The 1-Year Economic Impact of Work Productivity Loss Following Severe Lower Extremity Trauma

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Background: Severe lower extremity trauma among working-age adults is highly consequential for returning to work; however, the economic impact attributed to injury has not been fully quantified. The purpose of this study was to examine work and productivity loss during the year following lower extremity trauma and to calculate the economic losses associated with lost employment, lost work time (absenteeism), and productivity loss while at work (presenteeism).

Methods: This is an analysis of data collected prospectively across 3 multicenter studies of lower extremity trauma outcomes in the United States. Data were used to construct a Markov model that accumulated hours lost over time due to lost employment, absenteeism, and presenteeism among patients from 18 to 64 years old who were working prior to their injury. Average U.S. wages were used to calculate economic loss overall and by sociodemographic and injury subgroups.

Results: Of 857 patients working prior to injury, 47.2% had returned to work at 1 year. The average number of productive hours of work lost was 1,758.8/person, representing 84.6% of expected annual productive hours. Of the hours lost, 1,542.3 (87.7%) were due to working no hours or lost employment, 71.1 (4.0%) were due to missed hours after having returned, and 145.4 (8.3%) were due to decreased productivity while working. The 1-year economic loss due to injury totaled $64,427/patient (95% confidence interval [CI], $63,183 to $65,680). Of the 1,758.8 lost hours, approximately 88% were due to not being employed (working zero hours), 4% were due to absenteeism, and 8% were due to presenteeism. Total productivity loss was higher among older adults (≥40 years), men, those with a physically demanding job, and the most severe injuries (i.e., those leading to amputation as well as Gustilo type-IIIB tibial fractures and type-III pilon/ankle fractures).

Conclusions: Patients with severe lower extremity trauma carry a substantial economic burden. The costs of lost productivity should be considered when evaluating outcomes.

The economic burden to society of work and productivity loss following injury is substantial[1-3]. A 2006 study conducted by the U.S. Centers for Disease Control and Prevention (CDC) of >50 million injured patients estimated that the annual injury-related productivity loss from missed work alone totaled >300 billion dollars, 4 times the direct medical costs of those injuries[4]. Return to work (RTW) is thus an important measure of overall recovery after trauma. Studies examining RTW among patients with severe lower extremity trauma, including injuries that involved substantial bone loss and soft-tissue damage with complicated patterns of fracture that are challenging to surgically fix, found that many patients who are in the work force prior to injury remain unemployed long after injury[5]. However, estimates of the economic impact from traumatic injury vary[6,7].

A challenge in reporting work and productivity losses is the lack of a consensus around measurement. Prior studies have taken a dichotomous approach to measuring RTW or by reporting the time to first return[8-13]. These approaches potentially understate the true impact of injury on productivity for 2 reasons. First, they do not account for the change in work status over time[6]. Some individuals may RTW by 6 months but may not be working at 12 months because of circumstances related to the injury. Second, they do not consider other aspects of lost productivity. Some individuals may return to their job but miss work because of their injuries (absenteeism), and/or they

*A list of the METRC members is included in a note at the end of the article.

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJS/G910).

A **data-sharing statement** is provided with the online version of the article (http://links.lww.com/JBJS/G912).

may be less productive while at work (presenteeism)[14-16]. Cost-effectiveness analyses taking a societal perspective are increasingly used to evaluate treatment outcomes, and it is therefore important to understand the extent to which lost employment, work loss while employed, and productivity loss while working impact societal cost. While prior studies have captured some of these domains[7,17-20], the instruments used were not validated or conducive to conversion to the same relevant scale, namely dollars lost to society because of decreased work productivity.

The purpose of this study was to examine work and productivity loss during the year following severe lower extremity trauma and to calculate the economic losses associated with lost employment, lost work time, and productivity loss while at work.

Materials and Methods

Study Population

The study included patients from 18 to 64 years old who were surgically treated for severe lower extremity trauma and were enrolled in 1 of 3 prospective multicenter studies from 2011 to 2017: Assessment of Fixation Strategies for Severe Open Tibial Fractures (FIXIT study; ClinicalTrials.gov identifier NCT01494519); Outcomes Following Severe Distal Tibial, Ankle, and/or Mid/Hindfoot Trauma: Comparison of Limb Salvage and Transtibial Amputation (OUTLET study; NCT01606501); and Transtibial Amputation Outcomes Study (TAOS study; NCT01821976). Collectively, these studies enrolled a total of 1,168 patients; inclusion criteria have been described elsewhere[8,21,22]. The present analysis was restricted to 857 individuals (73.4%) who reported being employed at the time of injury and had completed at least 1 scheduled follow-up visit (Fig. 1).

Data Collection

Participant age, sex, race, insurance status, self-reported pre-injury work status, and injury characteristics were documented during the index hospitalization for surgical treatment from medical record review and participant interviews. Injuries were classified by the treating surgeon using the Gustilo-Anderson classification and AO-OTA fracture classification systems[23,24]. Work status prior to injury was characterized by hours worked per week, self-reporting of the physical demands of the participant's job, the organization or company the participant worked for, and the specific job duties. Free text responses regarding the employer organization and work duties were coded using an algorithm provided by the NIOSH (National Institute for Occupational Safety and Health) Industry and

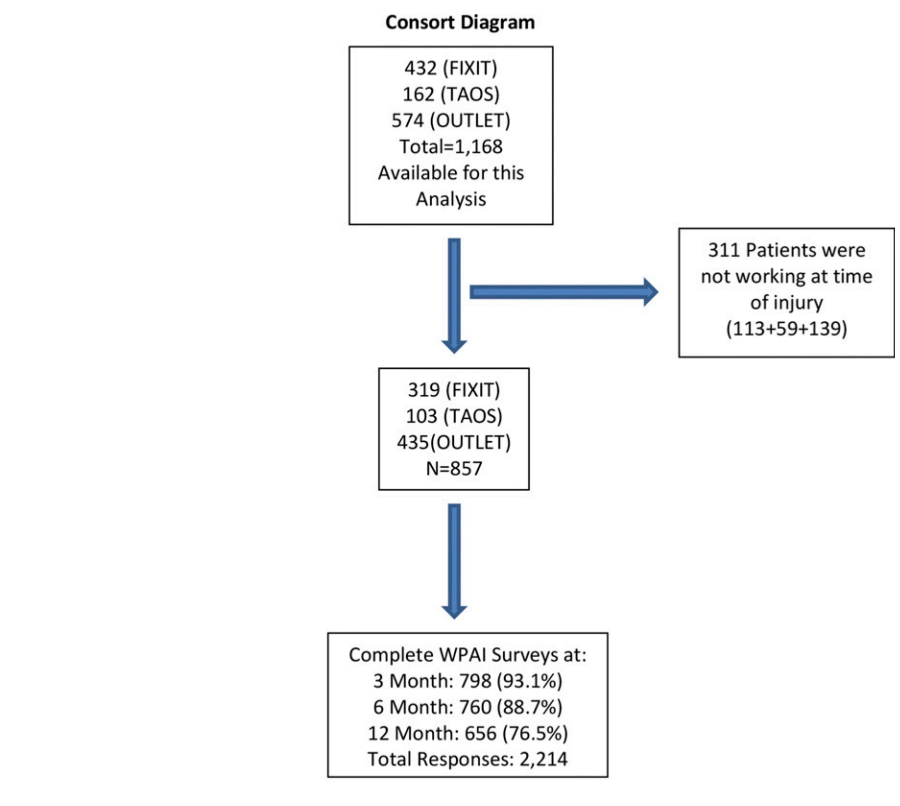

Fig. 1

Consolidated Standards of Reporting Trials (CONSORT) diagram.

Occupation Computerized Coding System (NIOCCS)[25] and were grouped into 1 of 23 Standard Occupation Codes (SOCs).

Work status was scheduled to be assessed at 3, 6, and 12 months following injury. The amounts of work and productivity loss were collected using the validated 6-item Work Productivity and Activity Impairment (WPAI) questionnaire[26]. Patients reported the number of work hours missed due to injury in the prior 7 days and rated how much their injury had affected productivity while at work on a scale from 0 to 10, with 0 indicating no effect and 10 indicating the injury completely prevented work. Outcomes included absenteeism (work time missed because of injury while continuing working) measured in hours, and presenteeism (the amount of work time that was unproductive because of injury) presented as a percentage, with 0% indicating all working hours were productive.

Work Productivity Loss

At each assessment, patients were classified as employed if they reported working any hours in the previous 7 days, and as not employed if they reported that they were unemployed or working no hours because of their injury. Using these classifications along with the exact timing of assessments, we estimated an autoregressive probit model[27]. From this model, we estimated the marginal probability of working at month t after injury and the conditional probability of working at month t after injury given the working status at month s after injury ($s < t$). These conditional probabilities were used to inform a 2-state Markov model with 8 cycles of 1.5 months each. In the model, individuals are not eligible for employment prior to 1.5 months and then switch into (or stay in) 1 of the 2 working states at months 1.5, 3, 4.5, 6, 7.5, 9, 10.5, and 12. We then used linear interpolation to estimate the amount of absenteeism and presenteeism while employed at month t based on WPAI data among those employed at each assessment. In the Markov model, work at month t is assumed to be 40 hours per week and the number of working hours is reduced by the estimated amount of absenteeism and presenteeism at that time.

To illustrate the calculation at 6 months, suppose that 80 of 100 individuals are working. The average amount of absenteeism observed among the 80 who are working is 8 hours per week, and the average amount of presenteeism is 10%. Workers contribute 28.8 hours of work weekly (8 lost to absenteeism and 3.2 lost to presenteeism). The overall average number of hours worked is weighted between 28.8 hours for those employed and 0 hours for those not employed. Thus, the average number of productive hours for a given individual is $28.8 \times (80/100) + 0 \times (20/100) = 23.04$ per week, with 16.96 hours lost per week.

Economic Loss

Economic losses were estimated using a human capital approach to productivity valuation[28,29]. This approach assumes that lost employment, missed hours of work due to injury, and lack of productivity while working are considered losses to society, which we value at the average population wage rate plus fringe benefits, a common assumption in health economic models[30]. To do this, we used the September 2018 U.S. Bureau of Labor Statistics (BLS) estimate of all U.S. workers' average hourly wages, $25.03, plus the fringe benefits (fringe rate of 46.3%), which brings the average total compensation to $36.63 per hour[31]. Use of this average wage plus fringe benefits for the entire U.S. population assumed that those injured are representative of the entire labor market, an assumption that we relaxed in our sensitivity analysis.

Analysis

Results are reported as the modeled probability of working 12 months after injury; total hours of work lost; hours of work loss attributed to lost employment, absenteeism, and presenteeism; and the average annual wages lost. Results are reported overall and by age, sex, injury type, race or ethnicity, insurance, and self-reported physical intensity of job.

Two sensitivity analyses that evaluated assumptions made in the base model were conducted. The first used participants' reported hours of work prior to injury rather than assuming all of them worked a standard 40-hour work week (or 2,080 hours per year). The second used the average wage and RTW domains specific to their occupation, based on the SOC, rather than assuming U.S. average wage for each individual. The occupation-specific average wage rates used come from the BLS and are reported in Table I[32].

We calculated the 95% confidence intervals (CIs) of expected productivity losses in dollars using nonparametric bootstrapping with 1,000 iterations. Analyses were conducted using R (version 3.5.1; R Foundation for Statistical Computing)[33]. The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement is in the Appendix.

Source of Funding

This work was supported by the U.S. Department of Defense awards W81XWH-10-2-0090 and W81XWH-09-2-0108.

Results

Participants had an average age of 39 years, 65.1% were non-Hispanic White, 78.2% were male, approximately 20% had a below-the-knee amputation, and approximately 75% reported having health insurance. The average number of hours worked per week prior to injury was 45.8, and 53% reported their occupation as "very physically demanding." The most prevalent occupations were categorized as transportation and/or moving (15.8%) and construction (15.4%) (Table I).

Table II describes the data used in the Markov model of productivity loss over time. The probit model estimates for the full sample were converted to a marginal probability of working at each 1.5-month cycle. The probability of working increased from 0.177 at 1.5 months to 0.472 at 12 months. Participant-reported absenteeism declined from 9.96 hours per week at 3 months to 2.83 hours per week at 12 months, and presenteeism declined from 40.6% to 26.6%.

Table III presents the modeled proportion of patients who returned to work, hours of work loss, and the economic impact on productivity 12 months following injury. Figure 2 shows these results over time. Results are presented overall and by age, sex, injury type, race, insurance, and physical demand

TABLE I Participant Characteristics (N = 857)

Characteristic	Value	Mean Hourly Wage
Sex *(no. [%])*		
Female	187 (21.8)	
Male	670 (78.2)	
Mean age (stand. dev.) *(yr)*	38.65 (12.15)	
Treatment and injury type *(no. [%])*		
Below-the-knee amputation	175 (20.4)	
Limb salvage		
Type-III pilon/ankle fractures	141 (16.5)	
Type-III talar/calcaneal fractures	95 (11.1)	
Type-IIIA tibial fracture	113 (13.2)	
Type-IIIB tibial fracture	200 (23.3)	
Foot crush and/or blast injuries	133 (15.5)	
Race or ethnicity *(no. [%])*		
Hispanic	122 (14.2)	
Non-Hispanic White	558 (65.1)	
Non-Hispanic non-White*	177 (20.7)	
Insurance *(no. [%])*		
Medicaid	80 (9.3)	
None	175 (20.4)	
Other insurance	198 (23.1)	
Private	404 (47.1)	
Mean preinjury work hours (stand. dev.)	45.8 (13.4)	
Work physical demand, self-report *(no. [%])*		
Very demanding	458 (53.4)	
Not very demanding	399 (46.6)	
Occupation† *(no. [%])*		
Transportation/moving	135 (15.8)	$18.71
Construction	132 (15.4)	$23.47
Management	60 (7.0)	$52.69
Production	60 (7.0)	$19.82
Sales	56 (6.5)	$22.59
Maintenance	55 (6.4)	$23.58
Administrative support	48 (5.6)	$18.64
Cleaning	44 (5.1)	$15.45
Food preparation/serving	43 (5.0)	$13.93
Other	169 (19.6)	$28.23
Unknown	55 (6.4)	$25.12

*Includes participants who were Black, Asian, unknown, and declined to answer. †Data from 2018 BLS[31].

of work. At 12 months, 47.2% of patients were working. Over the course of the year, patients lost an average of 1,758.8 productive hours of work, representing 84.6% of a full work year (considered to be 2,080 hours). Of the 1,758.8 lost hours, approximately 88% were due to not being employed (working zero hours); 4%, to absenteeism; and 8%, to presenteeism. Figure 2 disaggregates the hours lost by cycle. Combined, the economic impact per patient was $64,427 (95% CI: $63,183 to $65,680).

Total productivity loss was higher among older adults (≥40 years old), men, those with a physically demanding job, and those with the most severe injuries (i.e., those leading to amputation, Gustilo type-IIIB tibial fractures, and Gustilo type-III pilon/ankle fractures). Average absenteeism ranged from 32.2 to 90.5 hours per year depending on subgroup. There was an inverse relationship between hours lost due to lost employment and hours lost due to absenteeism, which is partially explained by the presence of absenteeism being contingent on patients having returned to employment. Notably, absenteeism was lowest both in absolute terms (32.2 hours)

TABLE II Inputs to Markov Model

	Value	95% CI*
Probability of working according to months from injury†		
0 mo	0‡	
1.5 mo	0.177	0.154-0.201
3 mo	0.211	0.188-0.234
4.5 mo	0.248	0.225-0.273
6 mo	0.289	0.265-0.314
7.5 mo	0.333	0.307-0.360
9 mo	0.379	0.350-0.407
10.5 mo	0.426	0.394-0.459
12 mo	0.472	0.435-0.511
WPAI outcomes§		
Absenteeism *(hr/wk)*		
3 mo	9.96	7.50-12.45
6 mo	6.47	4.93-8.25
12 mo	2.83	1.99-3.77
Presenteeism *(%)*		
3 mo	0.406	0.352-0.461
6 mo	0.338	0.297-0.382
12 mo	0.266	0.234-0.302
	Base Case	**Sensitivity Analysis**
Hours of work per week, when working	40	45.8#
Average hourly wage	$25.03	See Table I**
Fringe rate	46.3%	

*Estimated using empirical bootstrapping. CI = confidence interval. †Estimated from probit models in 1.5-month cycles. ‡Assumed. §WPAI = Work Productivity and Activity Impairment questionnaire. #45.8 hours was used in sensitivity analysis 1, reflecting reported hours working prior to injury. **Participant's occupation-specific wages were used in sensitivity analysis 2, reflecting average wages for jobs listed prior to injury.

TABLE III Return to Work, Hours of Work Lost, and Economic Impact on Productivity 12 Months Following Injury

	Returned to Work at 12 Mo		Annual Hours Lost*		Hours Lost Due to Lost Employment†		Hours Lost Due to Absenteeism†		Hours Lost Due to Presenteeism†		1-Year Economic Impact on Productivity‡	
	No.	%	No.	%	No.	%	No.	%	No.	%	Cost	95% CI
Full sample (n = 857)	405	47.2	1,758.8	84.6	1,542.3	87.7	71.1	4.0	145.4	8.3	$64,427	$63,183-$65,680
Age												
<40 yr (n = 451)	234	52.0	1,727.1	83.0	1,498.0	86.7	71.4	4.1	157.7	9.1	$63,145	$61,028-$65,516
≥40 yr (n = 406)	172	42.4	1,798.6	86.5	1,599.7	88.9	70.1	3.9	128.8	7.2	$65,881	$63,988-$67,496
Sex												
Female (n = 187)	102	54.7	1,672.8	80.4	1,436.9	85.9	70.9	4.2	165.0	9.9	$61,274	$57,344-$63,750
Male (n = 670)	303	45.3	1,781.7	85.7	1,570.7	88.2	71.5	4.0	139.5	7.8	$65,261	$63,810-$66,697
Treatment and injury type												
Below-the-knee amputation (n = 175)	77	43.7	1,777.1	85.4	1,582.3	89.0	69.3	3.9	125.5	7.1	$65,094	$61,997-$67,047
Limb salvage												
Type-III pilon/ankle fractures (n = 141)	64	45.5	1,792.3	86.2	1,555.6	86.8	82.9	4.6	153.8	8.6	$62,841	$59,235-$66,362
Type-III talar/calcaneal fractures (n = 95)	53	56.2	1,704.5	81.9	1,458.4	85.6	77.6	4.6	168.5	9.9	$59,697	$53,775-$65,131
Type-IIIA tibial fracture (n = 113)	56	49.4	1,679.0	80.7	1,460.4	87.0	70.8	4.2	147.8	8.8	$61,503	$54,776-$64,369
Type-IIIB tibial fracture (n = 200)	85	42.4	1,851.0	89.0	1,651.2	89.2	65.4	3.5	134.4	7.3	$67,466	$63,416-$69,067
Foot crush and/or blast injuries (n = 133)	73	54.7	1,663.6	80.0	1,439.9	86.6	65.8	4.0	157.9	9.5	$60,267	$55,329-$63,651
Race												
Hispanic (n = 122)	46	37.9	1,773.5	85.2	1,581.8	89.2	66.6	3.8	125.0	7.0	$64,962	$59,904-$67,315
Non-Hispanic White (n = 558)	293	52.5	1,718.1	82.6	1,485.4	86.5	71.1	4.1	161.7	9.4	$62,933	$61,437-$64,945
Non-Hispanic non-White (n = 177)	68	38.4	1,879.5	90.4	1,705.8	90.8	72.1	3.8	101.7	5.4	$66,817	$63,950-$68,956
Insurance												
Medicaid (n = 80)	22	27.7	1,900.4	91.4	1,736.9	91.4	72.2	3.8	91.2	4.8	$67,354	$64,425-$70,925
None (n = 175)	59	33.5	1,882.5	90.5	1,750.7	93.0	32.2	1.7	99.6	5.3	$68,957	$65,701-$70,919
Other insurance (n = 198)	92	46.4	1,793.6	86.2	1,533.7	85.5	90.5	5.0	169.4	9.4	$65,699	$61,929-$68,616
Private (n = 404)	231	57.2	1,668.6	80.2	1,424.7	85.4	78.7	4.7	165.2	9.9	$61,120	$59,344-$63,319
Work physical demand												
Very demanding (n = 458)	185	40.4	1,855.0	89.2	1,643.1	88.6	70.4	3.8	141.5	7.6	$67,950	$66,536-$69,568
Not very demanding (n = 399)	220	55.1	1,650.9	79.4	1,430.5	86.6	71.7	4.3	148.8	9.0	$60,473	$57,685-$62,443

*Percent of 2,080 hours, which is the estimated number of full-time hours worked. †Percentage is based on the total number of hours lost by the entire sample of 857 patients working prior to injury. ‡CI = confidence interval.

and as a percentage of possible work hours (32.2/[2,080 − 1,750.7] = 9.8%) for those without insurance. Presenteeism accounted for more lost hours than absenteeism across all subgroups. Younger people, women, and Whites experienced higher absolute levels of presenteeism and as a percentage of their worked hours. Those on Medicaid and the uninsured had the lowest amounts of presenteeism compared with those with other types of insurance.

Sensitivity Analysis

The impact of injury on productivity was $73,774 per year on average when the average participant-reported hours worked per week prior to injury (45.8 hours) was used. The economic impact was $66,525 when participant-reported occupation-specific average wages were used (Table I).

Discussion

The overall economic impact of work and productivity loss that we observed in the year following severe lower extremity trauma was $64,427 (Table III). Most lost hours (87.7%) were due to lost employment, while 4.0% were due to absenteeism, and 8.3% to presenteeism. Many did not return to work at all within the first year after injury, and only 47.2% were working at 12 months (Table III). The impact of injury on

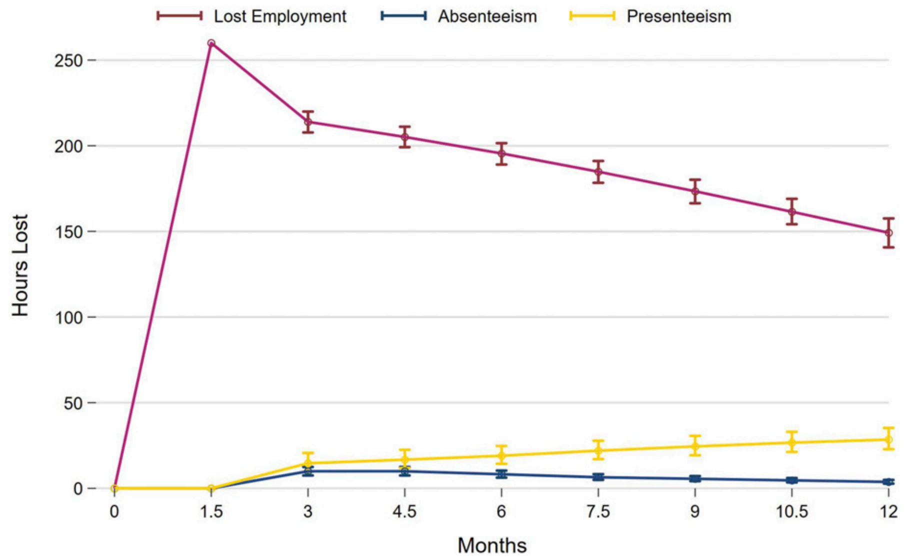

Fig. 2

Modeled average hours lost (and 95% confidence intervals) by domain of work. The modeled number of hours lost over time during each cycle of the Markov model are shown. Each point on the x axis represents the total hours lost in the previous 1.5 months. In the first cycle (1.5 months), lost employment was assumed to be complete (no one worked), and thus absenteeism and presenteeism are by definition equal to 0 as there were no working hours to be reduced. Lost employment decreases over time, while aggregate presenteeism increases as larger proportions of patients have returned to work over time even though average presenteeism levels are higher in early cycles as described in Table II.

productivity was 1,758.8 lost hours or 84.6% of the 2,080 hours we would have expected patients to work (Table III). These findings highlight the challenges faced by patients with severe lower extremity trauma.

Our findings are similar to those in past studies that examined RTW after severe lower extremity trauma[11,12]. MacKenzie et al. reported that 42% of patients working prior to injury returned to work by 1 year, which is similar although less than the 47% that we observed[6]. Notably, that study also reported that 68% of patients had some limitation in the amount or type of work they were able to do on the basis of the scores from the Work Limitations Questionnaire; however, this approach does not provide a clear method to quantify economic consequences. By modeling RTW as a dynamic process and estimating lost hours due to absenteeism and presenteeism over time, our approach provides a more comprehensive view of the hours of work loss and economic consequences of these injuries. Even though 47.2% of patients returned to work at 12 months, we found that 84.6% of otherwise productive hours were lost.

While the time prior to return to employment makes up the bulk of economic losses in the first year after trauma, there are still substantial costs associated with absenteeism and presenteeism. On average, absenteeism (71.1 hours) and presenteeism (145.4 hours) during the first year represented an economic impact of nearly $8,000 per year per injured patient (Table III). While the magnitudes of absenteeism and presenteeism may be less costly to society, they still represent substantial costs that are likely to persist many years after injury. Thus, interventions and treatment such as physical and occupational rehabilitation should focus not just on return to employment but also on interventions that can return patients to working at full capacity.

Overall, the differences in work hours lost by injury are what we would expect, with the most severe injuries and those leading to amputations having the greatest economic impact. However, presenteeism as a percentage of working hours at risk was lower among patients with an amputation. The percentage of working hours lost to presenteeism was 25.2% following amputation compared with 31.3% among patients with a type-IIIB tibial fracture treated with limb reconstruction (Table III). This suggests that ongoing reconstructive and rehabilitative care and/or treatment complications within a year of injury among limb salvage patients may present more challenges to working effectively than the complications from amputation and a prosthesis. There are interesting labor market findings in the examination of subgroups. For example, uninsured patients and those on Medicaid, who are more likely to work in a low wage occupation, had the largest number of hours lost due to lost employment—1,750.7 and 1,736.9, respectively.

Our study has several limitations. First, data were not available to project productivity loss beyond 1 year. This is problematic as we know that the impact of a traumatic injury on work can be lifelong[30,34]. Thus, our estimates should be considered a lower bound of the true economic consequences of these injuries. Second, the WPAI, while validated, asks only for recall over the past 7 days. Thus, we assumed that the week prior to a respondent completing the instrument was representative of the weeks since the previously completed data collection. Further, our probit model assumed linearity between data collections, which, if incorrect, may have biased the results. Third, study participants did not complete 14% of the planned WPAI assessments. If participants with worse productivity outcomes were more likely to miss assessments, then we may have underestimated lost productivity.

Fourth, our conversion of lost hours to dollars may have underestimated the true societal cost. While wages plus fringe benefits are a well-known proxy for the value of work to society, there is evidence that, for some occupations, firms incur greater costs associated with missed work than just the value of wages plus fringe benefits[35]. To avoid equity concerns with valuations of this kind, we presented the economic consequences relying on the average U.S. wage plus fringe benefits only. In the sensitivity analysis, we used the average wages for the self-reported occupations of the sample; however, the average wage of our sample ($24.31) was quite similar to the average wage of the U.S. population ($25.03). We also assumed that patients returned to the same job they had prior to injury. However, it is possible that patients changed their employer or role within the same organization as a result of injury, and we were unable to account for this impact on productivity in our analysis. Fifth, while the WPAI specifically asks about work and productivity loss attributed to the orthopaedic injury, concomitant injuries may have had an impact. Finally, our results are not generalizable to all patients with severe injuries; rather, they reflect the experiences of a segment of the trauma population with severe lower extremity trauma who chose to enroll in a prospective study and participate in survey follow-up evaluations.

In summary, we generated estimates of work and productivity loss and the economic consequences using a method that accounts for lost employment, absenteeism, and presenteeism. The ability to consider all domains of work jointly is important for patients with limb trauma as return to employment and the ability to be productive while working are important problems for this population. As cost considerations increasingly permeate medical research, and cost-effectiveness becomes relevant for clinical decision-making, it is important to develop and utilize best practices to assess all elements of societal cost. This method allows us to comprehensively capture work and productivity loss to society due to these injuries and can be used in future studies of the outcomes and cost of severe lower extremity trauma.

Appendix

eA Supporting material provided by the authors is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJS/G911). ■

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