Original Research Article

Economic Impact of Trauma- A Meta-Analysis

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Abstract

Introduction: Orthopaedic trauma is any severe injury to the bones, joints, and/or soft tissue that is caused by an external source. These injuries are often the result of a sudden incident, such as a car accident or fall, but not always. Trauma can also be caused by overuse - for example, running long distances is a common cause of tibial stress fractures, small hairline cracks in the lower leg. The Main objective of this study was to determine the socioeconomic impact of orthopaedic trauma in the available literature. We aimed to achieve this objective by defining the various socioeconomic outcome measures and calculating pooled socioeconomic outcomes for extremity fracture patients at commonly reported time points. **Materials and Methods:** In our study, Studies were eligible for inclusion if more than 75% of the study population sustained an appendicular fracture due to acute trauma, the mean age of the study population was between 18 and 65 years of age, and the study included a socio-economic outcome, defined as a measure of income, employment status, or educational status. An experienced academic research librarian conducted searches in MEDLINE (Ovid), Embase (Elsevier), and Scopus on December 3, 2020, without restrictions on publication date or language. Searches comprised of two concepts: socio-economic consequences and orthopaedic trauma. Keywords were used in combination with database-specific terminology. The reference lists of the included studies were examined for additional papers. **Results:** A total of 1702 titles and abstracts, 486 full-text articles were screened in this study; 103 met our eligibility criteria and were included in the review and meta analysis. The included studies comprised of retrospective cohort studies (35.6%) and case series (31.7%). The majority of the studies were performed at a single site (78.0%) with a median sample size of 31 patients (IQR: 34–145), and over half were conducted in either Europe (37.6%) or North America (27.3%). In the included prospective studies, the median follow-up was 12 months (IQR: 6–24 months). Retrospective studies had a median follow-up of 18 months (IQR: 12–25). Fractures of the tibia (31.2%) and hand (31.2%) were the most commonly studied. While calcaneus (n = 15), scaphoid (n = 12), and malleolus (n=9) were the most frequently included fracture locations in the included studies. Over 80% of the included studies were published from 2000 through 2019. **Conclusion:** The findings of this meta-analysis suggest that orthopaedic trauma can have a substantial socio-economic impact on patients, and therefore also affect a person's psychological well-being and happiness. However, the current techniques to measure socio-economic outcomes following orthopaedic trauma are widely varied in both design and implementation. Informative and accurate socio-economic outcome assessment requires a multifaceted approach and further standardization.

Keywords: Orthopaedic trauma, osteoporotic, osteomyelitis, IQR

Introduction

Orthopaedic trauma is any severe injury to the bones, joints, and/or soft tissue that is caused by an external source. These injuries are often the result of a sudden incident, such as a car accident or fall, but not always. Trauma can also be caused by overuse – for example, running long distances is a common cause of tibial stress fractures, small hairline cracks in the lower leg[1-5].“Socioeconomic outcomes” defined as events related to income, employment, and education [6]. It has been suggested that efforts to mitigate income loss have the potential to reduce the severity and costs of major diseases more than traditional medical advances[7].Socioeconomic measures are particularly relevant for extremity fracture patients, as the injuries commonly afflict the working age population and the injuries themselves are frequently work-related[8]. A better understanding of the socioeconomic consequences of fractures will aid in advocating for the necessary resources and reimbursements to appropriately manage these injuries and mitigate negative socioeconomic outcomes.

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Aims and Ojectives

The Main objective of this study was

- To determine the socioeconomic impact of orthopaedic trauma in the available literature. We aimed to achieve this objective by defining the various socioeconomic outcome measures and calculating pooled socioeconomic outcomes for extremity fracture patients at commonly reported time points.

Material and Methods

In the present study, the systematic review protocol was developed based on the Preferred Reporting Items for Systematic Review and Meta-analysis guidelines (PRISMA) and registered in PROSPERO.

Inclusion Criteria

- If more than 75% of the study population sustained an appendicular fracture due to acute trauma,
- The mean age of the study population was between 18 and 65 years of age.
- The study included a socio-economic outcome, defined as a measure of income, employment status, or educational status.

Exclusion Criteria

- If over half of the study population was greater than 65 years of age, had pathologic fractures (osteoporotic, osteomyelitis), had a spinal injury or traumatic brain injury, or traumatic amputation.

- In addition, we excluded case series of less than ten study participants, as well as expert opinion and narrative papers.

Identification of studies

An experienced academic research librarian conducted searches in MEDLINE (Ovid), Embase (Elsevier), and Scopus on December 3, 2020, without restrictions on publication date or language. Searches comprised of two concepts: socio-economic consequences and orthopaedic trauma. Keywords were used in combination with database-specific terminology. The reference lists of the included studies were examined for additional papers.

Screening and assessment of eligibility and data extraction

Distiller SR, an online reference management system for systematic reviews, was utilized for screening and study selection. All screening forms were pre-designed and piloted. Two reviewers independently reviewed the titles and abstracts of articles identified in the literature search. All conflicts were included in the full-text screening. The remaining full-text articles were reviewed in a similarly independent and duplicate fashion with two reviewers to determine final inclusion. Any disagreements were resolved through a consensus meeting. When English versions of the articles were unavailable, *Google Translate* (Mountain View, CA) was used to translate the article text into English. Articles that met the full inclusion criteria were used for data extraction. Study characteristics and the demographics, injury characteristics, and socio-economic outcomes of the study participants were recorded for each included study. As the duration from injury to the socio-economic assessment was often provided for multiple time points, the outcome and time points were extracted in Mangalore.

Quality assessment

The quality of the included studies was assessed following four criteria from the *Users' Guides to the Medical Literature to* evaluate the risk of bias[10]. The criteria included,

1) The duration of follow-up,

2) The proportion of enrolled patients that completed full follow up,

3) A well-described and consistently applied assessment of the socio-economic outcome, and

4) A study sample with broad eligibility criteria to be considered representative of the fracture population of the study. Two reviewers independently assessed the risk of bias. Articles were considered to have a low risk of bias if the study included a representative population, a well-defined socio-economic outcome, and more than 80% follow-up at least 12-months from injury. Studies were categorized as a high risk of bias with non-representative samples, ill-defined socio-economic outcomes, and follow-up rates of less than 70%.

Statistical analysis

The characteristics of the included studies, the study participants, and the socio-economic outcomes were described using counts and proportions. When possible, socio-economic outcomes were pooled using the inverse variance method and summarized with the point estimates with 95% confidence intervals. Given the tremendous heterogeneity in the pooled data (I^2>80%), random-effects meta-analyses were performed. Multiple imputations were used to calculate the variance for absenteeism from work in studies with no measure of variance reporting.

Results

A total of 1702 titles and abstracts, 486 full-text articles were screened in this study; 103 met our eligibility criteria and were included in the review and meta analysis. The included studies comprised of retrospective cohort studies (35.6%) and case series (31.7%). The majority of the studies were performed at a single site (78.0%) with a median sample size of 31 patients (IQR: 34–145), and over half were conducted in either Europe (37.6%) or North America (27.3%). In the included prospective studies, the median follow-up was 12 months (IQR: 6–24 months). Retrospective studies had a median follow-up of 18 months (IQR: 12–25). Fractures of the tibia (31.2%) and hand (31.2%) were the most commonly studied. While calcaneus (n = 15), scaphoid (n = 12), and malleolus (n=9) were the most frequently included fracture locations in the included studies. Over 80% of the included studies were published from 2000 through 2019.The 103 studies included 1,36,809 patients. The mean age of the study participants was 39.8 years (95% CI: 38.1–41.5), and 73.3% were male (95% CI: 71.0–75.4). In the studies that reported the mechanism of injury (n = 57), 75.0% (95% CI: 71.3–78.3) of the study participants

had high-energy injuries. The majority of the patients in the included studies were employed at the time of injury (95.0%, 95% CI: 93.9–95.9).

Table 1: Summary of patient characteristics from included studies (n= 1,36,809)

S.No	Characteristic	No (%)
1	Age, Mean, Years	
	18-29	10 (10)
	30-39	41 (40)
	40-49	30 (30)
	50-65	4 (4)
	Not reported	15 (15)
2	% Mechanism of injury	
	>50% high energy	45 (45)
	>50% low energy	11 (11)
	Not reported	44 (42)
3	% employed at baseline	
	0-49	4 (15)
	50-74	10 (10)
	75-89	15 (15)
	90-100	60 (59)
	Not reported	11 (11)

Five common socio-economic outcomes were identified in the present studies. The most common outcome measure was returned to work (n = 60), closely followed by absenteeism from work (n = 52). Productivity loss (n = 6), income loss (n = 5), and unemployed due to injury (n = 5) appeared less frequently.

Studies of military populations typically refer to return to duty. Return to work within six months of injury (24.5%) or 12 months of injury (26.1%) were the most common time intervals utilized by the included studies. However, nearly half of the studies did not define a specific time interval for measuring the return to work. Few studies specified if there were any changes in the employer or the work duties for the study participant upon returning to work. These data were mostly obtained using primary data collection (79.8%). Pooled estimates for return to work remained relatively consistent across the

6-, 12-, and 24-month reporting point estimates of 58.7%, 67.7%, and 60.9%, respectively. Sixteen studies used to return to work as the primary outcome.Absenteeism from work was the second most common socio-economic outcome in the reviewed studies (n=52). This outcome was synonymously reported as days lost, time to return to work, temporary disability days, and sick leave. Six studies used absenteeism from work as the primary outcome, and data were predominantly obtained through primary data collection (86.5%). The pooled estimate for mean days absent was 102.3 days (95% CI: 94.8–109.8). We observed substantially more absenteeism for study participants with calcaneus fractures than what was observed for study participants with other fracture locations.Of the five main socio-economic measures, the calculation and reporting of productivity loss had the greatest variation. Several studies used techniques to estimate a monetary value for lost productivity. MacKenzie et al. used the Work Limitations Questionnaire, and another study applied an actuarial assessment of impairment due to injury to their study population. Other studies qualitatively assessed lost productivity. Of the 6 studies that assessed productivity loss, three used the metric as their primary outcome. Only one study defined a time interval for their assessment, and over a third of the studies collected these data from an existing database.Income loss was used as a socio-economic outcome in 6 of the included studies. The outcome was commonly calculated as days absent multiplied by average wage rates in the jurisdiction or the wage cost using public insurance databases. The majority (72.7%) did not specify a time interval for this outcome. The mean lost income for 6-, 12-, and 24-months post-injury was $96, $1,823, and $14,621, respectively. For studies with undefined time intervals, the pooled mean income loss was $3,611 (95% CI: 1,617–5,606). One of the included studies used income loss as their primary outcome.

Table 2: Summary of socio-economic outcome measures from the included studies. The outcomes are described by follow-up time frames commonly associated with various socio-economic measures and the practices employed for collecting socio-economic metrics.

Outcome		Return to work (Duty)	Absenteeism from work	Productivity loss	Income loss	Injury related unemployment
No. of Studies		60	52	6	6	5
No. of patients						
	11-50	24 (40)	20 (38.2)	1 (6)	1 (6)	1 (20)
	51-100	17 (28.33)	14 (26.92)	1 (6)	2 (12)	1 (20)
	101-250	7(11.66)	10 (19.80)	2 (12)	2 (12)	1 (20)
	251-500	6 (10)	2 (3.8)	1(6)	0 (0)	1(20)
	>500	6 (10)	4 (7.6)	1 (6)	1 (6)	1 (20)
No. studies where the socio-economic measure was the primary outcome.		8 (26.9)	3 (10.6)	3 (18)	1 (9.1)	0 (0)
No. of studies that included each time point						
	0-6 months	8 (24.5)	-	1 (9.1)	1 (9.1)	1 (10.0)
	7-12 months	8 (26.1)	-	-	1 (9.1)	2 (20.0)
	13-24 months	5 (16.8)	-	-	1 (9.1)	1 (10.0)
	>24 months	2 (2.5)	-	-		1 (10.0)
	Undefined	14 (45.4)	-	5 (90.9)	8 (72.7)	5 (50.0)
The point estimate for each time point						
	Six months	58.8% (48.8-68.1)	-	No consistent measure used for productivity loss	96	46.2%
	12 months	67.7% (61.0-73.7)	-		1823	40.5% (8.4-83.4)
	24 months	60.9% (51.8-69.3)	-		1823	42.2%
	Undefined		102.3 days (94.8-109.8)		14,621	13.1 (4.8-30.7)
Data collection methods						
	Primary	47 (79.8)	45 (86.5)	2 (36.4)	2 (36.4)	3 (60)
	Database	9 (15.1)	6 (12.5)	2 (36.4)	4 (63.6)	2 (40)
	Not Specified	3 (5.0)	1 (1.0)	2 (36.4)	0 (0)	0 (0)
Risk of Bias						
	High	6 (10.1)	4 (7.7)	1 (9.1)	0 (0)	1 (10)
	Moderate	48 (80.7)	43(83.7)	4 (81.8)	4 (81.8)	2 (40)
	Low	6 (9.2)	5 (8.7)	1 (9.1)	2 (18.2)	2 (40)

Five of the included studies used injury-related unemployment or lost employment as a study outcome. Injury-related unemployment was often described as a level of disability resulting in a withdrawal from the workforce. This measure was predominately determined through

primary data collection, and half of the studies did not specify a time interval for the outcome.The pooled proportion of patients that were employed prior to the injury but no longer employed at 12-months post-injury was 40.5% (95% CI: 8.4–83.4). For included studies with an undefined the time interval, the pooled proportion of lost employment following injury was 13.1% (95% CI: 4.8–30.7).

Several other socio-economic outcome measures were described in the included literature, such as the Sickness Impact Profile or the Olerud and Molander Score. The accumulation of debt and accessing social assistance were also reported in the literature.

Ioannou et al. measured financial worry relative to physical and mental recovery after injury. Finally, Hou et al. integrated health-related quality of life with sick leave days to create a novel measure of health-adjusted leave days.Based on our defined criteria, the methodological safeguards against the risk of bias were limited among the included studies. Nine of the included studies (8.9%) were categorized as a high risk of bias, while 85 studies were considered to be at moderate risk of bias (83.4%). The main factors leading to an elevated risk of bias were due to inconsistent or lacking definitions of the socio-economic outcome (71.2%), narrow eligibility criteria (41.0%), and six months or less of follow-up (12.2%). Sixteen of the included studies (7.8%) were deemed to be at low risk of bias.

Table 3: Risk of bias assessment for the included studies

Assessment Criteria		Bias Risk	N (%)
Duration of follow up			
	0-6 months	High	13(12.62)
	7-12 months	Moderate	24 (23.30)
	13-24 months	Low	25 (24.27)
	>24 months	Low	41 (39.80)
The proportion of the sample that completed full follow-up			
	>(90% Follow up)	Low	58 (56.31)
	80-90% Follow up	Low	14 (13.59)
	70-80% Follow up	Moderate	6 (5.82)
	<70% Follow up	High	16 (15.53)
	Not reported	High	9 (8.73)
Described and consistently applied definition of socio-economic outcome			
	Well-described consistently applied	Low	65 (32.5)
	Inconsistent or lacking description	High	70 (70)
A sample representative of the studied fracture population			
	Broad eligibility criteria	Low	62 (61)
	Narrow eligibility criteria	High	40 (39)

Discussion

Orthopaedic trauma can have a socio-economic impact on patients, particularly after one year of orthopaedic injury. In our study, one-third of patients had not returned to work at one-year post-injury, and, on average, patients missed over 100 days of work following their orthopaedic fracture. Data on the long-term socio-economic impact of orthopaedic trauma is limited but it suggests that 13% of fracture patients may lose employment due to injury[9].Return to work and absenteeism from work was the most commonly used socio-economic outcomes in this study. Productivity loss, income loss, and lost employment were used with much less frequency. Primary data collection was used to capture the socio-economic outcomes in over three-quarters of the included studies. The majority of the included prospective studies calculated their socio-economic measures at one year or less from injury.

However, even in retrospective studies, over one-third measured their socio-economic outcomes within one year of injury. The bias assessment concluded that the methods for measuring the socio-economic outcomes were vague or lacking entirely in three-quarters of the included studies. Tremendous heterogeneity was observed in the pooled socio-economic outcomes[10].

The large registry data presents an opportunity for long-term, population-level estimates of the socio-economic effects of fractures. However, to realize this opportunity, socio-economic data must be routinely and reliably collected in health data registries, or health registry data must include identifiers that can be linked to available socio-economic data.The review study identified opportunities to improve the societal relevance of orthopaedic trauma research by demonstrating the limitations in the current approaches of commonly used socio-economic outcomes. Socio-economic recovery following an injury can be very nuanced and applying only a single measure of socio-economic recovery yields inherent bias. Absenteeism from work fails to describe study participants that do not return to work or return with impairment. Return to work rarely accounts for changes in the employment situation or productivity of the study participants. Productivity loss is difficult to compare across study participants and can be confounded by baseline productivity. Income loss is largely dependent on the pre-injury income distribution of the study population. As study duration increases, new unemployment tends to be a rare outcome for most types of fractures and is easily confounded by the type of pre-injury employment.In this study, many of the included studies highlight practical approaches to measuring socio-economic impact. Several of the included studies, such as those by Mac Kenzie et al. and Gardner et al., utilized a multifaceted approach to assessing the socio-economic outcomes for the study population. Mortelmans et al. combine absenteeism from work and an estimate of impairment for a detailed understanding of the socio-economic outcomes following an intraarticular calcaneus fracture.

However, the specific method for quantifying impairment lacks a description. Nusser et al. added a minimum duration of work absence to their socio-economic outcome reporting. Several other studies

specifically characterized the sustained absence from work into categories such as retired, unemployed, undergoing rehabilitation, recipient of disability payments, in school, never working, or retraining for a different job. Prognostic modeling and stratified analysis included in five studies highlight several common confounders, such as the physical demands of pre-injury employment. The systematic review and meta-analysis included a broad range of extremity fracture research from 30 countries and strictly adhered to the guideline for conduct and reporting. However, despite these strengths, there were several limitations. Socio-economic outcomes were reported at inconsistent time intervals in the included studies, therefore limiting our ability for both pooled and subgroup analyses. Other subgroup analyses were not possible due to inconsistent reporting of potential confounders, such as the severity of the injury, patient comorbidities, the type of pre-injury employment, and legal adjudication for compensation.All these factors are likely to affect the patient's economic well-being after orthopaedic injury. The assessment of study generalizability and a consistent socio-economic outcome definition used in our risk of bias assessment carries a level of subjectivity. However, the appraisal was performed in duplicate. The described socio-economic measure does not represent a fully inclusive list; rather, it includes those socio-economic outcomes currently being utilized in orthopaedic trauma research. There are other socio-economic outcomes, such as the Work Productivity and Activity Impairment questionnaire that are available but were not utilized by the included studies.

Conclusion

This study suggests that orthopaedic trauma can have a substantial socio-economic impact on patients, and therefore it also affect a person's psychological well-being and happiness. However, the current techniques to measure socio-economic outcomes following orthopaedic trauma are widely varied in both design and implementation.Informative and accurate socio-economic outcome assessment requires a multifaceted approach and further standardization.

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