higher socioeconomic status to possess over higher capabilities for overcoming illnesses and injuries despite earlier discharge dates.

Since it could not be ultimately concluded, whether the tremendous cost differences are caused by lacking personal resources for managing diseases in individuals with a lower educational status, future polytrauma studies should be focused on socio-demographic and socio-economic capacities of the patients.

On a critical note, our patient population was not a representative sample, and no data were available on the patients' insurance status. The available data also do not show whether patients suffered from certain preexisting conditions that may have distorted results; given the average age of 34.9 years, however, this is fairly unlikely. We cannot establish with certainty whether occupational activity and, correspondingly, the educational level may have a causal effect on the types of accidents and the resulting injuries.

Future research should target this area in an attempt to obtain valid results, particularly regarding indirect costs. Longer survey periods are necessary, particularly for the costs which are not included in present analysis because of missing data.

Conclusions

The direct costs of treating trauma patients at the hospital appear to be lower in patients with a higher level of education than in patients with a lower educational level. Because of missing data, the calculated indirect costs can merely represent a general trend, so that the bivariate analysis can only be seen as a starting point for further studies.

Notes

Competing interests

The authors declare that they have no competing interests.

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