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Rehabilitation Costs and Long-Term Consequences of Motor Vehicle Injury

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16. Abstract

In 2000, we estimate that $127.5 million was spent for inpatient rehabilitation of injuries in motor vehicle crashes excluding motorcycles, and an estimated $16.3 million was spent on motorcycle crashes, reported in 2002 dollars. Public funds paid for 26 percent of the other motor vehicle costs and 19.5 percent of motorcycle costs. According to estimates generated with the costing methods in Miller, Romano and Spicer (2000), inpatient rehabilitation accounted for an estimated 3 percent of inpatient care costs for motor vehicle injuries and 4 percent of the of the inpatient care costs for motorcycle injuries. The methods used provide a model that can readily be applied to available data to update the national cost estimate in the future.

Motor vehicle and motorcycle injuries generate other costs related to lost functional capacity and the resulting impacts on social and role functions. Although this study did not estimate those costs, it showed the losses for some injuries can be quite significant. For comparison, this study also provides data on rehabilitation costs, hospital length of stay and cost-related outcomes such as employment and living status for other injury causes such as assault and attempted suicide.

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Table of Contents

EXECUTIVE SUMMARY

Introduction and Data Sources

Although the immediate hospitalization costs of motor vehicle and motorcycle crash-related injuries have been examined, the longer-term costs of injury rehabilitation have not been fully addressed. Cost analyses are often conducted before adopting injury prevention programs or laws, and the rehabilitation costs are a potentially important but often overlooked element of the total cost. No one database provides the information needed to estimate the national costs of inpatient rehabilitation for motor vehicle crash injuries. Motor vehicles were defined according to the ICD-9-CM (International Classification of Diseases, Ninth Revision, Clinical Modification), and included any mechanically or electrically powered device, not operated on rails, upon which any person or property may be transported or drawn upon a highway. In this report we estimate costs and explore cost-related rehabilitation outcomes such as changes in employment and living status, using data from six different sources. Secondary data were collected on the frequency, duration, and costs of motor vehicle injury from six sources: American Medical Rehabilitation Provider's Association (AMRPA), Uniform Data System for Medical Rehabilitation (UDSMR), Traumatic Brain Injury (TBI) Model System National Database, pooled 1997 or 1998 Hospital Discharge Survey census data from 21 states, the Health Care Utilization Program 2000 National Inpatient Sample (HCUP-NIS), and the Colorado Traumatic Brain Injury Registry and Follow-Up System. When it was available, we collected demographic data, employment data, and functional outcome data. Data in this analysis includes only crashes that occurred on public roadways, except in chapter four where the traumatic brain injury data includes data on motorcycle crashes occurring both on-road and off-road.

We developed a model that estimates the cost of inpatient rehabilitation for motor vehicle and motorcycle-related injuries. The model combines prospective payment system (PPS) rates for inpatient rehabilitation with UDSMR data on the severity of injuries requiring rehabilitation and multi-State data on the probability of requiring rehabilitation. It estimates average costs per inpatient rehabilitation. When applied to Year 2000 HCUP-NIS data on hospital discharges by cause, the model estimates total cost of inpatient rehabilitation for motor vehicle and motorcycle injuries in 2000.

To better understand the costs of motor vehicle and motorcycle-related injuries, comparisons were made with three other injury causes: assault, attempted suicide, and other unintentional injuries.

Findings

Inpatient rehabilitation costs for motor vehicle injuries average $11,265 per patient (in 2002 dollars, and excluding motorcycle injuries) and $13,200 for motorcycle injuries. Throughout this report we refer to "other motor vehicles," a term that contains motor vehicles but excludes motorcycles, which are considered in a separate category. For motor vehicle injuries, the costs for single-problem cases range from $9,052 for fractures to $26,656 for spinal cord injuries (SCIs). Under the Prospective Payment System, net of labor market price adjustments, these figures are flat-rate total payments for inpatient rehabilitation of a patient on Medicare or Medicaid. Analysis of the AMRPA data shows they are roughly comparable to all-payer average payments in 1999, three years before PPS implementation.

Overall, HCUP-NIS suggests 243,000 patients were admitted for motor vehicle injuries and 24,000 patients were admitted for motorcycling injuries in 2000. Five percent of these patients had an inpatient rehabilitation stay separate from their acute care stay. Spinal cord injury victims had the highest probability of a separate stay, with 30 percent of acute admissions subsequently admitted to rehabilitation facilities. Next came lower-extremity amputations at 11 percent, TBIs with fractures or amputations at 9 percent, lower-extremity fractures at 6 percent, and isolated TBIs at 5 percent.

In 2000, we estimate that $127.5 million was spent for inpatient rehabilitation of injuries in motor vehicle crashes and $16.3 million was spent for inpatient rehabilitation of injuries in motorcycle crashes (in 2002 dollars)

Public funds paid for 26.1 percent of the motor vehicle crash injury costs and19.5 percent of the motorcycle crash injury costs. By comparison, including professional fees, we estimate the acute care hospitalization costs for motor vehicle injuries were $3.665 billion in 2000 and $422 million for motorcycle injuries. These acute care bills included some bundled rehabilitation costs. Separately billed inpatient rehabilitation accounted for an estimated 3 percent of the total inpatient care costs for motor vehicle injuries and 4 percent for motorcycle injuries. The methods used provide a model that can readily be applied to HCUP-NIS data to update the national cost estimate in the future.

Other findings from the study are as follows:

Other Motor Vehicle and Motorcycle injuries generate other costs related to functional losses and the resulting impacts on social and role functions. Although this study did not estimate those costs, it showed the losses for some injuries can be quite significant. UDSMR data shows that across all injury categories, more than 50 percent of patients in the workforce changed their vocational status to nonworking or disabled at the time of rehabilitation discharge. Of the previously employed people injured in Other Motor Vehicle crashes, 64 percent were not working or disabled at the time of discharge and (54.1% and 9.9% respectively) for motorcycle crashes, 62 percent were not working or disabled, (51.1% and 10.6% respectively).

Five categories of impairment are the most common causes of inpatient rehabilitation: TBI; “other” multiple trauma; TBI with fracture and amputation; “other” orthopedic; and hip/knee replacement. These categories account for 81 percent of the motorcycle cases and 79 percent of the Other Motor Vehicle cases. Employment drops among TBI patients were notable. Employment status changed dramatically one-year post-injury. Overall, the proportion of employed patients fell 34.2 percent, from 59.8 percent to 25.6 percent. For Other Motor Vehicle injuries, the drop was from 60.7 percent to 26.1 percent and for motorcyclists, the drop was from 80.2 percent to 44.7 percent. Unemployment rose 27.6 percent overall (from 17.1% to 44.7%), and nearly tripled among motorcyclists (from 10.8% to 31.9%). Those on disability or in sheltered employment more than quadrupled, rising from 1.3 percent to 5.7 percent. The drop in employment may be due to some loss of aptitude or changes in personality. It may also be due to patients still being out of work or finding job search difficult after losing jobs during the months they spent recovering from their TBIs.

Our analysis of the Colorado Traumatic Brain Injury Registry and Follow-Up System, which tracked a large sample of Colorado TBI cases for four years, yielded a similar finding. Although considerable numbers of TBI victims return to work after an injury, permanent or temporary disability or extended medical care prevents many individuals from returning to a productive life. The TBI Model System National Database analysis revealed that of the TBI cases in rehabilitation, 85 percent were tested for BAC in the emergency department (table 8 in Chapter 3). Of those tested, 48 percent of both motor vehicle and motorcycle cases tested positive for alcohol. By comparison, an analysis of 2001 FARS data found that 37 percent of motorcycle riders killed in crashes were positive for alcohol (Shankar, 2003a). An analysis of AMRPA data provides rehabilitation hospital costs for 1999 for specific diagnoses, (see tables in appendix A) ranging from $7,613 for the replacement of a lower-extremity joint to $29,495 for a traumatic spinal cord injury. Average cost per day ranged from $716 for a hip fracture to $991 for burns. Traumatic spinal cord injuries required the longest length of stay – on average 34.3 days, while replacement of a lower extremity joint had the shortest – on average 10.5 days. These finding are relatively consistent among age groups.

The PPS appears to have contained inpatient rehabilitation costs, holding 2002 costs to the levels in the 1999 AMRPA data.

INTRODUCTION

For many motor vehicle crash victims, acute hospital care might be only the first stage of a long and costly treatment program. For many crash victims, lost wages from missed work or reduced work opportunities resulting from permanent impairment will outweigh medical costs. This study was designed to increase knowledge about crash costs and consequences, and provide a more comprehensive picture of the full cost of motor vehicle and crash injuries. Some aspects of the these costs are well documented, but data on rehabilitation costs and permanent disabilities resulting from motor vehicle injury and the source of payment for these costs have been lacking.

This study separately analyzes motorcycle and other motor vehicle injuries because motorcycles account for a disproportionately large share of the burden imposed by highway crashes (Miller, Spicer, Lestina, and Levy, 1999), and may have differential rehabilitation costs. The objectives of this study were to: (1) define rehabilitation costs resulting from injuries received in a traffic crashes; (2) analyze these costs to develop a national model for estimating rehabilitation costs resulting from crashes; (3) identify the source of payment for short- and long-term rehabilitation costs; and (4) capture other data that rehabilitation-related data sets included about the long–term outcomes of motor vehicle injury. Comparable data on other injury causes were captured where possible for comparative purposes. Unless otherwise stated, data in this analysis includes only crashes that occurred on public roadways. The costs reported in this study are only for those patients who were admitted to a hospital for rehabilitation and exclude additional charges for outpatient rehabilitation and related professional services.

Background

Little information is available on the rehabilitation costs of motor vehicle and motorcycle injuries. For traumatic brain injury, which is the most common diagnosis for hospitalized motor vehicle injury, average costs rise dramatically for those individuals who undergo rehabilitation. In one study (Brooks et al., 1995) after a four-year follow-up, average costs for medical and long-term care services averaged $196,460 for survivors receiving rehabilitation services, compared to $17,893 for those receiving no rehabilitation.

A study of Chicago motorcycle crash victims in the acute rehabilitation setting identified 77 patients. Of these, the majority were admitted with a primary diagnosis of traumatic brain injury (TBI, n=50), followed by spinal cord injury (SCI, n=18) and orthopedic injuries or amputations (n=9). Most of the patients with TBI were not wearing their helmets at the time of injury (n=39, 78%). People with spinal cord injuries (SCI) incurred the largest rehabilitation hospital charges (mean $94,548) due to significantly longer rehabilitation stays (mean 42.6 days). Helmet use was unrelated to discharge destination. Although there was no difference in total Functional Independence Measures (FIM) instrument, (discussed further in chapter 3) scores for helmeted and unhelmeted patients, people not wearing helmets had significantly lower cognitive FIM scores at admission and discharge. The study authors conclude that the protective effect of helmet use in motorcycle crashes is reflected even in this post-acute care population of rehabilitation patients (Lombard, Kelly, Heinemann, and Kychlik, 2003).

In 1998 a comment in the Journal of the American Medical Association (JAMA) described a study that analyzed costs for 105 motorcyclists hospitalized in a major trauma center over a 12-month period. Here total direct costs were followed up for a mean of 20 months and were more than $2.7 million with an average of $25,764 per patients. Only 60 percent of the direct costs were accounted for by the initial hospital care; 23 percent of costs were for rehabilitation care or preadmission for treatment of acute problems. The majority (63.4%) of care was compensated with public funds, with Medicaid accounting for more than half of all charges (Rivara, Dicker, Bergman, Dacey, and Herman, 1988).

Methodology

In this study, secondary data were collected on the frequency, duration, and costs of motor vehicle and motorcycle injury from five sources: American Medical Rehabilitation Provider's Association (AMRPA), Uniform Data System for Medical Rehabilitation; Traumatic Brain Injury Model System National Database; pooled 1997 or 1998 Hospital Discharge Survey census data from 21 States; the Health Care Utilization Program 2000 National Inpatient Sample; and the Colorado Traumatic Brain Injury Database. We had intended to use the National Spinal Cord Injury Data Base but new Health Information Portability and Protection Act (HIPPA) regulations precluded getting access to these data within the contract period. When they were available, we collected demographic data, employment data, and outcome data such as FIM scores.

The specific description of each database and the methodology used in the analysis can be found in the chapters of this report, which each provide an introduction, methods, results, and a discussion describing strengths and limitations of the analysis and salient implications.

As an overview, **AMRPA** provided data on 83,000 non-Medicare patients from rehab hospitals, 1997–2001, and contained ICD–9 data. The dataset overlaps heavily with the UDSMR data, but has additional cost and charge data; and is considered the most reliable source of cost data. These data allowed us to examine rehabilitation costs for selected diagnoses (e.g., fractures, sprain/strain, head injury, amputation, spinal cord injury, and other/unspecified).

The **Uniform Data System for Medical Rehabilitation** collects and redistributes data from rehabilitation hospitals nationwide for use in evaluating the effectiveness and efficiency of their rehabilitation programs. It provides the most comprehensive data available on rehabilitation patients across diagnostic categories. This report presents data on people injured in motor vehicle crashes, including demographics, type of injury, length of stay, primary payers, and post-injury rehabilitation circumstances such as employment status, living situation, and the Functional Independence Measure (Guide for the Uniform Data Set for Medical Rehabilitation, 1996) the most widely accepted functional assessment measure in use in the rehabilitation community. The FIM is an 18-item ordinal scale used with all diagnoses within a rehabilitation population.

Traumatic brain injuries are one of the most common injuries of admitted motor vehicle and motorcycle crash victims. The **Traumatic Brain Injury Model System National Database** collects data from 17 sites across the United States and provided one of the largest available samples of rehabilitation patients who incurred TBI: 2,071 cases in motor vehicle crashes and 227 in motorcycle crashes. These data were collected from 1990 to 2002. This data set provides important pre- and post-admission measures on selected TBI impacts on patient residence, marital status, and employment status.

The **Hospital Discharge Survey** census data were leased or purchased from the individual States, then “cleaned” and pooled by PIRE for other purposes. These data come from all hospitals in 19 States in 1997 and 2 additional States that lacked 1997 data but had 1998 data. Rehabilitation hospital discharges only were identifiable in a few of the States.

The **HCUP** National Inpatient Sample is a large, statistically representative sample of U.S. hospital discharges compiled by the Agency for Health Quality and Research (AHQR) of the U.S. Department of Health and Human Services (DHHS). Data on the file identified injury cause for 87 percent of injury admissions. The external cause codes used pinpoint motor vehicle and motorcycling injuries.

The **Colorado Traumatic Brain Injury Registry and Follow-Up System** provided data on incidence of new cases of TBI among Colorado residents. Although it does not contain rehabilitation data, it does provide information on the prevalence and severity of crash-related TBI for specific demographic groups, as well as different outcome variables.

In collecting rehabilitation costs we found information on longer-term outcomes that had not previously been reported and have reported it in this report.

New Prospective Payment System in 2002

As of January 2002, the Health Care Financing Administration (HCFA) (now the Center for Medicare and Medicaid Services, called CMS) adopted a new system of payment for Medicare using Prospective Payment System rates. Medicare has paid acute-care hospitals under a prospective payment system since 1983. Rehabilitation facilities, which provide extensive occupational, physical, and speech therapy services, were formerly exempt from that system. Starting in 2001, rehabilitation facilities are paid on a per-discharge basis based on the patient diagnoses, with hospitals paid more to care for patients with greater needs. For the most part, private insurers appear to have adopted the Medicare reimbursement rates for rehabilitation.

Chapter 3 provides estimates of the national costs of inpatient rehabilitation for motor vehicle and motorcycle injuries and who pays those costs. The methods used here are a model that can readily be applied to HCUP-NIS data to update the national cost estimate in the future.

Chapter 1: Motor Vehicle and Motorcycle Injury Rehabilitation: Findings from the Uniform Data System for Medical Rehabilitation

Abstract

The UDSMR collects and redistributes data from rehabilitation hospitals nationwide for use in evaluating the effectiveness and efficiency of their rehabilitation programs. It provides the most comprehensive data available on rehabilitation patients across diagnostic categories. This chapter provides UDSMR information on people injured in other motor vehicles and motorcycle crashes, including demographics, type of injury, length of stay, primary payers, and post-injury rehabilitation circumstances such as employment status, living situation, and functional independence.

Methods

The UDSMR has established a data repository and reporting system for medical rehabilitation facilities. Subscribing facilities receive quarterly reports of their own data as well as regional and national comparison data for use in evaluating the effectiveness and efficiency of their rehabilitation programs, as well as for hospital accreditation. In 2002, 783 comprehensive medical rehabilitation (CMR) facilities sent data to UDSMR. Of the CMR subscribers, 590 agreed to provide data for this study. Only cases containing E-codes were selected for analysis.

Five years of data (1998–2002) were combined into one dataset. The data were cleaned. For example, obvious miscoding in the E-codes was corrected and variables with missing data or codes out of range were excluded from the appropriate analyses. Because E-codes were indicated in multiple fields, each case was assigned to one unique etiology by a hierarchy scheme. Motorcycle injuries were primary, followed by other motor vehicle, suicide, assault, and other unintentional injury.

Results

Demographic Characteristics of People in Rehabilitation for Injury Due to Motor Vehicle and Motorcycle Crashes

Of the 15,046 rehabilitation patients who incurred injury in a motor vehicle crash, excluding motorcycles, during the 5-year period, 58 percent were male and 42 percent were female. The patients were 75.2 percent White, 14.3 percent African American, 6.4 percent Hispanic and 4.1 percent "Other." Table 1 provides the age distribution of the patients.

Of the 1,437 rehabilitation patients who incurred injury in motorcycle crashes during the 5-year period, 85 percent were male and 15 percent were female. The patients were 84.4 percent White, 7.2 percent African American, 4.9 percent Hispanic, and 3.3 percent Other. Table 1 provides the age distribution of the patients. Seventy percent of the patients were ages 16–44. Consistent with the ages of the rehabilitation patients, in 1998, the mean age of a motorcycle owner was 38.1 years, and the mean age of motorcyclists killed in fatal crashes in 2001 was 36.3 (NHTSA, 2003). The age pattern is similar to the age distribution of motorcycle crash victims found in the analysis of the Traumatic Brain Injury Model System (TBIMS) data in Chapter 3, although the broader rehabilitation group are a bit older than the TBI group. Some TBI cases in these two datasets overlap.

Table 1. Age Distribution of Rehabilitation Patients with Injury Incurred in Motor Vehicle and Motorcycle Crashes and Comparison to Traumatic Brain Injury Model System Data

Age Group	Motor Vehicle Cases	Percent	Motorcycle Cases	Percent	Comparison: (TBIMS) Motorcycle Cases (%)
<16	344	2.3	21	1.5	NA
16–24	3526	23.4	284	19.8	26.9
25–44	4884	32.5	708	49.3	51.1
45–64	3435	22.8	381	26.5	20.7
>=65	2858	19.0	43	3.0	1.3
TOTAL	15047	100.0	1437	100.0	100.0

Type of Injury by Impairment Group and Cause

In this analysis injuries are presented in five categories: Motorcycle, Other Motor Vehicle, Suicide, Assault, and Other Unintentional (which includes falls). Other Motor Vehicle includes any highway vehicle other than a motorcycle. Rehabilitation patients injured in Other Motor Vehicle crashes comprise 18 percent of this dataset and motorcycle crashes comprise only 1.7 percent. The Motorcycle and Other Motor Vehicle categories include only on-road crashes, and for crashes occurring on roads the data does not distinguish between on-road and off-road motorcycle body types. The majority of the injury cases (71.2%) were in the Other Unintentional category.

Of the 22 impairment diagnoses, the most common diagnosis for motor vehicles, excluding motorcycle crashes, requiring rehabilitation was TBI (30.7%) followed by Other Multiple Trauma (18.8%) and TBI with Fracture and Amputation (10.1%) (Table 2). The hip/knee replacement group contained 10 percent and the Other Orthopedic group contained 9.1 percent of the cases. In comparison to Other Motor Vehicle crashes, the Motorcycle crash victims are very similar in the distribution of impairments requiring rehabilitation, sharing the same top five categories --TBI; Other Multiple Trauma; TBI with Fracture and Amputation; Other Orthopedic; and hip/knee replacement. These categories account for 79 percent of the Other Motor Vehicle and 81 percent of the Motorcycle cases. The Motorcycle group was slightly more likely to have TBI rehabilitation services than the Other Motor Vehicle and the Suicide patients, but less likely than the Assault cases. Other Unintended injury causes often had hip/knee replacements as this injury group often includes falls and other injuries occurring in older populations.

Table 2. Distribution of Impairment Group by Injury Cause for Patients in Rehabilitation

	Injury Cause					
Impairment Group	**Other Motor Vehicle (excluding MCs)**	**Motorcycle**	**Attempted Suicide**	**Assault**	**Other Unintended**	**Total**
Total Cases (%)	**15,047 (22.8%)**	**1,437 (2.2%)**	**376 (0.6%)**	**2,145 (3.3%)**	**46,947 (71.2%)**	**65,952 (100%)**
	Percent					
Traumatic Brain Injury (TBI)	30.7	36.5	31.6	48.0	8.8	15.8
Other Multiple Trauma	18.8	18.6	4.5	5.5	4.0	7.8
TBI + Fracture + Amputation	10.1	11.7	1.9	2.1	0.8	3.2
Other Orthopedic	9.1	7.6	0.8	2.5	13.0	11.6
Hip/Knee Replacement	10.0	6.4	1.9	3.3	46.6	35.6
SCI Paraplegia Complete	2.3	3.5	2.1	10.7	0.9	1.6
TBI + Spinal Cord Injury (SCI)	2.5	2.5	0.3	0.9	0.4	0.9
Other Specified	4.0	2.4	42.8	8.8	17.8	14.4
SCI Paraplegia Incomplete	1.5	2.2	1.3	5.3	0.8	1.1
Lower-Extremity Amputation	0.7	2.0	1.1	0.6	0.3	0.3
SCI + Fracture + Amputation	0.7	1.7	0.8	0.3	0.1	0.3
SCI Quadriplegia Incomplete	3.4	1.3	1.9	3.7	1.5	2.0
SCI Quadriplegia Complete	2.7	1.0	1.6	3.8	0.8	1.3
SCI Other	1.5	0.9	1.6	1.9	0.9	1.1
SCI Paraplegia Unspecified	0.7	0.8	0.8	1.3	0.3	0.4
SCI Quadriplegia Unspecified	0.5	0.3	0.3	0.6	0.2	0.3
Other Amputation	0.0	0.2	0.0	0.0	0.1	0.1
SCI Unspecified	0.1	0.1	0.3	0.2	0.1	0.1
Burns	0.1	0.1	4.3	0.5	1.0	0.8
Neck + Back Pain	0.3	0.1	0.3	0.0	1.0	0.8
Upper-Extremity Amputation	0.0	0.0	0.0	0.1	0.0	0.0
Other Pain	0.1	0.0	0.0	0.0	0.5	0.4
Total Percent	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Rehabilitation Length of Stay

Table 3 describes the mean length-of-stay (LOS) for rehabilitation for five causes of injury and for 22 injury categories. These varied widely by impairment diagnoses. For Other Motor Vehicles, the LOS ranged from 68.4

for spinal cord injury - quadriplegia complete to 10.1 days for neck and back pain. For the Motorcycle group LOS ranged from 71.4 days for spinal cord injury - quadriplegia complete to 10.3 days for Other Orthopedic. By cause of injury, the total mean length of stay was lowest for Other Unintended (16.7), moderate for Motorcycle (23.8) and Other Motor Vehicle (23.9) and highest for Assault (27.5) and for Suicide (29.3).

Table 3. Average Length of Stay by Impairment Group and Injury Cause for Patients in Rehabilitation

	Injury Cause					
Impairment Group	Motorcycle	Other Motor Vehicle	Attempted Suicide	Assault	Other Unintended	Total
	Average Length of Stay (Days)					
SCI Quadraplegia Complete	71.4	68.4	--	67.9	64.2	66.4
TBI + SCI	50.1	40.5	--	40.7	45.8	42.5
SCI Quadriplegia Incomplete	42.8	46.3	--	43.3	42.7	44.1
SCI Paraplegia Complete	41.5	41.4	--	40.0	40.5	40.8
SCI Paraplegia Incomplete	38.1	31.1	--	30.0	28.1	29.7
SCI+Fracture+Amputation	29.9	25.7	--	--	29.1	27.3
TBI	28.7	27.9	35.5	24.0	21.6	25.2
Other Specified	28.4	22.2	26.3	25.2	17.4	13.6
SCI Paraplegia Unspecified	24.4	31.1	--	27.6	31.0	30.6
TBI+Fracture+Amputation	21.6	21.7	--	23.8	20.4	21.5
Other Multiple Trauma	13.7	14.4	17.9	16.3	13.8	14.2
Lower-Extremity Amputation	13.3	16.8	--	10.9	16.6	25.6
Hip/Knee Fracture Or Replacement	11.2	12.8	--	12.1	14.2	15.5
SCI Other	10.8	19.5	--	20.0	19.1	19.1
Other Orthopedic	10.3	13.5	--	13.1	13.6	13.5
Upper-Extremity Amputation	NA	--	NA	--	11.3	12.2
Other Pain	NA	10.4	NA	--	12.8	12.6
SCI Unspecified	--	27.9	--	--	23.2	24.1
SCI Quadriplegia Unspecified	--	49.0	--	34.6	37.8	41.5
Other Amputation	--	--	NA	NA	22.7	22.3
Neck And Back Pain	--	10.1	--	--	13.0	12.7
Burns	--	35.6	24.8	14.5	16.0	16.9
TOTAL	23.8	23.9	29.3	27.5	16.7	18.9

-- Indicates fewer than 10 cases.
* Indicates no injury cases in the category.

Primary Payer by Cause of Injury, 1998–2002

The most commonly reported payer for people injured as a result of a motor vehicle crash was private insurance (40.2%), followed by public funding –(Medicaid or Medicare) (26.1%) and no-fault insurance (19.9%) (see table 4.)

For motorcycle crash injuries private insurance was more likely to be the payer (63%). Public funding accounted for 19.5 percent of the cases, followed by no-fault automobile insurance (6.9%), Other/ Unknown (5.5%), self-pay (2.4%), unreimbursed (1.6%) and Workers' Compensation (1%). The distribution is similar to Motor Vehicle Crashes, but is dissimilar from Suicide, Assault, and Other Unintended injuries that have public funding sources ranging from 49.5 percent to 76.7 percent.

Table 4. Distribution of Primary Payer by Cause of Injury

	Injury Cause				
Primary Payer	**Motorcycle**	**Other Motor Vehicle**	**Attempted Suicide**	**Assault**	**Other Unintended**
	Percent				
Private Insurance	63.0	40.2	34.3	25.7	15.9
Public Funding (Medicare or Medicaid)	19.5	26.1	49.5	53.7	76.7
No-Fault Auto	6.9	19.9	0.5	0.2	0.5
Other/Unknown	5.5	5.6	7.2	6.4	2.0
Self-Pay	2.4	2.0	4.0	3.4	0.5
Unreimbursed	1.7	2.5	3.7	8.6	0.6
Workers' Compensation	1.0	3.7	0.8	2.0	3.9
TOTAL	100	100	100	100	100

Pre- and Post-Measures

Data were gathered from patients via telephone surveys at one-year post–injury and at subsequent anniversaries of the injury throughout the duration of the study. Not all facilities followed up with patients after discharge from the rehabilitation facility. Table 5 lists the number and percentage of cases with follow-up data available. This very small subset of the original number of cases may not be a representative sample. However, for the most part, facilities either conduct follow-up interviews or not, so the results are more affected by facility bias than nonrespondent bias.

Table 5. Rehabilitation Cases with Follow-Up Data by Cause of Injury

	Injury Cause					
	Motorcycle	**Other Motor Vehicle**	**Attempted Suicide**	**Assault**	**Other Unintended**	**Total**
Followed Cases	328	3,335	68	336	11,027	15,094
% with Follow-Up Data	22.8	22.2	18.1	15.7	23.5	29.7

Living Status

Patients were asked at time of discharge where they would be living. Of those injured in Other Motor Vehicles crashes, 94 percent lived in private homes both before and after rehabilitation. A similar but slightly higher proportion was found for motorcycle crash injury victims - 97 percent of those with known pre- and post-measures. (n=328). For attempted suicide, Assault, and Other Unintended Injuries, the percents were 75 percent, 92 percent, and 89 percent respectively.

Vocational Status at Time of Rehabilitation Discharge

Table 6 shows that across all injury categories, more than 50 percent of patients in the workforce changed their vocational status to nonworking or disabled at the time of rehabilitation discharge. Of the previously employed people injured in Other Motor Vehicle crashes, 64 percent were not working or disabled. This number was similar -- 62 percent (51.1% and 10.6% respectively) -- for motorcycle crash victims at the time of discharge.

Table 6. Post-Rehabilitation Vocational Status, by Cause of Injury, for Patients Employed at the Time of Admission

Post-Vocational Status	Cause of Injury				
	Motorcycle	Other Motor Vehicle	Attempted Suicide	Assault	Other Unintended
Total Cases	237	1541	24	134	1506
	Percent				
Employed	32.5	27.1	12.5	15.7	32.0
Not Working	51.1	54.1	70.8	69.4	41.6
Disability	10.6	9.9	12.5	9.7	8.2
Student	0.8	1.9	0.0	2.2	0.5
Other	5.1	7.0	4.2	3.0	17.7
Total	100	100	100	100	100

Functional Independence Measure Scores at Time of Discharge

FIM[1] scores are standardized scales used in medical rehabilitation units to measure ability to function independently. The FIM System is comprised of 13 motor activities and 5 cognitive skills in the areas of self-care, sphincter control, transfers, locomotion, and social cognition. Each of the 18 items is rated on a seven-level ordinal scale, with Level 7 representing “Complete Independence” and Level 1 describing “Total Assistance.” The sum of the item scores describes the severity of an individual’s disability and

[1] Note: The specific FIM scores are as follows, from worst to best. A score of "1" means "total assistance," in which the person puts forth less than 25 percent of the effort necessary to do a task. A score of "2" means "maximal assistance," in which the person puts forth less than 50 percent of the effort necessary to do a task, but at least 25 percent. If someone gets an FIM score of "1" or "2", the person is classified as having "complete dependence," because the person puts forth less than half the energy, requires maximal or total assistance, or even worse -- the activity is not performed at all.

An FIM score of "3" means "moderate assistance," in which the person puts forth between 50 percent and 75 percent of the effort necessary to do a task. A score of "4" means "minimal contact assistance," in which the person puts forth 75 percent or more of the effort necessary to do a task, and requires no more help than touching. A score of "5" means "supervision or setup," in which the person only needs someone to standby and cue or coax him/her (without physical contact) so the task can be done. A score of 5 can also be obtained if a helper is needed to set up items or assistive devices for the person. If someone gets an FIM score of 3, 4, or 5, he/she is classified as having "modified dependence," because the person can at least put forth half or more of the energy to complete the task.

A FIM score of "6" means "modified independence," in which no helper is needed and the person needs an assistive device. A score of 6 can also be obtained when no help is needed but the person takes considerable time to do a task or may complete the task in an unsafe manner. A score of "7" means "total independence," in which no helper is needed and the person performs the task safely, within a reasonable amount of time, and without assistive devices, aids, or changes. If someone gets an FIM score of 6 or 7,the person is classified as being "independent," because another person is not needed to complete the activity.

reflects the amount of assistance required for an individual to complete daily activities.

Table 7 presents the mean FIM motor score for Motorcycle and Other Motor Vehicle injury for 20 diagnostic groups, arrayed for Motorcycle crash injury patients from the highest (most independent) motor score, to the lowest (requiring most assistance). The possible score range is from 13 for complete mobility loss to 91 for full mobility. Many of the patients had a near-total recovery, with mean FIM scores in the 70s. The lowest average FIM motor score is seen for SCI Quadriplegia Complete in both the Motorcycle and the Other Motor Vehicle Categories.

Table 7. Post-Rehabilitation Average FIM Motor Score by Motorcycle versus Other Motor Vehicle Injury by Diagnosis Group

Impairment Group	Motorcycle		Other Motor Vehicle	
Diagnosis Group	Number of Cases	Avg FIM Motor Score	Number of Cases	Avg FIM Motor Score
Upper-Extremity Amputation	29	76.4	6	66.3
SCI Other	13	75.6	225	66.3
Other Orthopedic	109	72.0	1,365	68.4
TBI	523	69.0	4,605	67.9
Hip/Knee FX/Replacement	92	69.0	1,501	70.0
SCI Paraplegia Incomplete	31	67.5	223	66.2
Other Multiple Trauma	268	66.9	2,830	66.5
SCI Paraplegia Unspecified	12	64.7	103	59.8
TBI + Fracture + Amputation	168	64.6	1,522	64.7
Other Specified	34	63.0	607	63.0
SCI Paraplegia Complete	51	59.4	349	59.1
SCI Quad Incomplete	19	52.7	516	51.4
SCI + Fracture + Amputation	24	50.9	109	56.5
TBI + SCI	36	50.3	376	55.7
SCI Quadriplegia Complete	15	29.1	400	29.0
SCI Unspecified	*	*	22	69.1
SCI Quadriplegia Unspecified	*	*	71	42.9
Lower-Extremity Amputation	*	*	100	70.0
Neck + Back Pain	*	*	46	71.0
Other Pain	*	*	18	65.7

* Indicates fewer than 10 cases.

Table 8 presents the mean FIM cognitive scores for Motorcycle and Other Motor Vehicle. These must have a different scale than motor, with a range from 5 to 35. The mean scores range from a low of 23.3 for TBI to 34.4 for SCI Paraplegia Unspecified. Spinal cord injuries and amputations would not be expected to impair cognitive functioning and presumably strike people of similar demographics as those who experience TBIs. Thus, absent TBI, mean cognitive scores for TBI victims would have been about 33 to 34 for Motorcyclists and 32 to 33 for Other Motor Vehicle injury victims.

Importantly, patients may continue to recover and rehabilitate after discharge from inpatient rehabilitation, which can improve their ultimate FIM levels.

Table 8 Post-Rehabilitation Average FIM Cognitive Score by Motorcycle versus Other Motor Vehicle Injury by Diagnosis Group

Diagnosis Group	Motorcycle		Other Motor Vehicle	
	Number of Cases	Avg FIM Cognitive Score	Number of Cases	Avg FIM Cognitive Score
SCI Paraplegia Unspecified	12	34.4	103	32.6
SCI Other	13	34.2	225	32.7
Lower Extremity Amputation	29	34.1	100	32.6
SCI+Fracture+Amputation	24	34.0	109	31.5
Other Orthopedic	109	33.8	1,365	32.6
SCI Paraplegia Complete	51	33.8	349	33.2
SCI Paraplegia Incomplete	31	33.6	223	33.4
SCI Quadriplegia Incomplete	19	33.4	516	32.8
SCI Quadriplegia Complete	15	33.3	400	31.9
Hip/Knee FX/Replacement	92	33.2	1,501	33.1
Other Multiple Trauma	268	32.7	2,830	32.3
Other Specified	34	31.3	607	29.4
TBI + SCI	36	29.1	376	28.1
TBI+Fracture+Amputation	168	26.6	1,522	26.7
TBI	523	23.3	4,605	23.9
SCI Unspecified	*	*	22	33.1
Burns	*	*	18	33.4
SCI Quadriplegia Unspecified	*	*	71	32.2
Neck+Back Pain	*	*	46	32.0
Other Pain			18	32.1

* Indicates fewer than 10 cases.

Discussion

The UDSMR provides the most comprehensive data available on rehabilitation patients across diagnostic categories, and provides one of the largest datasets of motor vehicle and motorcycle-related rehabilitation data available. These data are the only existing source for impairment across a range of causes. It also provides limited pre- and post-measures. With these data we can understand the distribution of cases that the rehab PPS rules apply to. One shortcoming of these data is that they often lack cause codes; some facilities refused us access to their data. Therefore the cause-coded cases accessible to us may not be representative.

The data also do not distinguish between on-road and off-road motorcycles such as motocross motorcycles for crashes occurring on roads]. However, crashes occurring with off-road motorcycles are believed to be a very small proportion of on-road motorcycle crashes. An analysis of the Fatality Analysis Reporting System (FARS) finds that off-road vehicles account for only 1.2 percent of on-road motorcycle fatalities.

Chapter 2: Analysis of the Colorado Traumatic Brain Injury Registry

Introduction

The Colorado Traumatic Brain Injury Registry and Follow-Up System (CTBIRFS) was a joint surveillance activity of the Colorado Department of Public Health and Environment, Craig Hospital, and the Centers for Disease Control and Prevention. The purpose of the system was to identify outcomes associated with traumatic brain injury including quality of life, reintegration into the community, return to work and school, functional status, service use, and secondary complications. A random sample of traumatic brain injury cases was drawn from the State of Colorado's Hospital Discharge File for 1966 through 1999. Patients selected were Colorado residents 16 and older, who had been discharged alive from a Colorado hospital from an acute care hospitalization with TBI. A complex questionnaire was developed which drew upon established interview scales and prior instruments. Sources of scales and questions that were incorporated into the interviews include, among others, the Craig Handicap Assessment and Reporting Technique (CHART); FIM score; Health Status Questionnaire (HSQ); and the Health-Related Quality of Life (SF-36) form. Patients selected for inclusion in the system (or their proxies) were interviewed one year after discharge and on subsequent anniversaries of their discharge.

The content of the survey changed somewhat over time. For example, shorter versions of established health scales were substituted for longer ones, allowing for continued calculation of important measures of health status and/or disability, though decreasing the length of successive surveys. Finally, some questions were not asked in the fourth year of follow-up.

Methods

The database contained a wealth of information directly relevant to its purpose of characterizing sequellae and recovery from TBI but was lacking in some aspects. For example, though broad cause-and-intent categorical codes were included in the database, external cause-of-injury codes were absent. As a consequence, we recoded the cause-and-intent data into the following categories: Motor Vehicle Crashes (includes motorcycle crashes); Assault or Suicide (non-firearm); Unintentional Falls; Other Unintentional (includes sports injuries); and Other and Unknown (includes firearms-related injuries).

Using data collected from 1990 to 2002, we examined the distribution of cases across the four follow-up years. As one of the goals of this report is to provide longitudinal information on health and disability trends in survivors of traumatic brain injury, we linked cases across each of the four follow-up years and identified a subset of patients who had been interviewed in each of the four years. As noted previously, some variables were only available for the first three years of the study. Basic demographic characteristics, case mix, and severity of the first year interviewees (N=1, 603) were compared with the group that had completed all four interviews (N=380). Tables 1 and 2 show the basic age distribution of initial and long-term interviewees. Over 60 percent of patients in the database were 16 to 44, and patients 65 or older accounted for approximately 15 percent of the cases.

Table 1. Age Distribution for Patients Completing the 1st Interview

Age Band	Frequency	Percent
< 25	389	24.3
25-44	587	36.6
45-64	345	21.5
65+	270	16.8
Unknown	12	0.7
Total	**1,603**	**100.0**

Table 2. Age Distribution for Patients Completing All Interviews

Age Band	Frequency	Percent
< 25	95	25.0
25-44	143	37.6
45-64	86	22.6
65+	56	14.7
Unknown	0	0.0
Total	**380**	**100.0**

Tables 3 and 4 show the distribution of males and females in the database. Relative to the initial interviewees, women represent a slightly higher proportion of the patients who completed all interviews.

Table 3. Distribution of Males and Females for Patients Completing the 1st Interview

Gender	Frequency	Percent
Male	1,028	64.1
Female	563	35.1
Unknown	12	0.8
Total	**1,603**	**100.0**

Table 4. Distribution of Males and Females for Patients Completing All Interviews

Gender	Frequency	Percent
Male	235	61.8
Female	145	38.2
Total	**380**	**100.0**

Tables 5 and 6 show the breakdown by race of patients in the study. The patients completing the first and follow-up interviews were predominantly white. A somewhat greater proportion of minorities were represented among initial interviewees than among long-term interviewees.

Table 5. Breakdown by Race for Patients Completing the 1st Interview

Race	Frequency	Percent
Asian	17	1.1
Black	36	2.2
Native American	8	0.5
White	1,335	83.3
Other	2	0.1
Unknown	205	12.8
Total	**1,603**	**100.0**

Table 6. Breakdown by Race for Patients Completing All Interviews

Race	Frequency	Percent
Asian	4	1.1
Black	9	2.4
Native American	3	0.8
White	341	89.7
Other	0	0
Unknown	23	6.1
Total	**380**	**100**

Tables 7 and 8 show the distribution of injury cause for patients included in the study.

Table 7. Injury Cause Distribution for Patients Completing the 1st Interview

Race	Frequency	Percent
Motor Vehicle Crash	814	50.8
Assault/Suicide	110	6.9
Unintentional Falls	434	27.1
Other Unintentional	215	13.4
Other and Unknown	30	1.9
Total	**1,603**	**100.0**

Table 8. Injury Cause Distribution For Patients Completing All Interviews

Cause	Frequency	Percent
Motor Vehicle Crash	208	54.7
Assault/Suicide	26	6.8
Unintentional Falls	92	24.2
Other Unintentional	49	12.9
Other and Unknown	5	1.3
Total	**380**	**100.0**

Motor vehicle crashes predominate, followed by unintentional falls, other unintentional, assault/suicide, and other and unknown. Neither the rankings nor relative proportions of the injury cause vary dramatically between first and long-term interviewees. Unfortunately the file does not differentiate motorcycle crashes from other motor vehicle crashes.

Finally, Tables 9 and 10 show average age and length of stay in days by injury cause.

Table 9. Average Age and Length of Stay (LOS) for Patients Completing the 1st Interview

Cause of Injury	Number of Cases	Average Age	Average LOS (days)
MVA	814	35.1	7.8
Assault/Suicide	110	35.1	6.1
Unintentional Falls	434	59.1	6.1
Other Unintentional	215	37.6	4.0
Other and Unknown	18	34.6	13.6
Missing Data	12	N/A	N/A

Table 10. Average Age and Length of Stay for Patients Completing All Interviews

Cause of Injury	Number of Cases	Average Age	Average LOS (days)
MVA	208	35.7	7.6
Assault/Suicide	26	34.6	6.5
Unintentional Falls	92	55.5	6.0
Other Unintentional	49	38.2	3.0
Other and Unknown	5	30.8	10.4

The most noticeable difference between first and long-term interviewees is the somewhat lower average age of patients discharged after unintentional falls. Otherwise, the two groups are quite comparable.

In conclusion, based on the tabular analysis of demographics, injury cause and length of stay, the subgroup of patients who completed all interviews is not substantially different from the initial interviewees.

Payer Source by Injury Category

These data also show primary payer by injury cause in table 11. “Other liability insurance” — presumably automobile insurers — dominated the payers for motor vehicle crashes (51.4%) and “Self-pay,” which includes the uninsured, accounted for 14.4 percent of payers for motor vehicle crashes.

Table 11. Analysis of Payer Source by Injury Category – Number and (Percent)

Payer	Injury Category					
	Motor Vehicle	Assault & Suicide	Unintentional Falls	Other Unintentional	Other and Unknown	All
Blue Cross	7 (3.4)	4 (15.4)	2 (2.1)	3 (6.1)	0 (0)	16 (4.2)
Other health insurance company	11 (5.2)	2 (7.7)	22 (23.9)	17 (34.7)	2 (40.0)	54 (14.2)
Other liability insurance	107 (51.4)	0 (0)	0 (0)	2 (4.1)	0 (0)	109 (28.8)
Medicare	6 (2.9)	3 (11.5)	24 (26.1)	4 (8.2)	0 (0)	37 (9.7)
Medicaid	2 (1.0)	2 (7.7)	2 (2.1)	0 (0)	0 (0)	6 (1.6)
Workers' Comp	5 (2.4)	2 (7.7)	15 (16.3)	7 (14.3)	0 (0)	29 (7.6)
HMO	7 (3.4)	3 (11.5)	18 (19.6)	4 (8.2)	0 (0)	32 (8.4)
CHAMPUS	1 (0.5)	0 (0)	1 (1.1)	0 (0)	0 (0)	2 (0.5)
Other govt. payer	0 (0)	0 (0)	0 (0)	0 (0)	1 (20.0)	1 (0.3)
Self-pay	30 (14.4)	5 (19.2)	4 (4.4)	6 (12.2)	0 (0)	45 (11.8)
Other	0 (0)	1 (3.9)	0 (0)	0 (0)	0 (0)	1 (0.3)
Unknown	32 (15.4)	4 (15.4)	4 (4.4)	6 (12.2)	2 (40.0)	48 (12.6)
Total	208 (100)	26 (100)	92 (100)	49 (100)	5 (100)	380 (100)

Analysis of Outcomes, Long-Term Disability, and Recovery

We first examined reported head injury severity as a function of injury cause, presented here in table 12. Two findings are clear:

1. Moderate head injuries represented a relatively greater proportion of cases (37%) among motor vehicle crash (MVC) patients than among other causes, and

2. Critical and severe injuries represented a relatively greater proportion of cases (54.1%) among unintentional fall patients than among other causes.

Table 12. Analysis of Head Injury Severity by Injury Cause – Frequency and (Percent)

Severity Category	Motor Vehicle	Assault & Suicide	Unintentional Falls	Other Unintentional	Other and Unknown	All
1. Moderate Injury	77 (37.0)	4 (15.4)	17 (18.5)	9 (18.4)	0 (0.0)	107 (51.4)
2. Serious Injury, Not Life Threatening	61 (29.3)	10 (38.5)	28 (30.4)	14 (28.6)	4 (1.9)	117 (56.3)
3. Severe Injury, Life Threatening, Probable Survival	41 (19.7)	7 (26.9)	22 (23.9)	20 (40.8)	0 (0.0)	90 (43.3)
4. Critical Injury, Survival Uncertain	28 (13.5)	5 (19.2)	25 (27.2)	6 (12.2)	1 (0.5)	65 (31.3)
5. Unknown	1 (0.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.5)
Total	208 (100.0)	26 (100.0)	92 (100.0)	49 (100.0)	5 (100.0)	380 (100.0)

The database offers a large number of scale scores and individual questions about outcomes. We screened many of these measures and present representative findings.

The Craig Handicap Assessment and Reporting Technique was designed to quantify the extent of handicap in individuals. CHART consists of six dimensions, each with a maximum score of 100. The dimensions are occupation, cognitive independence, physical independence, mobility, social integration, and economic self-sufficiency. A total CHART score of 600 indicates no handicap at all. Table 13 displays available CHART occupation scores for each of the four one-year anniversary follow-ups. These scale scores measure participation in work and related matters. CHART occupational scores tended to be higher for those involved in motor vehicle crashes as compared to All Others in Years 1 and 2, though larger number of Missing or Not Asked in Years 3 and 4 preclude further interpretation.

Table 13. CHART Occupational Scores by Year and Injury Cause, Mean and (N), Perfect = 100

Measure	Motor Vehicle	All Others	Not Asked or Missing
Occupational Score Year 1	81.6 (198)	76.6 (164)	(18)
Occupational Score Year 2	86.0 (197)	79.3 (163)	(20)
Occupational Score Year 3	78.1 (138)	70.7 (110)	(132)
Occupational Score Year 4	75.3 (117)	66.5 (94)	(169)

Table 14 presents CHART social integration scores. These scores, available only for the Year 1 and Year 2 follow-up, show that relative to patients involved in MVCs, all other patients were more socially isolated.

Table 14. CHART Social Integration Scores by Year and Injury Cause – Mean and (N), Perfect = 100

Measure	Motor Vehicle	All Others
Social Integration Score Year 1	85.8 (201)	81.7 (?167 ?)
Social Integration Score Year 2	86.1 (204)	84.6 (?168?)

Finally, Table 15 displays total CHART scores for the four years of follow-up. The analysis reveals few differences across the injury categories and the four years of follow-up. Scores declined in the third and fourth follow-up years for victims of falls, many of them elderly.

Table 15. Total CHART Scores by Year and Injury Cause = Mean and (N), Perfect Health = 600

Measure	Motor Vehicle	All Others
Total CHART Scores Year 1	531.7 (188)	527.0 (151)
Total CHART Scores Year 2	539.6 (187)	537.0 (153)
Total CHART Scores Year 3	523.2 (132)	509.0 (102)
Total CHART Scores Year 4	516.9 (109)	495.00 (86)

We compared FIM scores for motor and cognitive scales (Tables 16 and 17). These scale totals are a composite of a series of questions scaled from 1 (Total Assistance) to 7 (Complete Independence). The scores show little variation across injury cause and little variation across Years 1 and 2, the two years for which relatively complete data are available.

Table 16. FIM Motor Scores by Injury Cause for Years 1 and 2 – Mean and (N), Perfect = 91

Measure	Motor Vehicle	All Others
FIM Motor Scores Year 1	88.2 (193)	88.8 (156)
FIM Motor Scores Year 2	88.0 (192)	88.9 (158)

Table 17. FIM Cognitive Scores by Injury Cause for Years 1 and 2 – Mean and N, Perfect = 35

Measure	Motor Vehicle	All Others
FIM Cognitive Scores Year 1	32.1 (197)	32.2 (162)
FIM Cognitive Scores Year 2	31.9 (191)	32.4 (158)

Tables 18 and 19 display analyses of elements and total scores from the Health Status Questionnaire (HSQ). The HSQ is an outcomes measurement tool that yields scores on eight health attributes and can be used to measure the risk of a depressive disorder. The attributes are health perception, physical functioning, role limitations/physical health, role limitations/ emotional problems, social functioning, mental health, bodily pain, and energy/fatigue. HSQ physical function scores were somewhat lower for patients involved in motor vehicle crashes than for all others, as were HSQ mental health scores (Table 19). Scores for victims of motor vehicle crashes and Other and Unknown tended to be slightly lower in the first-year follow-up. Scores tended to increase in Year 2. HSQ total scores were lower for patients involved in motor vehicle crashes than for all others. Scores generally improved in Year 2 (Table 20).

Table 18. HSQ Physical Function Scores by Injury Cause for Years 1 and 2 – Mean and (N)

Measure	Motor Vehicle	All Others
HSQ Physical Function Year 1	77.0 (206)	81.0 (171)
HSQ Physical Function Year 2	82.9 (208)	85.4 (168)

Table 19. HSQ Mental Health Scores by Injury Cause for Years 1 and 2 – Mean and (N)

Measure	Motor Vehicle	All Others
HSQ Mental Function Year 1	62.7 (204)	71.7 (169)
HSQ Mental Function Year 2	82.9 (208)	72.2 (169)

Table 20. Total HSQ Scores by Injury Cause for Years 1 and 2 – Mean and (N)

Measure	Motor Vehicle	All Others
HSQ Total Scores Year 1	339.1 (201)	370.6 (169)
HSQ Total Scores Year 2	357.0 (208)	382.2 (165)

Employment Impacts

We probed the impacts of head injury on employment by examining several sets of measures. Respondents were asked to report their current job hours worked at each of the four anniversaries of injury. Table 21 reports simple employment trends by year and injury cause. Overall reported levels of employment increased through Year 3 and declined slightly in Year 4 (Table 22).

Table 21. Jobs Hours Worked per Week by Injury Cause and Year – Mean and (N)

Measure	Motor Vehicle	All Others
Current Job Hours Year 1	21.6 (204)	21.4 (169)
Current Job Hours Year 2	25.3 (202)	23.2 (167)
Current Job Hours Year 3	26.6 (207)	25.7 (172)
Current Job Hours Year 4	25.8 (208)	24.5 (172)

Table 22. Are You Employed? By Injury Cause and Year – Frequency and (Percent)

	Motor Vehicle Crash			
	Year 1	Year 2	Year 3	Year 4
YES	119 (57.5)	130 (62.5)	140 (67.6)	135 (64.9)
NO	88 (42.5)	78 (37.5)	67 (32.4)	73 (35.1)

	All			
	Year 1	Year 2	Year 3	Year 4
YES	213 (56.3)	225 (59.2)	246 (64.9)	237 (62.9)
NO	165 (43.7)	155 (40.8)	133 (35.1)	140 (37.1)

Table 23 displays the distribution of stated reasons for non-employment by victims at each of the anniversary follow-ups. The ‘Other’ category includes miscellaneous categories such as students and homemakers. This table suggests that unplanned or premature retirement may be associated with injury outcomes. Permanent or temporary disability and extended medical treatment also clearly prevent some victims from re-entering the workforce, even as much as five years after injury.

Table 23. Why Are You Not Working? By Injury Cause and Year – Frequency and (Percent)

	Motor Vehicle Crash					All			
	Year 1	Year 2	Year 3	Year 4		Year 1	Year 2	Year 3	Year 4
Retired	17 (19.1)	19 (24.7)	19 (28.8)	22 (30.6)	Retired	54 (32.0)	61 (40.1)	57 (43.5)	67 (47.9)
Not Released by Doctor	9 (10.1)	4 (5.2)	1 (1.5)	1 (1.4)	Not Released by Doctor	16 (9.5)	8 (5.3)	3 (2.3)	1 (0.7)
Perm/Temp Disabled	18 (20.2)	17 (22.1)	22 (33.3)	25 (34.7)	Perm/Temp Disabled	27 (16.0)	29 (19.1)	40 (30.5)	40 (28.6)
Other	45 (50.6)	37 (48.1)	24 (36.4)	24 (33.3)	Other	72 (42.6)	54 (35.5)	31 (23.7)	32 (22.9)
Total	89 (100.0)	77 (100.0)	66 (100.0)	72 (100.0)	Total	169 (100.0)	152 (100.0)	131 (100.0)	140 (100.0)

Discussion

This chapter analyzes perhaps the most comprehensive disability outcome database for traumatic brain injury. The cases in the database are primarily white males 16 to 64; individuals 65 or older account for approximately 15 percent of the cases. The average initial hospital length of stay was greatest for motor vehicle crashes.

Head injuries of moderate severity were more commonly associated with motor vehicle crashes than with other injury categories. Life-threatening head injuries were most commonly associated with unintentional falls, though this may in part reflect the average older age of this group. One shortcoming of the analysis is the small cell frequencies for some injury categories; comparisons between causes should be interpreted with caution.

Interestingly, different scales revealed different views. For example, CHART scores tended to be higher for patients involved in motor vehicle crashes, whereas FIM scores were relatively similar and HSQ scores tended to be lower for the those patients.

Finally, our analyses suggest that although many TBI victims return to work after their injuries, permanent disability, lengthy temporary disability, or extended medical care prevents many others from returning to a productive life. (Whiteneck, Charlifue, Gerhart, Overholser, and Richardson, 1992)

Chapter 3 – Rehabilitation Costs and Payment Sources for Traumatic Brain Injury

Abstract

This chapter provides data for traumatic brain injury rehabilitation patients on source of payment, length of stay, charges, and outcome measures such as changes in residence, marital status, and employment for four categories of injury cause: Motorcycle, Other Motor Vehicle, Violence (Self or Other) and Other Unintended. Special emphasis is placed on motorcycle injuries in this chapter, as TBI is of particular interest in motorcycle injuries.

Introduction

The TBIMS collects injury, charge, and outcome data from 17 medical centers. We analyzed These data to compare source of payment, charges, and outcome measures such as changes in residence, marital status, and employment for four categories of injury cause: Motorcycle, Other Motor Vehicle, Violence (Self or Other) and Other Unintended, which includes items not included in the former categories, such as falls, cuts, or poisoning.

Methods

Subjects

All subjects were participants in the National Institute on Disability and Rehabilitation Research (NIDRR) funded TBIMS program, a collaborative effort between 17 medical centers initiated in 1987. (Harrison-Felix, Newton, Hall, and Kreutzer, 1996); (Dahmer *et al.*, 1993). Each center includes emergency medical services, intensive and acute medical care, inpatient rehabilitation, and a spectrum of community rehabilitation services. All patients were admitted to an acute care hospital within 24 hours of injury. Individuals with a history of prior brain injury, preexisting neurological condition, or substance abuse, are included in the TBIMS program. Informed consent was obtained from the patient or responsible family member.

Of the 3,762 TBI cases available in the TBI Model Systems National Database, 2,266 (60.2%) contained one-year post-injury follow-up data and were included in this analysis.

Procedure

Data collected at 17 model systems rehabilitation centers were analyzed. An individualized, comprehensive program of inpatient rehabilitation had been provided to each patient including nursing care;

occupational therapy; physiatry; physical therapy; psychology and neuropsychology; therapeutic recreation; social services; and speech and language therapy. Each program's admission and discharge criteria were based on Rehabilitation Accreditation Commission (CARF) standards. Rehabilitation charges were available. These did not include physician fees. Cases were analyzed by cause of injury, using codes developed by the Traumatic Brain Injury Model System. The Motorcycle category includes motorcycles and motorized vehicles including mopeds and motorized dirt bikes, and did not distinguish between crashes occurring on-road or off-road. Incidents involving 3-wheeled and 4-wheeled recreational vehicles, dune buggies and go-carts were included in the "other unintended" category, which also includes falls, cuts or poisoning.

Every effort was made to ensure the reliability of the model systems data. The data entry program for the model systems database restricts the ranges for data entered. In addition, error reports are generated by the National Data Center's database software, highlighting suspect entries. The National Data Center also provides summaries of the data, which are reviewed by the project directors for their respective centers as well as for the database as a whole.

An annual follow-up interview was attempted with every individual entered in the database in prioritized order of (a) an in-person interview, (b) a telephone interview, or (c) a mailed questionnaire and/or interview with a "significant other" or family member.

Results

This section presents demographic data on people in rehabilitation due to motorcycle crashes. It describes the charges incurred in treating these patients, sources of payment for those charges, and the longer-term consequences of TBI for these patients. Except for tables probing details of TBI in motorcycle crashes, we generally present all-victim data with breakdowns comparing motorcyclists with other victims.

Length of Stay (LOS) and Charges

As Table 1 shows, length of stay (LOS) for TBI rehabilitation patients averaged 20.9 days in acute care and 29.4 days in inpatient rehabilitation. Per diem charges were much lower in the rehabilitation than the acute care stage (averaging $1,452 versus $5,360 in 2000 dollars). One caveat in reading Table 1 and subsequent tables is that the ratio of per diem charges was not computed by dividing the mean per diem charge for rehabilitation by the mean per diem charge for acute care; rather the ratio is calculated for each patient, then averaged. The two sets of numbers differ, and the ones reported are the conceptually appropriate numbers. These ratios and the similarly computed ratio of charges per stay provide a means for estimating rehabilitation charges (and possibly costs) when only more readily obtainable hospital charges and costs are available. As expected, the standard deviations in Table 1 were high due to wide case-to-case variation.

Table 1. Length of Stay (LOS) and Charges for Acute Care and Rehabilitation of TBI Rehabilitation Patients by Cause of Injury (Including Only Live Discharges from Rehabilitation Hospitals)

	Motorcycle (Including Dirt Bike)	Other Motor Vehicle	Violence (Self Or Other)	Other Unintended	All TBI
All Patients	227	2,071	636	828	3,762
LOS Acute Care (Mean, Standard Deviation)	21.93 (16.58)	22.26 (16.92)	19.53 (16.74)	18.29 (16.19)	20.90 (16.79)
LOS Rehab (Mean, SD)	31.01 (25.27)	30.44 (25.57)	28.79 (24.48)	26.86 (22.89)	29.41 (24.84)
Charges Per Day - Acute Care (Mean, SD)	$5,561.07 (3,208.93)	$5,569.54 (2,887.81)	$4,744.34 (2,792.68)	$5,260.27 (3,368.78)	$5,360.41 (3,017.01)
Charges Per Day-Rehab (Mean, SD)	$1,394.57 (435.82)	$1,469.75 (489.54)	$1,449.26 (445.33)	$1,425.90 (437.99)	$1,452.09 (468.52)
Ratio of Charges Per Day – Rehab/Charges Per Day – Acute Care (Mean, SD)	.3091 (.1667)	.3322 (.2794)	.4064 (.3009)	.3612 (.2613)	.3499 (.2755)
Ratio of Charges Per Patient – Rehab/ Charges Per Patient – Acute Care (Mean, SD)	.5259 (.5449)	.5521 (.5732)	.7537 (.7518)	.7092 (.8608)	.6195 (.6819)

Additional Information on Motorcycle Crash Rehabilitation Cases

Additional analysis was conducted on the demographic characteristics of motorcycle crash rehabilitation cases and costs of these cases. These data are included in appendix C.

Payer Distribution

For rehabilitation services, Table 2 shows the most commonly reported payer for people receiving traumatic brain injuries as a result of Other Motor Vehicle crashes was private insurance (60.9%), followed by public funding (Medicaid or Medicare) (25.2 %), no-fault automobile insurance (11.2%), free care (5.5%), and self-pay, workers' compensation, other or unknown sources (8.3%). For the motorcycle crash category, payers were private insurance (62.3%), followed by Medicaid (23.2%). This distribution is quite similar to the distribution for TBI in motor vehicle crashes, but quite dissimilar from violence-related TBIs, which burden public pockets much more heavily. Importantly, the payer distributions for acute care and rehab were quite similar.

Table 2. Payer Distribution for Acute Care and Rehabilitation by Cause of Injury

Payer Distribution	Motorcycle (Including Dirt Bike)	Other Motor Vehicle	Violence (Self Or Other)	Other Unintended	All TBI
All Patients	227	2,071	636	828	3,762
			Acute Care		
Public Funding (Medicare or Medicaid)	23.9%	24.4%	59.9%	38.5%	33.3%
Workers' Comp	0.4%	2.9%	1.9%	14.4%	5.3%
Private Insurance (BC/BS, Private, HMO, PPO)	60.0%	57.5%	24.2%	37.3%	47.6%
No-Fault Auto	2.7%	13.6%	0.3%	1.6%	8.1%
Free Care (Charity)	4.4%	3.8%	4.4%	1.8%	3.5%
Self-Pay	3.6%	4.8%	5.5%	3.4%	4.6%
Other/Unknown	7.5%	6.6%	4.0%	4.6%	5.7%
TOTAL	102.50%	113.60%	100.20%	101.60%	108.10%
			Rehabilitation		
Public Funding (Medicare or Medicaid)	25.8%	25.2%	62.5%	38.9%	34.6%
Workers' Comp	0.0%	3.0%	1.6%	15.0%	5.2%
Private Insurance (BC/BS, Private, HMO, PPO)	65.9%	60.9%	24.1%	39.1%	50.4%
No-Fault Auto	3.6%	11.2%	0.3%	1.0%	6.7%
Free Care (Charity)	5.3%	5.5%	5.9%	2.9%	5.0%
Self-Pay	1.8%	3.1%	4.3%	2.2%	3.0%
Other/Unknown	1.3%	2.2%	1.6%	1.8%	1.9%
TOTAL	103.70%	111.10%	100.30%	100.90%	106.80%

Blood Alcohol Concentration (BAC)

Of the TBI cases in rehab, 81 percent were tested for BAC, including 85 percent of motorcyclists (Table 3). The proportion of injured motorcycle riders who tested positive for alcohol was 48.1 percent. By comparison, an analysis of 2001 FARS data found that 37 percent of motorcycle riders killed in crashes were positive for alcohol (Shankar, 2003a). The percentage of BAC-positive was virtually identical for TBI victims injured in motorcycle and other motor vehicle crashes. More violence victims and less victims of unintentional injury were BAC-positive. BAC-positive cases had alcohol in their bloodstreams, although not necessarily at concentrations above the legal limit for intoxication (.08 or .10 grams per deciliter).

Table 3. Percent of Cases Positive for BAC at Time of Injury by Cause of Injury

Cases with BAC information	Motorcycle (Including Dirt Bike)	Other Motor Vehicle	Violence (Self Or Other)	Other Unintended	All TBI
% Tested	85.0%	82.5%	86.5%	71.8%	81.0%
Of those tested, % cases BAC-positive	48.1%	48.2%	56.7%	39.1%	48.0%

Patient Residence at Three Points in Time

Data on patients' main place of residence was gathered for three points in time: before the injury, at the time of discharge, and at a one-year follow-up. As Table 4 shows, most of the patients lived in private residences prior to the injury, including almost the entire Motorcycle group (99.1%) and the Other Motor Vehicle group (98.6%). Slightly fewer people in the Violence category lived in private residences (93.5%), with 3.3 percent listed as homeless. Upon discharge, the proportion of TBI clients living in private residences fell an average of almost 12 percent. Patients were placed in varied care settings, including nursing homes (5%), adult homes (2.4%), rehabilitation facilities (1.2%), or hospital settings — sub-acute care (2.4%), acute care (1.1%), or other hospital (0.9%). By the one-year follow-up, an average of 91.4 percent of the patients were back in private residences. Most of the others were in nursing homes (3.1%) or adult homes (2.6%). The Motorcycle group was more likely than the other groups to be in private residences after one year (97.1%), followed by the Other Motor Vehicle group (94.1%)

The TBI data set lacks information on rehospitalizations, but other studies find a relatively high rate of rehospitalization in the long term following traumatic brain injury (Kreutzer, Marwitz, High Jr., Englander, and Cifu, 2001) reported that TBI rehospitalization ranged from 22.9 percent at one-year post-injury to 17.0 percent at five-years post-injury. At one-year post-injury, one-third of the rehospitalizations were elective admissions.

Table 4. Patient Residence Prior to Injury, Upon Discharge and at One Year.

Residence Pre Injury	Motorcycle (Including Dirt Bike)	Other Motor Vehicle	Violence (Self Or Other)	Other Unintended	All TBI
Private	99.1%	98.6%	93.5%	97.3%	97.5%
Adult home		.2%	.6%	.4%	.3%
Correctional facility		.1%	.2%	.1%	.1%
Hotel		.2%	.9%	.1%	.3%
Homeless		.6%	3.3%	1.2%	1.2%
Acute care			.2%		.0%
Rehab facility				.1%	.0%
Other hospital				.1%	.0%
Other	.9%	.2%	1.3%	.6%	.5%
At Discharge					
Private	89.3%	87.8%	83.0%	81.6%	85.7%
Nursing home	2.7%	3.3%	7.9%	7.6%	5.0%
Adult home	1.3%	2.3%	3.3%	2.2%	2.4%
Correctional facility		.1%	.2%	.1%	.1%
Hotel		.2%	.3%		.2%
Homeless			.3%	.4%	.1%
Acute care	1.3%	1.0%	1.0%	1.3%	1.1%
Rehab facility	2.2%	1.4%	.3%	1.2%	1.2%
Other hospital	.9%	.7%	.6%	1.7%	.9%
Sub-acute-care facility	1.3%	2.3%	2.5%	2.9%	2.4%
Other	.9%	.9%	.5%	1.0%	.9%
One-Year Follow-up					
Private	97.9%	94.1%	84.5%	88.0%	91.4%
Nursing home		1.4%	6.8%	5.7%	3.1%
Adult home	.7%	2.1%	4.6%	3.0%	2.6%
Correctional facility	.7%	.3%	2.2%	.6%	.7%
Hotel		.1%		.4%	.1%
Homeless		.3%		.4%	.3%
Acute care		.2%			.1%
Rehab		.3%	.3%	.2%	.3%
Other hospital		.1%		.2%	.1%
Sub-acute-care facility	.7%	.6%	.5%	.6%	.6%
Other		.6%	1.1%	.8%	.7%

Marital Status

Table 5 reports marital status before the injury and at the one-year follow-up. Pre-injury, 31.0 percent of victims were married, including 28.5 percent of the Other Motor Vehicle group and 32.5 percent of Motorcyclists. The Other Unintended injury victims were more likely to be married than victims in the other categories -- perhaps because this group includes more elderly people. Conversely, those in the Violence category were less likely to be married, and tended to be younger.

The marital status of the TBI patients did not noticeably change from before the injury to the time of one-year follow-up. In the first year post-TBI, families largely stayed together.

Table 5. Marital Status Pre-Injury and at One-Year Follow-Up

Marital Status Pre-Injury	Motorcycle (Including Dirt Bike)	Other Motor Vehicle	Violence (Self Or Other)	Other Unintended	All TBI
Single	46.4%	55.3%	55.8%	31.0%	49.5%
Married	32.1%	28.5%	16.1%	48.4%	31.0%
Divorced	12.5%	10.1%	15.6%	11.0%	11.4%
Separated	5.8%	3.6%	8.7%	3.0%	4.5%
Widowed	3.1%	2.5%	3.8%	6.5%	3.7%
One-Year Follow-up					
Single	41.3%	53.2%	54.4%	31.0%	47.8%
Married	34.3%	28.8%	14.5%	45.3%	30.4%
Divorced	18.2%	12.0%	18.6%	14.1%	13.9%
Separated	2.8%	3.3%	7.7%	3.1%	3.9%
Widowed	3.5%	2.7%	4.9%	6.5%	3.9%

Employment Status

In comparing the four injury categories, Motorcycle TBI patients were most likely to be employed before the injury (80.2%) (see Table 6). The Other Unintended group contains 58 percent employed and 18.8 percent retired. This grouping includes many older people injured in falls. The Violence (Self or Other) category has the largest number of unemployed patients pre-injury (34.6%).

Employment status changed dramatically one-year post-injury. Overall, the proportion of employed patients fell 34.2 percentage points, from 59.8 percent to 25.6 percent. For Other Motor Vehicle injuries, the drop was from 60.7 percent to 26.1 percent and for motorcyclists, the drop was from 80.2 percent to 44.7 percent. Unemployment rose 27.6 percentage points overall (from 17.1% to 44.7%), and nearly tripled among motorcyclists (from 10.8% to 31.9%). Those on disability or in sheltered employment more than quadrupled, rising from 1.3 percent to 5.7 percent.

The drop in employment may be due to some loss of aptitude or changes in personality. It may also be due to patients still being out of work or finding job search difficult after losing jobs during the months they spent recovering from their TBIs.

Although this data set does not address the issue, the employment status of caregivers also may change. A study of 51 caregivers of TBI inpatients (Hall et al. 1994) were interviewed by phone at 12- and 24-months post-injury. Forty-seven percent of caregivers had altered or given up their jobs at one year post-injury and 33 percent at two years post-injury.

Table 6. Employment Status Before and After Injury

Employment Status Pre-Injury	Motorcycle (Including Dirt Bike)	Other Motor Vehicle	Violence (Self or Other)	Other Unintended	All TBI
Employed	80.2%	60.7%	51.8%	58.0%	59.8%
Special employment		.2%	.5%	.7%	.4%
Unemployed	10.8%	14.1%	34.6%	13.0%	17.1%
Student	5.9%	16.2%	6.2%	5.3%	11.5%
Retired	2.3%	4.7%	3.2%	18.8%	7.4%
Homemaker		2.0%	.6%	2.0%	1.6%
On disability		1.0%	1.0%	1.0%	.9%
Other	.9%	1.1%	2.1%	1.2%	1.3%
One-Year Follow-up					
Employed	44.7%	26.1%	15.3%	26.4%	25.6%
Special employment	.7%	.6%	.8%	.6%	.7%
Unemployed	31.9%	43.9%	61.3%	38.0%	44.7%
Student	5.7%	12.9%	5.2%	5.1%	9.5%
Retired	1.4%	4.2%	5.2%	17.4%	7.1%
Homemaker		2.7%	1.1%	2.0%	2.1%
On disability	7.8%	4.8%	4.4%	5.3%	5.0%
Other	7.8%	4.8%	6.8%	5.1%	5.4%

Discussion

The data presented comes from a self-selected sample of 17 TBI model systems that chose to pool their data. The charges and duration for care at other rehabilitation providers may vary. So may the outcomes. Nevertheless, this dataset includes follow-ups at one year and is by far the largest case series available. The ratios of rehabilitation charges to acute care charges provide a credible basis for costing rehab care from known acute care hospitalization costs.

Chapter 4 – National Estimate Model

Abstract

For many types of motor vehicle crash injuries, acute hospital care is only the first stage of a long and costly treatment program. Until now, the rehabilitation costs of motor vehicle injuries have not been determined. No one database provides the information needed to make a national estimate of motor-vehicle-related rehabilitation costs. Using data from four different sources we calculate that motor vehicle crash injuries resulted in an estimated $127.5 million in rehabilitation costs in 2000 and motorcycle crash injuries resulted in an estimated $16.3 million. The methods used here provide a model that can be applied to regularly collected data to update the national cost estimate in the future. This chapter estimates cost per case and length of stay for motor vehicle and motorcycle crash rehabilitation.

Background

Effective January 1, 2002, the Health Care Financing Administration (now the Center for Medicare and Medicaid Services) shifted Medicare payment for inpatient rehabilitation to a Prospective Payment System . Although Medicare has paid acute-care hospitals under a PPS since 1983, rehabilitation facilities, which provide extensive occupational, physical and speech therapy services, had been exempt from that system. With PPS, rehabilitation facilities are paid on a per-discharge basis based on the patient diagnoses, with hospitals paid more to care for patients with greater needs. For the most part, private insurers appear to have adopted the Medicare reimbursement rates for rehabilitation. The Federal payment data, thus, provides a reliable basis for estimating rehabilitation expenditures.

Methods

To calculate a national estimate of rehabilitation costs this study used four sources:

- Federal guidance on rehabilitation payments and length of stay for federally funded rehabilitation for 2002;

- Uniform Data System for Medical Rehabilitation data on the distribution of motor-vehicle-related crash injuries by diagnosis group;

- The Healthcare Cost and Utilization Project - National Inpatient Sample national estimates of hospitalized motor vehicle-related crash injuries by diagnosis group in 2000; and

- A three-State 1997 census of hospital discharge records, which yielded the percentage of admissions by diagnosis group that were followed by rehabilitation admissions.

Prospective Payment System: Effective January 1, 2002, the Health Care Financing Administration shifted Medicare payment for inpatient rehabilitation to a Prospective Payment System system.[1] Although Medicare has paid acute-care hospitals under a PPS since 1983, rehabilitation facilities, which provide extensive occupational, physical, and speech therapy services, had been exempt from that system. With PPS, rehabilitation facilities are paid on a per-discharge basis based on the patient diagnoses, with hospitals paid more to care for patients with greater needs. For the most part, private insurers appear to have adopted the Medicare reimbursement rates for rehabilitation. The Federal payment data, thus, provides a reliable basis for estimating rehabilitation expenditures.

The prospective payment rates were reported in the Federal Register, Inpatient Rehabilitation Facility Prospective Payment System report, which provided payment rates for three tiers of serious co-morbidities (e.g., stroke plus hip fracture) and one payment rate for cases with no serious co-morbidities. Although the PPS provides four payment tiers based on co-morbidities, all injuries fall into the no-co-morbidity rate unless complicated by an illness (e.g., stroke, tuberculosis). Our estimates ignore such illness complications, since the cost differential is attributable to the illness, not the injury. The Federal Prospective Payments for Case-Mix Groups (CMG) only provided allowable payments broken down by CMG (categories determined by age and motor and cognitive FIM scores) as well as tier and diagnosis (Table 2 in the regulations).

Uniform Data System for Medical Rehabilitation: UDSMR collects and redistributes data from rehabilitation hospitals nationwide for use in evaluating the effectiveness and efficiency of their rehabilitation programs. It provides the most comprehensive data available on rehabilitation patients across diagnostic categories. In 2002, 783 comprehensive medical rehabilitation (CMR) facilities sent data to UDSMR. Of the CMR subscribers, 590 agreed to provide data for this study. Only cases containing cause-of-injury codes (E-codes) were selected for analysis.

Five years of data (1998–2002) were combined into one dataset. The data were cleaned. For example, obvious miscoding in the E-codes was corrected and variables with missing data or codes out-of-range were excluded from the appropriate analyses. Because E–codes were indicated in multiple fields, we assigned each case to one unique etiology using a hierarchy scheme. Motorcycle riders, lacking the protection of a steel-encased vehicle, are more vulnerable to injury. Therefore motorcycle injuries were primary, followed by other motor vehicle, suicide, assault, and other unintentional injury. This resulted in 1,437 rehabilitation patients who incurred injury in motorcycle crashes. We collapsed the cases into the diagnosis groupings used in the PPS data's CMGs (e.g., traumatic brain injury, lower-limb amputation). Table 1 lists the groupings. This was done by using UDSMR data on each patient's diagnoses, admission FIM motor score and cognitive score, and where relevant, age.

Within each diagnosis group, the PPS payment rates for no-co-morbidity were multiplied by the proportion of motorcycle injury rehabilitation cases in the CMG, then summed over the CMGs within the impairment class to get mean payment rates for motorcycle injuries by impairment class. (Appendix A table 1 provides adjusted Federal prospective payments by diagnosis group across five cause categories and appendix A table 2 provides length of stay.) Five years of data (1998–2002) were combined into one dataset and cleaned. For example, obvious miscoding in the E-codes was corrected and variables with missing data or codes out-of-range were excluded from the appropriate analyses. Because E-codes were indicated in multiple fields, we assigned each case to one unique cause using a hierarchy scheme. Motorcycle injuries were primary, followed by other motor vehicle, suicide, assault, and other unintentional injury. This resulted in 84,870 rehabilitation patients. We collapsed the cases into the diagnosis groupings used in the PPS data's CMGs (e.g., traumatic brain injury, lower-limb amputation). This was done by using UDSMR data on each patient's diagnoses, admission FIM motor score and cognitive score, and, where relevant, age. Within each diagnosis group, the PPS no-co-morbidity payment rates were multiplied times the proportion of injury rehabilitation cases in the CMG, then summed over the CMGs within the impairment class to get mean payment rates by impairment class. This calculation was as follows:

Let, p_{Ij} = proportion of cases in an impairment class (I) in CMG_{Ij}

PAY_{Ij} = payment rate for impairment class I in the jth CMG with no co-morbidities

APR_I = adjusted payment rate for impairment class I

Then $APR_I = \Sigma (p_{Ij} \times PAY_{Ij})$

The same procedure was used to calculate mean allowable length of stay in days, which is also shown in Table 1.

Table 1. Adjusted Federal Prospective Payment Rehabilitation Rates* and Mean Length of Stay for Motorcycle Injuries by Diagnosis Group (2000 Estimates in 2002 dollars)

Diagnosis Group	Motorcycle Payment Rate	Mean Length of Stay	Other Motor Vehicle Payment Rate	Mean Length of Stay
Traumatic Brain Injury	$ 16,545	23	$16,441	22
Spinal Cord Injury Unspecified	$ 21,777	30	$16,112	23
Spinal Cord Injury Paraplegia Unspecified	$ 16,743	25	$18,919	27
Spinal Cord Injury Paraplegia Incomplete	$ 17,091	25	$17,449	25
Spinal Cord Injury Paraplegia Complete	$ 19,932	28	$20,044	29
Spinal Cord Injury Quadriplegia Unspecified	$ 26,406	35	$25,360	34
Spinal Cord Injury Quadriplegia Incomplete	$ 21,236	29	$25,017	34
Spinal Cord Injury Quadriplegia Complete	$ 28,966	38	$28,823	38
Spinal Cord Injury Other	$ 12,401	19	$15,461	23
Lower-Extremity Amputation	$ 10,135	15	$11,845	18
Other Amputation	$ 10,716	16	$14,339	17
Traumatic Brain Injury + Spinal Cord Injury	$ 22,998	32	$21,813	22
Traumatic Brain Injury + Fracture + Amputation	$ 17,728	25	$17,402	30
Spinal Cord Injury + Fracture + Amputation	$ 20,221	28	$19,965	24
Other Multiple Trauma	$ 11,830	17	$12,146	27
Neck + Back Pain	$ 7,817	13	$9,348	17
Hip/Knee Fracture/Replacement	$ 9,186	14	$9,052	13
Other Orthopedic	$ 9,587	15	$9,771	15
Burns	$ 9,929	16	$18,988	. [?]
Other Specified	$ 14,163	20	$12,354	18

*Source: Federal Register, Vol. 66, No.152, Tuesday 7, 2001, Rules and Regulations, adjusted.

Under the PPS, rehabilitation hospital costs would have ranged from $7,817 for neck and back pain to a high of $28,966 for spinal cord injury with complete quadriplegia, which also is reimbursed for the longest length of stay–on average 38 days. The Healthcare Cost and Utilization Project - National Inpatient Sample 2000 is a large, statistically representative sample of U.S. hospital discharges compiled by the Agency for Health Research and Quality of the U.S. Department of Health and Human Services. We used the 2000 HCUP-NIS data file to develop estimates of the number of injury episodes resulting in hospitalizations with live discharges in 2000. The HCUP-NIS provides information annually on approximately 5 million to 8 million inpatient stays that resulted in discharges in 2000 from about 1,000 hospitals. These hospitals represent a 20 percent cluster sample of non-Federal, short-term, general, and other specialty hospitals, excluding hospital units of institutions, drawn from a convenience sample of 28 States that agreed to supply AHRQ with discharge census data. All discharges from sampled hospitals are included in the HCUP-NIS database, and sampling weights are included to allow for generating nationally representative estimates.

From this dataset we selected only those cases with an injury diagnosis in any of the first three diagnosis fields. When E-codes were missing from the record (approximately 20 percent of the cases), we assigned them probabilistically.[2] We then dropped fatalities, rehabilitation visits, and all visits that were not for acute traumatic injury (e.g., poisonings). Based on the primary injury E-code, we selected cases whose cause was a highway crash (E–codes in the range E810–E819) and whose victim was a motorcyclist (fifth digit of 2 or 3).

We then classified injuries into the Rehabilitation Impairment Code (RIC) groups prescribed in the PPS according to the primary injury diagnosis using 13 categories collapsed from the Barell Injury Diagnosis Matrix, which groups ICD–9-CM codes by body region and nature of injury. In order to capture surgical amputations as well as traumatic amputations, when any procedure codes indicated that an amputation was performed, the case was re-categorized as an amputation of the appropriate body region – unless the case was a TBI, SCI, or burn. In these cases it was not re-categorized.

The three-state 1997 census of hospital discharge records: PIRE previously had obtained, cleaned and pooled the injury discharges from hospital discharge census data for 1997 from acute and rehabilitation hospitals in California, Maryland, and Pennsylvania. These three States were selected because they report data on rehabilitation specialty hospitals, in addition to general acute-care hospitals. Validity checks were completed among the States, and when needed, variables were recoded to produce uniform coding categories and value labels across States for variables such as discharge status and ethnicity. The collecting agencies required the hospitals

[2] When a record identified as an acute injury admission lacked an E-code, we assigned E-codes probabilistically based on the primary injury diagnosis. We determined the frequency distribution of E-codes from all E-coded records in the dataset with the same primary injury diagnosis. We then created a series of duplicate records, one with each E-code that was found, and weighted them by their frequency of occurrence. Example: A non-E-coded record has a primary injury diagnosis of 830.0, closed dislocation of jaw. The dataset includes three E-coded cases with this diagnosis - two E812.0 (motor vehicle driver in traffic collision) and one E960.0 (unarmed fight). So two copies of this record are created - one with an E-code of E812.0 and the case weight multiplied by two-thirds, and one with an E-code of E960.0 and the case weight multiplied by one-third.

to report E-codes for the acute care discharges, with 92 percent compliance. Rehabilitation discharges, however, were voluntarily coded and according to some States' coding rules (oriented toward getting an unduplicated count of injury incidents) should not have been cause-coded.

California and Pennsylvania identified the hospital type, including rehabilitation. Although the Maryland data does not explicitly indicate rehabilitation visits, it contained Diagnosis-Related Group (DRG) codes and diagnosis codes that allowed us to identify these visits. We then looked at the distribution of patient rehabilitation status by hospital. If a hospital's patients were predominantly rehabilitation patients (80% or more), we labeled the hospital a rehabilitation hospital. (Other hospital types are acute care, psychiatric, and nursing.) Note that many acute-care hospitals have rehabilitation wards; therefore not all rehabilitation patients are treated in rehabilitation specialty hospitals. We classified as rehabilitation visits both patients coded as receiving inpatient rehabilitation treatment and all patients admitted to rehabilitation facilities.

We tabulated the rehabilitation probabilities by diagnosis using the same diagnosis categories we used in the HCUP-NIS calculations. We then multiplied the HCUP-NIS injury case counts by the three-state rehabilitation probabilities for each diagnosis group to produce estimates of the number of admissions for rehabilitation in the United States for 2000. The estimates of rehabilitation admissions were then multiplied by the PPS-based rehabilitation costs per case to yield an estimate of aggregate rehabilitation costs in 2000. Final computations are based on unrounded, weighted numbers and are shown to the nearest whole numbers. Table 2 shows the rehabilitation probabilities by diagnosis group and cause.

Table 2. Percentage of Hospital Admitted Injuries that Involve Inpatient Rehabilitation by Cause and Diagnosis Group, California, Maryland, and Pennsylvania, 1997

Diagnosis Group	Motorcycle Injury	Other Motor Vehicle	Attempted Suicide	Assault	Other Unintentional
Traumatic Brain Injury (TBI) Only	5.2	5.3	6.9	6.6	6.1
TBI + Amputation + Fracture	9.2	9.3	11.3	10.6	9.6
Spinal Cord Injury (SCI) Only *	30.8	30.8	30.8	30.8	30.8
TBI + SCI*	25.9	25.9	25.9	25.9	25.9
SCI + Fracture + Amputation*	30.4	30.4	30.4	30.4	30.4
Lower-Extremity Amputation Only	10.8	10.4	11.4	5.3	9.4
Upper Extremity Amputation Only	1.5	0.6	0.8	0.6	0.3
Lower-Extremity Fracture Only	6.0	6.1	6.3	6.4	8.9
Upper-Extremity Fracture Only	2.2	2.2	2.2	2.2	2.2
Other Fracture Only	4.7	4.6	5.6	1.3	5.3
Lower Extremity Other	2.0	2.5	1.6	1.6	2.4
Upper Extremity Other	1.2	1.1	0.5	0.6	1.0
Other	1.2	1.2	1.0	0.9	1.0
Burns	1.9	1.4	1.2	1.2	1.3

Note: Small case counts precluded decomposing SCI probabilities by cause.

By applying the percentages of hospital admissions involving rehabilitation by diagnosis category to the number of injury admissions estimated using the 2000 HCUP estimates, we calculated an estimated number of rehabilitation cases in 2000. A rehabilitation cost per case was calculated as described above, by multiplying the motorcycle-injury-related probabilities of receiving inpatient rehabilitation (estimated using UDSMR and HCUP/NIS data) by the Federal PPS reimbursement for those services. Multiplying the estimated number of rehabilitation cases by the rehabilitation cost per case yields an annual estimate of rehabilitation costs.

Findings

Inpatient rehabilitation costs for Other Motor Vehicles (excluding motorcycles) average from $9,771 for upper-extremity and other fractures to $26,656 for spinal cord injuries. For motorcycles, inpatient rehabilitation costs average $14,965 per patient (in 2002 dollars). As Table 4 shows, the costs for single-problem cases range from $9,587 for fractures to $16,545 for traumatic brain injuries to $19,698 for spinal cord injuries. Under the Prospective Payment System, net of labor market price adjustments, these figures are flat-rate total payments for inpatient rehabilitation of a patient on Medicare or Medicaid. Analysis of the AMRPA data shows they are roughly comparable to all-payer average payments in 1999, three years before PPS implementation.

Overall, HCUP-NIS suggests 243,229 patients were admitted for other motor vehicle injuries in 2000 and 24,028 patients were admitted for motorcycling injuries. Five percent of the other motor vehicle and 5 percent of the motorcycling injury patients had received inpatient rehabilitation either separately from or as a part of their hospitalized acute-care stays. For both motor vehicle and motorcycle injuries, spinal cord injury victims with or without other major injuries had the highest probability of receiving rehabilitation services, of admissions involving rehabilitation facilities.

Table 3. Rehabilitation Costs of Hospital-Admitted Other Motor Vehicle Injuries (Excluding Motorcycle), 2000 (in 2002 dollars)

Diagnosis Group/Subgroup	2000 HCUP-NIS Cases	Rehab Cases	% of Cases that Are Rehab	Rehab Cost/Case	Total Cost (1,000s of $)	% of Total Cost
Traumatic Brain Injury Only	33,795	1,794	0.05	$16,441	$11,553	0.09
TBI+ Fracture + Amputation	26,192	2,426	0.09	$17,402	$42,215	0.33
Spinal Cord Injury Only	2,261	696	0.31	$26,656	$4,630	0.04
TBI + SCI	999	259	0.26	$21,813	$5,649	0.04
SCI + Fracture + Amputation	881	268	0.30	$19,965	$5,345	0.04
Lower-Extremity Amputation Only	284	29	0.10	$11,845	$349	0.00
Upper-Extremity Amputation Only	372	2.2	0.01	$12,169	$26	0.00
Lower-Extremity Fracture Only	42,484	2,612	0.06	$9,052	$23,642	0.19
Upper-Extremity Fracture Only	15,959	357	0.02	$9,771	$3,488	0.03
Other Fracture Only	39,997	1,835	0.05	$9,771	$17,926	0.14
Lower Extremity Other	8,031	200	0.02	$12,134	$2,422	0.02
Upper Extremity Other	5,881	64	0.01	$12,134	$776	0.01
Other	65,692	769	0.01	$12,134	$9,327	0.07
Burns	400	6	0.02	$18,988	$109	0.00
Total/Average	243,229	11,315	0.05	$11,265	$127,458	1.00

Table 4. Rehabilitation Costs of Hospital-Admitted Motorcycling Injuries, 2000 (in 2002 dollars)

Diagnosis Group/Subgroup	2000 HCUP-NIS Cases	Rehab Cases	% of Cases that Are Rehab	Rehab Cost/Case	Total Cost (1,000s of $)	% of Total Cost
Traumatic Brain Injury Only	2,172	114	0.05	$16,545	$1,886	11.6
TBI + Fracture +Amputation	3,032	278	0.09	$17,728	$4,928	30.3
Spinal Cord Injury Only	192	59	0.31	$19,698	$1,162	7.1
TBI + SCI	100	26	0.26	$22,998	$598	3.7
SCI + Fracture + Amputation	134	41	0.31	$20,221	$829	5.1
Lower-Extremity Amputation Only	117	13	0.11	$10,135	$132	0.8
Upper-Extremity Amputation Only	29	.5	0.02	$11,927	$6	00
Lower-Extremity Fracture Only	7,300	436	0.06	$9,186	$4,005	24.6
Upper-Extremity Fracture Only	2,735	61	0.02	$9,587	$585	3.6
Other Fracture Only	2,707	129	0.05	$9,587	$1,237	7.6
Lower Extremity Other	1,113	22	0.02	$12,065	$265	1.6
Upper Extremity Other	582	7	0.01	$12,065	$84	.5
Other	3,730	45	0.01	$12,065	$543	3.3
Burns	85	1.6	0.02	$9,929	$16	0.1
Total/Average	24,028	1,232	0.05	$13,200	$16,276	1.0

Rehabilitation Costs as a Percentage of Total Medical Costs

Other Motor Vehicles

Using the HCUP-NIS charge data and cost-to-charge ratios computed by AHRQ from Medicare cost reports, we estimate that the average acute care discharge for other motor vehicle injuries (excluding Motorcycles) in 2000 cost $12,102. (Costs reported here are in 2002 dollars.) Applying ratios of professional fees to hospital payments from Medstat's 1996-1997 MarketScan Commercial Claims and Encounters database suggests the associated professional fees were $2,970 per discharge, bringing total medical costs per acute care discharge to $15,072. Multiplying by the number of people hospitalized for other motor vehicle crash injuries shows acute medical care costs totaled $3.665 billion. These acute care bills included some bundled rehabilitation costs. The $127.5 million in separately billed inpatient rehabilitation costs constitutes 3 percent of the total hospitalization cost.

Motorcycle Injuries

Similarly, we estimate that the average acute care discharge for motorcycle injury in 2000 cost $17,557 (in 2002 dollars) including associated professional fees and acute medical care costs totaled $422 million. The $16.3

million in separately billed inpatient rehabilitation costs constitutes 4 percent of the total hospitalization cost.

Discussion

One weakness of this approach is the difficulty in mapping between diagnosis systems. The UDSMR categorizes cases by multiple diagnoses, whereas hospital discharge data normally is categorized by only a single injury diagnosis. The rules to follow in creating the combined categories were not always clear.

Table 4 compares average costs per inpatient rehabilitation from the APRMA data reported in with the UDSMR/PPS estimates calculated here. These two analyses are not completely equivalent. The APRMA data include all injury victims while the UDSMR/PPS analysis focuses specifically on people who were injured in motorcycle crashes. Also, the UDSMR codes do not map exactly with the RICs used in the AMRPA data.

Our PPS-based estimates for 2002 tend to be a bit lower than the AMRPA average cost data for 1999. That is predictable; PPS was designed to contain or sharply reduce inflation in inpatient rehabilitation care costs Nevertheless, the two sets of costs are similarly ranked by diagnosis, providing corroboration for our estimates. The PPS forced down prices, but some payers still may be paying the higher rates in the AMRPA data. To the extent they are, our estimates are conservative.

The models and methods presented here readily can be replicated in future years. All that is required is a price-inflator keyed to the PPS system motor vehicle and motorcycle-related injury hospitalization counts from the most recent HCUP-NIS data set.

Table 4. Comparison of APRMA Average Cost Data to UDSMR/PPS Cost Estimates

RICs	APRMA Average Cost FY 1998-1999 (in 1999 Dollars)	UDSMR /PPS Estimates, All Injuries (in 2002 Dollars)
Amputation, Lower Extremity	$13,468	$11,896
Amputation, Other	$13,486	$11,783
Burns	$15,555	$15,763
Major Multiple Trauma, with Brain or SCI	$22,450	SCI + fracture + amputation $19,500 TBI + fracture + amputation $17,476
Major Multiple Trauma, with No Brain or SCI	$12,585	Other multiple trauma $12,072
Other Orthopedic	$10,451	$9,955
Pain Syndrome	$9,925	Neck pain + back pain $9,487
Replacement of Lower-Extremity Joint	$7,613	Hip, knee, ankle replacement $9,941
Traumatic Brain Injury	$20,821	$15,531

Chapter 5 - Conclusions

In 2000, we estimate that $127.5 million was spent for inpatient rehabilitation of injuries in other motor vehicle crashes and $16.3 million inpatient rehabilitation of injuries in motorcycle crashes. Public funds paid for 26.1 percent of the other motor-vehicle-related costs and 19.5 percent of the motorcycle-crash-related costs. Inpatient rehabilitation accounted for an estimated 3 percent of inpatient care costs for motor vehicle injury costs and 4 percent for motorcycle injuries.

Motor vehicle injuries generate other costs related to functional losses and the resulting impacts on social and role functions. Although this study did not estimate those costs, it showed the losses for some injuries can be quite significant. Employment drops among TBI patients were notable.

Chapter 1 describes findings from UDSMR, which provides the most comprehensive medical rehabilitation data available. This not only is the sole source for primary payer across diagnosis groups but provides follow-up data on patient living status, vocational status, and FIM scores. These data are often missing cause codes; and some facilities refused us access to their data. Because of this, cause-coded cases accessible to us may not be representative.

This chapter shows that Other Motor Vehicle crash and Motorcycle crash victims are very similar in the distribution of impairments requiring rehabilitation, sharing the same top five categories: TBI; other multiple trauma; TBI with fracture and amputation; other orthopedic; and hip/knee replacement. These categories account for 81 percent of the Motorcycle cases and 79 percent of the Other Motor Vehicle cases. The Motorcycle group was slightly more likely to have TBI rehabilitation services than the Other Motor Vehicle and the Suicide patients, but less likely than the Assault cases.

The most frequent payer for inpatient rehabilitation of motor vehicle (excluding motorcycle) crash injuries was private insurance (40.2%). Public funding accounted for 26.1 percent of the cases, followed by no-fault automobile insurance (19.9%), other/unknown (5.6%), self-pay (2.0%), unreimbursed (2.5%), and Workers' Compensation (3.7%).

Payer distributions for inpatient rehabilitation of motorcycle crash injuries were similar to that of other motor vehicle, although we see more reliance on private insurance (63%) and less on public funding (19.5%). Other payers included no-fault automobile insurance (6.9%), other/unknown (5.5%), self-pay (2.4%), unreimbursed (1.6%), and Workers' Compensation (1%).

Patients were asked at time of discharge where they would be living. Of those injured in motorcycle crashes, 97 percent of those with known pre-and post-measures lived in private homes both before and after rehabilitation (n= 328).

Across all injury categories, more than 50 percent of patients in the workforce changed their vocational status to nonworking or disabled at the time of rehabilitation discharge. Of the previously employed people injured in Other Motor Vehicle crashes, 64 percent were not working or disabled, (54.1% and 9.9%, respectively) at the time of discharge. Of those injured in Motorcycle crashes, we see a similar pattern: 62 percent were not working or disabled, (51.1% and 10.6%, respectively) at the time of discharge.

Chapter 2 analyzes perhaps the most comprehensive TBI disability outcome database. The data tracked a large sample of Colorado TBI cases for four years. The cases are predominantly white males 16 to 64. But, individuals 65 or older accounted for approximately 15 percent of the cases. Unlike in other chapters of this report, the database contained motor vehicle injury, including motorcycle injury. Among causes, the average initial hospital length of stay was greatest for motor vehicle crashes. Head injuries of moderate severity were more commonly associated with motor vehicle crashes and less so with other injury categories. Life-threatening head injuries were most commonly associated with unintentional falls, though this may in part reflect the average older age of this group.

What are most remarkable about the analysis of functional impacts is not the differences between injury cause groups but the strong similarities between causes. For example, total CHART and HSQ scores were approximately similar for all injury cause groups. Our analyses suggest that HSQ scores may have been slightly more effective in identifying differences between groups. In addition, with the exception of HSQ scores, the analysis did not reveal noticeable change over time. For example, the FIM cognitive, motor and total scores changed little from Year 1 to Year 2.

Finally, our analyses suggest that although considerable numbers of TBI victims return to work after an injury, permanent or temporary disability or extended medical care prevents many individuals from returning to a productive life.

Chapter 3 provides Traumatic Brain Injury data from a self-selected sample of 17 TBI model systems that chose to pool their data. The charges and duration for care at other rehabilitation providers may vary. So may the outcomes. Nevertheless, These data include follow-up at one year and is by far the largest case series available. The ratios of rehabilitation charges to acute care charges provide a credible basis for costing TBI rehab care from known acute care hospitalization costs.

Of the TBI cases in rehab, 81 percent were tested for BAC, including 85 percent of motorcyclists and 82.5 percent of other motor vehicle groups (table 8). The proportion of injured motorcycle riders in rehabilitation who tested positive for alcohol in the emergency department was 48.1 percent. By comparison, an analysis of 2001 FARS data found that 37 percent of motorcycle riders killed in crashes tested positive for alcohol. (Shankar, 2003b). The percentage of BAC-positive cases at emergency department admission was virtually identical for TBI rehabilitation patients injured in motorcycle and other motor vehicle crashes.

The marital status of TBI patients did not change noticeably from before the injury to the time of one-year follow-up. In the first year post-TBI, families largely stayed together.

In comparing the four injury categories, Motorcycle TBI patients were most likely to be employed before the injury (80.2%), compared to Other Motor Vehicle (60.7%) and violence (self or other) (51.8%). Employment status changed dramatically one-year post-injury. Overall, the proportion of employed patients fell 34.2 percentage points, from 59.8 percent to 25.6 percent. For motorcyclists, the drop was from 80.2 percent to 44.7 percent and for other motor vehicle crash injuries employment fell from 60.7 percent to 26.1 percent. Unemployment rose 27.6 percentage points overall (from 17.1% to 44.7%), and nearly tripled among motorcyclists (from 10.8% to 31.9%). Those on disability or in sheltered employment more than quadrupled, rising from 1.3 percent to 5.7 percent. The drop in employment may be due to some loss of aptitude or changes in personality. It may also be due to patients still being out of work or finding job search difficult after losing jobs during the months they spent recovering from their TBI.

Although this data set does not address the issue, the employment status of caregivers also may change. (Hall et al., 1994) interviewed 51 caregivers of TBI inpatients by telephone at 12- and 24-months post-injury. Forty-seven percent of caregivers had altered or given up their jobs at one-year post injury and 33 percent at two years post-injury.

Chapter 4 combines prospective payment rates for inpatient rehabilitation with data on the severity of injuries requiring rehabilitation and the probability of requiring rehabilitation to estimate average costs per inpatient rehabilitation and total cost in 2002 of inpatient rehabilitation for motor vehicle and motorcycle injuries. PPS appears to have contained costs, holding them roughly to the levels in the 1999 AMRPA data. Overall, inpatient rehabilitation of motor vehicle injuries cost an estimated $127.5 million in year 2000 dollars and for motorcycle crash injuries cost an estimated $16.3 million.

Appendix B reports that AMRPA data shows that rehabilitation hospital costs for all injury causes in 1999 ranged from $7,613 for the replacement of a lower-extremity joint to $29,495 for a traumatic spinal cord injury. Average cost per day ranged from $716 for a hip fracture to $991 for burns. Traumatic spinal cord injuries required the longest length of stay–on average 34.3 days, while replacement of a lower-extremity joint had the shortest – on average 10.5 days. These findings are relatively consistent among age groups.

Length of stay has been dropping since 1999 due to the implementation of a Medicare prospective payment system. With PPS, rehabilitation hospitals are paid a set fee for each patient, providing an incentive to shorten hospital stay to conform to the available payment. Chapter 4 presents 2002 length of stay and cost data under PPS.

Limitations and unresolved problems

One of the largest problems in an analysis of this sort is mapping the diagnosis codes from one dataset to another. AMRPA's data tables used rehabilitation impairment categories (RICs). Diagnoses coded using the International Classification of Diseases (ICD) were limited in this dataset and thus unusable. Data from the UDSMR used ICD groups and listed co-morbidities. HCUP data also was coded in the ICD codes, as was the three-state hospital discharge dataset. However, the new Prospective Payment System used diagnostic Case-Mix Groups (CMGs) that considered both diagnostic and impairment information. With UDSMR data on impairment levels, we collapsed the PPS data into RIC-like categories. The diagnostic categories had to be mapped from one system to another, providing the potential for inexact classification. Further imprecision arose in using modest numbers of cases to collapse the data into the common categories. Some data sets lacked cause codes completely or made cause coding voluntary for rehabilitation, leading to many uncoded cases. Other data sets did not distinguish motorcycle injury patients from other motor vehicle injury patients. Thus, the motorcycle cases available could be a biased sample, and some data were not differentiated by motor vehicle user type. This study was not able to separately analyze rehabilitation costs of on-road motorcycle crashes involving off-road motorcycles.

This study analyzed only inpatient rehabilitation costs. Unlike acute-care hospital payments, professional services generally are bundled into rehabilitation payments. We did not study post-discharge rehabilitation costs for physical therapy, speech therapy, occupational therapy and counseling, chiropractic services, doctor visits, etc. *The Databook on Nonfatal Injury* (Miller, Pindus, Douglass, and Rossman, 1995) gives post-discharge rehabilitation cost estimates by injury diagnosis drawn from the Workers'

Compensation System, which had a vested interest in providing rehabilitation to the point of maximum medical improvement.

Despite its limitations, this study provides a good picture of inpatient rehabilitation costs for injuries in motor vehicle and motorcycle crashes. It also substantially increases our knowledge of the longer-term impacts of motor vehicle and motorcycle injury on functioning, work, and marriage.

Appendix A: Chapter 4, Tables 1-6

Table 1. Adjusted Federal Prospective Payment for Motorcyclists by Diagnosis Group (in 2002 dollars)

Diagnosis Group	Motorcycle Injury	Other Motor Vehicle	Attempted Suicide	Assault	Other Unintentional
Traumatic Brain Injury	$ 16,545	$ 16,441	$ 17,096	$ 15,369	$ 15,169
Spinal Cord Injury Unspecified	$ 21,777	$ 16,112	$ 31,035	$ 15,520	$ 17,852
Spinal Cord Injury Paraplegia Unspecified	$ 16,743	$ 28,919	$ 15,243	$ 17,658	$ 17,886
Spinal Cord Injury Paraplegia Incomplete	$ 17,091	$ 17,449	$ 21,125	$ 16,274	$ 16,616
Spinal Cord Injury Paraplegia Complete	$ 19,932	$ 20,044	$ 18,105	$ 18,172	$ 18,765
Spinal Cord Injury Quadriplegia Unspecified	$ 26,406	$ 25,360	$ 20,690	$ 23,139	$ 24,647
Spinal Cord Injury Quadriplegia Incomplete	$ 21,236	$ 25,017	$ 24,814	$ 24,309	$ 24,448
Spinal Cord Injury Quadriplegia Complete	$ 28,966	$ 28,823	$ 26,225	$ 28,890	$ 28,821
Spinal Cord Injury Other	$ 12,401	$ 15,461	$ 13,158	$ 13,914	$ 15,382
Upper-Extremity Amputation	*	$ 12,169	*	$ 12,179	$ 11,731
Lower-Extremity Amputation	$ 10,135	$ 11,845	$ 11,475	$ 10,151	$ 12,003
Other Amputation	$ 10,716	$ 14,339	*	*	$ 11,270
Traumatic Brain Injury + Spinal Cord Injury	$ 22,998	$ 21,813	$ 7,437	$ 22,864	$ 21,719
Traumatic Brain Injury + Fracture + Amputation	$ 17,728	$ 17,402	$ 15,523	$ 17,891	$ 17,511
Spinal Cord Injury + Fracture + Amputation	$ 20,221	$ 19,965	$ 11,477	$ 19,983	$ 19,297
Other Multiple Trauma	$ 11,830	$ 12,146	$ 12,484	$ 12,149	$ 11,989
Neck + Back Pain	$ 7,817	$ 9,348	$ 11,960	$ 7,817	$ 9,503
Other Pain	*	$ 9,888	$ 7,948	$ 7,817	$ 9,763
Hip/Knee Fracture/Replacement	$ 9,186	$ 9,052	$ 14,369	$ 9,322	$ 10,002
Other Orthopedic	$ 9,587	$ 9,771	$ 15,024	$ 9,618	$ 10,004
Burns	$ 9,929	$ 18,988	$ 11,982	$ 15,223	$ 15,765
Other specified	$ 14,163	$ 12,354	$ 17,096	$ 12,596	$ 12,120

Source: Federal Register/ Vol. 66, No.152, Tuesday 7, 2001, Rules and Regulations
*Not enough cases to develop an accurate estimate.

Table 2. Adjusted Federal Prospective LOS for Motorcyclists by Diagnosis Group (in days)

Diagnosis Group	Motorcycle Injury	Other Motor Vehicle	Attempted Suicide	Assault	Other Unintentional
Traumatic Brain Injury	22.6	22.5	23.2	21.2	21.0
Spinal Cord Injury Unspecified	29.5	23.5	40.0	23.3	25.6
Spinal Cord Injury Paraplegia Unspecified	24.5	27.3	22.7	25.9	26.0
Spinal Cord Injury Paraplegia Incomplete	25.1	25.4	29.8	24.0	24.4
Spinal Cord Injury Paraplegia Complete	28.5	28.7	26.6	26.5	27.2
Spinal Cord Injury Quadriplegia Unspecified	34.8	34.1	30.0	31.3	33.3
Spinal Cord Injury Quadriplegia Incomplete	29.4	33.6	33.4	32.8	33.0
Spinal Cord Injury Quadriplegia Complete	38.0	37.8	34.8	37.9	37.7
Spinal Cord Injury Other	19.2	22.8	20.0	21.1	22.7
Upper-Extremity Amputation		18.3	*	18.5	17.6
Lower-Extremity Amputation	15.5	17.2	16.8	15.6	17.3
Other Amputation	16.0	21.7			16.9
Traumatic Brain Injury + Spinal Cord Injury	31.7	30.1	10.0	31.6	29.9
Traumatic Brain Injury + Fracture + Amputation	24.6	24.2	21.1	25.0	24.3
Spinal Cord Injury + Fracture + Amputation	27.5	27.4	16.0	27.1	26.5
Other Multiple Trauma	16.9	17.2	17.6	17.2	17.1
Neck + Back Pain	13.0	14.8	18.0	13.0	15.0
Other Pain		15.5	12.1	13.0	15.3
Hip/Knee Fracture/Replacement	13.5	13.3	*	13.7	14.6
Other Orthopedic	14.8	15.1	21.0	15.0	15.4
Burns	16.0	.	*	*	*
Other specified	19.8	17.8	17.4	18.1	17.5

Source: Federal Register, Vol. 66, No.152, Tuesday 7, 2001, Rules and Regulations

*No cases available.

Table 3. Rehabilitation Costs of Hospital-Admitted Self-Inflicted Injuries, 2000 (in 2002 dollars)

Diagnosis Group	2000 HCUP-NIS Cases	Rehab Cases	Rehab Cost/Case	Total Cost (Thousands)
Traumatic Brain Injury Only	668	46	$17,096	$782
TBI + Fracture/Amputation	169	19	$15,523	$298
Spinal Cord Injury Only	67	20	$20,484	$419
TBI + SCI	17	4	$7,437	$32
SCI + Fracture/Amputation	52	16	$11,477	$182
Lower-Extremity Amputation Only	11	1.3	$11,475	$15
Upper-Extremity Amputation Only	34	0.3	$12,169	$3
Lower-Extremity Fracture Only	438	28	$7,948	$220
Upper-Extremity Fracture Only	318	7	$14,369	$102
Other Fracture Only	423	24	$14,369	$343
Lower Extremity Other	1,328	22	$12,030	$259
Upper Extremity Other	16,595	91	$12,030	$1,091
Other	8,938	90	$12,030	$1,081
Burns	879	11	$15,024	$259
Total/Average	29,937	378	$13,176	$1,091

Table 4. Rehabilitation Costs of Hospital-Admitted Assault Injuries, 2000 (in 2002 dollars)

Diagnosis Group	2000 HCUP-NIS Cases	Rehab Cases	Rehab Cost/Case	Total Cost (Thousands)
Traumatic Brain Injury Only	13,143	862	$15,369	$13,245
TBI + Fracture/Amputation	2,073	219	$17,891	$3,922
Spinal Cord Injury Only	865	266	$19,877	$5,289
TBI + SCI	55	14	$22,864	$325
SCI + Fracture/Amputation	192	58	$19,983	$1,167
Lower-Extremity Amputation Only	41	2.2	$10,151	$22
Upper-Extremity Amputation Only	132	0.8	$12,179	$9
Lower-Extremity Fracture Only	5,968	383	$9,322	$3,568
Upper-Extremity Fracture Only	4,381	98	$9,618	$943
Other Fracture Only	14,416	187	$9,618	$1,798
Lower Extremity Other	3,272	52	$12,395	$641
Upper Extremity Other	6,686	38	$12,395	$474
Other	38,202	343	$12,395	$4,246
Burns	329	4	$15,223	$59
Total/Average	89,754	2,527	$14,132	$35,707

Table 5. Rehabilitation Costs of Hospital-Admitted Other Unintentional Injuries, 2000 (in 2002 dollars)

Diagnosis Group	2000 HCUP-NIS Cases	Rehab Cases	Rehab Cost/Case	Total Cost (Thousands)
Traumatic Brain Injury Only	76,255	4,629	$15,169	$70,221
TBI + Fracture/Amputation	17,450	1,673	$17,511	$29,302
Spinal Cord Injury Only	5,341	1,644	$21,262	$34,944
TBI + SCI	800	207	$21,719	$4,502
SCI + Fracture/Amputation	889	270	$19,297	$5,211
Lower-Extremity Amputation Only	2,783	263	$12,003	$3,153
Upper-Extremity Amputation Only	7,276	25	$11,731	$290
Lower-Extremity Fracture Only	493,058	43,862	$10,002	$438,710
Upper-Extremity Fracture Only	129,922	2,906	$10,004	$29,075
Other Fracture Only	144,522	7,714	$10,004	$77,167
Lower Extremity Other	108,330	2,604	$11,950	$31,112
Upper Extremity Other	83,975	825	$11,950	$9,862
Other	241,104	2,445	$11,950	$29,219
Burns	26,174	351	$15,765	$5,532
Total/Average	1,337,876	69,418	$11,068	$768,299

Table 6. Rehabilitation Costs of All Hospital-Admitted Injuries, 2000 (in 2002 dollars)

Diagnosis Group	2000 HCUP-NIS Cases	Rehab Cases	Rehab Cost/Case	Total Cost (Thousands)
Traumatic Brain Injury Only	126,033	7,444	$13,122	$97,680
TBI + Fracture/Amputation	48,916	4,615	$17,476	$80,660
Spinal Cord Injury Only	8,725	2,685	$17,300	$46,446
TBI + SCI	1,970	511	$21,742	$11,103
SCI + Fracture/Amputation	2,149	653	$19,500	$12,727
Lower-Extremity Amputation Only	3,237	308	$11,896	$3,667
Upper-Extremity Amputation Only	7,844	28	$11,784	$334
Lower-Extremity Fracture Only	549,247	47,320	$9,935	$470,143
Upper-Extremity Fracture Only	153,315	3,430	$9,970	$34,195
Other Fracture Only	202,065	9,888	$9,958	$98,467
Lower Extremity Other	122,074	2,899	$11,972	$34,702
Upper Extremity Other	113,719	1,025	$11,986	$12,289
Other	357,666	3,691	$12,033	$44,419
Burns	27,867	373	$15,763	$5,874
Total/Average	1,724,826	84,870	$11,226	$952,704

Appendix B – Length of Stay and Costs of Injury Rehabilitation by Injury Category

Introduction

Although the immediate hospitalization costs of various injuries have been examined, the longer-term costs of injury rehabilitation have not been fully addressed. In conducting cost analyses before adopting injury prevention programs or laws, the rehabilitation costs are an important but often overlooked element of the total cost. This section provides data on injury, rehabilitation costs, and rehabilitation hospital length of stay (LOS) by age group.

Cost and length of stay data were provided by the American Medical Rehabilitation Provider's Association (AMRPA). These data are from 106 U.S. rehabilitation centers. This cost dataset on rehabilitation patients is considered the most reliable cost dataset available, as the cost data has been uniformly identified, quality-controlled, and cleaned. Diagnoses and cost data were available for 76 percent of the approximately 83,000 AMRPA patient records.

AMRPA provided data on average length of stay, average cost, and average cost per day by rehabilitation impairment category (RIC) and age group.

Methods

Data Collection and Analysis Methods

The AMRPA dataset contains records for 83,000 non-Medicare patients from rehabilitation hospitals for the years 1997 – 2001 from 106 facilities. The dataset overlaps heavily with the UDSMR, but contains additional cost data for 75 percent to 80 percent of the patients. We received data on 69,023 rehabilitation cases, of which 41,602 were injury cases.

Case Selection

Although the data contained a smattering of E-codes, these were too sparse to use in selecting cases for analysis. Diagnoses coded using the International Classification of Diseases were also limited in the rehabilitation data and thus unusable. Thus, we only could conduct our analysis using the rather limited RIC categories.

Rehabilitation Impairment Categories

RICs describe the impairments that serve as the primary cause for the inpatient rehabilitation admission. Most RICs differentiate traumatic injuries. This system was designed and validated by (Carter et al., 2000). The

Department of Health and Human Services selected 21 RICs—ranging from *Stroke* (category 01) to *Burns* (category 21)—to form a Prospective Payment System for rehabilitation services (Department of Health and Human Services, 2001).

(Carter et al., 2000) examined specific facets of a rehabilitation Inpatient Rehabilitation Facility PPS — such as its system of categorization, its construction of weights, its procedures for handling univariate outliers, etc.— through use of cost data (from hospitals), discharge information, and FIM data for calendar years 1996–97. Of relevance to the present study, these researchers' explicit goals included improving cost descriptions through the use of RIC definitions. With the exception of the creation of a new category for burns, variation in RIC definitions did not appreciably increase their ability to explain costs.

Data Years

Cases with a discharge date of fiscal year 1999 were selected for analysis. These data give us the last data in a free market rehabilitation system. Thereafter, HCFA (now CMS) moved the system to prospective payment at rates that do not necessarily reflect actual costs of care. The new PPS rates for 2002 are listed in the chapter reporting our analysis of UDSMR data.

Analysis

Cases were selected if they contained RICs and cost data. We calculated basic descriptive statistics on costs and length of stay by age groups. The average cost per day of inpatient rehabilitation was computed by dividing the average cost per rehab stay by the average length of stay per rehab patient.

Results

Table 1 presents the RIC injury data across all age groupings. Traumatic spinal cord injuries required the longest length of stay–on average 34.3 days, followed by major multiple trauma with brain or spinal cord injury (26.3 days); and traumatic brain injuries (25.8) days.

The average cost per rehab day ranged from $716 (hip fracture) to $991 (burns). The top five RICs in average costs for all age groupings were burns ($991), traumatic spinal cord ($860), major multiple trauma with brain or spinal cord injury ($854), traumatic brain injury ($807), and neurological ($802).

Table 1. Rehabilitation Costs for All Age Groups: Number of Cases, Average Length of Stay, Average Cost, and Average Cost per Day as a Function of RICs, FY 1998–1999 Data in 1999 Dollars.

RICs	Cases	Average Length of Stay (LOS)	Standard Deviation (LOS)	Average Cost	Standard Deviation of Cost	Average Cost per Day (mean total cost/LOS)
Amputation, Lower Extremity	2,184	17.4	11.3	$13,468	$10,069	$774
Amputation, Other	282	16.9	10.6	$13,486	$9,017	$798
Burns	163	15.7	10.3	$15,555	$14,517	$991
Hip Fracture	6,203	15.2	7.8	$10,877	$6,590	$716
Major Multiple Trauma, With Brain or Spinal Cord Injury	593	26.3	24.3	$22,450	$24,104	$854
Major Multiple Trauma, With No Brain or Spinal Cord Injury	1,100	16.5	11.6	$12,585	$10,395	$763
Miscellaneous	6,226	16.0	10.0	$12,668	$11,213	$792
Neurological	2,873	17.7	11.4	$14,193	$10,986	$802
Other Orthopedic	3,220	14.1	8.4	$10,451	$7,262	$741
Pain Syndrome	844	13.7	8.6	$9,925	$6,662	$724
Replacement of Lower Extremity Joint	14,185	10.5	5.5	$7,613	$4,370	$725
Traumatic Brain Injury	2,372	25.8	22.5	$20,821	$21,435	$807
Traumatic Spinal Cord	1,357	34.3	30.1	$29,495	$29,583	$860
TOTALS	41,602					

An examination of the RIC data by age group (tables 2–4) revealed a consistent trend in LOS and average costs by RICs similar to the aggregated age data.

Table 2. Individuals Less Than 30 Years Old: Number of Cases, Average Length of Stay, Average Cost, and Average Cost per Day as a Function of Rehabilitation Impairment Categories

RICs	Cases	Average Length of Stay (LOS)	Standard Deviation (LOS)	Average Cost	Standard Deviation of Cost	Average Cost per Day (mean total cost/LOS)
Amputation, Lower Extremity	33	24.0	36.0	$17,735	$25,388	$739
Amputation, Other	7	20.8	22.9	$16,539	$16,183	$795
Burns	14	19.2	7.7	$14,288	$6,890	$744
Hip Fracture	75	11.2	6.1	$7,809	$4,285	$697
Major Multiple Trauma, With Brain or Spinal Cord Injury	209	26.9	29.4	$23,594	$29,791	$877
Major Multiple Trauma, With No Brain or Spinal Cord Injury	159	13.5	9.8	$10,374	$8,474	$768
Miscellaneous	101	20.0	14.9	$16,507	$13,318	$825
Neurological	111	18.2	11.9	$15,737	$13,099	$865
Other Orthopedic	108	12.6	8.2	$9,966	$7,024	$791
Pain Syndrome	15	17.6	10.4	$12,721	$10,474	$723
Replacement of Lower-Extremity Joint	41	11.2	7.0	$8,700	$6,617	$777
Traumatic Brain Injury	735	28.8	27.9	$24,401	$28,606	$847
Traumatic Spinal Cord	353	40.6	36.1	$35,696	$36,347	$879
TOTALS	1,961					

Table 3. Individuals 30 to 64 Years Old: Number of Cases, Average Length of Stay, Average Cost, and Average Cost per Day as a Function of Rehabilitation Impairment Categories

RICs	Cases	Average Length of Stay (LOS)	Standard Deviation (LOS)	Average Cost	Standard Deviation of Cost	Average Cost per Day (mean total cost/LOS)
Amputation, Lower Extremity	805	15.7	9.9	$12,611	$10,592	$803
Amputation, Other	99	15.7	10.7	$12,469	$8,652	$794
Burns	54	18.8	12.3	$19,477	$20,806	$1,036
Hip Fracture	715	12.9	8.2	$9,595	$7,446	$744
Major Multiple Trauma, With Brain or Spinal Cord Injury	286	27.3	22.6	$23,191	$22,094	$849
Major Multiple Trauma, With No Brain or Spinal Cord Injury	485	16.6	12.4	$12,699	$10,479	$765
Miscellaneous	1,537	16.4	11.5	$13,669	$14,690	$833
Neurological	1,159	18.3	13.0	$14,988	$12,196	$819
Other Orthopedic	864	13.1	9.9	$10,120	$8,912	$773
Pain Syndrome	250	13.3	9.8	$9,856	$7,115	$741
Replacement of Lower-Extremity Joint	3,410	9.1	4.8	$6,786	$3,932	$746
Traumatic Brain Injury	961	26.8	22.6	$21,355	$19,967	$797
Traumatic Spinal Cord	713	34.5	28.2	$28,915	$26,277	$838
TOTALS	11,338					

Table 4. Individuals 65 and Older: Number of Cases, Average Length of Stay, Average Cost, and Average Cost per Day as a Function of Rehabilitation Impairment Categories

RICs	Cases	Average Length of Stay (LOS)	Standard Deviation (LOS)	Average Cost	Standard Deviation of Cost	Average Cost per Day (mean total cost/LOS)
Amputation, Lower Extremity	1,346	18.3	10.7	$13,877	$9,005	$758
Amputation, Other	176	17.4	9.8	$13,937	$8,860	$801
Burns	95	13.5	8.9	$13,512	$9,962	$1,001
Hip Fracture	5,413	15.6	7.7	$11,089	$6,466	$711
Major Multiple Trauma, With Brain or Spinal Cord Injury	98	22.3	15.6	$17,849	$13,518	$800
Major Multiple Trauma, With No Brain or Spinal Cord Injury	456	17.5	11.0	$13,235	$10,821	$756
Miscellaneous	4,588	15.7	9.2	$12,248	$9,679	$780
Neurological	1,603	17.2	10.1	$13,511	$9,797	$786
Other Orthopedic	2,248	14.5	7.8	$10,601	$6,529	$731
Pain Syndrome	579	13.8	8.0	$9,882	$6,328	$716
Replacement of Lower-Extremity Joint	10,734	11.0	5.6	$7,871	$4,458	$716
Traumatic Brain Injury	676	21.2	13.2	$16,170	$11,001	$763
Traumatic Spinal Cord	291	26.5	24.5	$23,396	$26,616	$883
TOTALS	28,303					

Discussion

If all ages are considered, rehabilitation hospital costs in 1999 ranged from $7,613 for the replacement of a lower-extremity joint to $29,495 for a traumatic spinal cord injury. Average cost per day ranged from $716 for a hip fracture to $991 for burns. Traumatic spinal cord injuries required the longest length of stay – on average 34.3 days -- while replacement of a lower-extremity joint had the shortest – on average 10.5 days. These finding are relatively consistent among age groups.

One caveat on our analysis is length of stay reportedly has been dropping for at least 10 years and more notably since 1999, due to market distortions related to the implementation of prospective payment system. With PPS, rehabilitation hospitals are paid a set fee for each patient, providing an incentive to shorten hospital stay to conform to the available payment.

Appendix C– Characteristics of People in TBI Rehabilitation Due to Motorcycle Crashes and Associated Costs

Characteristics of People in TBI Rehabilitation Due to Motorcycle Crashes

Of the 227 rehabilitation patients who incurred TBI in motorcycle crashes, 91.2 percent were male and 8.8 percent were female. This group was 79.2 percent White, 17.3 percent Black, and 3.5 percent Hispanic. The ages are listed in Table 1. Consistent with the ages of the TBI patients, in 1998 the mean age of a motorcycle owner was 38.1 years and the mean age of motorcyclists killed in fatal crashes was 34.6.

Table 1. Age Distribution of Rehabilitation Patients with TBI Incurred in Motorcycle Crashes

Age	Percent
16–24	26.9%
25–44	51.1%
45–64	20.7%
>65	1.3%

Diagnosis Breakdown for Motorcyclists

For the 227 people diagnosed with Traumatic Brain Injury as a result of a motorcycle crash, across three diagnosis categories, Table 2 shows the mean acute care lengths of stay varied from 20.8 to 22.9 days. Mean LOS for rehabilitation was longer, ranging from 29.3 to 32.5 days. Surprisingly, spinal cord injury co-morbidity did not noticeably affect the LOS or rehabilitation charges.

The charges per day were much higher for acute care than for rehabilitation. The ratio of *charges per day* for rehabilitation to acute care ranged minimally, from 0.30 to 0.31, suggesting that the overall mean of 0.31 can be applied to all TBI rehabilitation. The ratio of *charges per patient* for rehabilitation to acute care weigh in both cost and length of stay variations. They ranged from 0.47 for skull fracture without spinal cord injury to 0.55 for TBI plus spinal cord injury to 0.56 for concussion without spinal cord injury.

Table 2. LOS and Charges for People with TBI Incurred in Motorcycle Crashes, by Diagnosis Group

	Concussion – No Spinal Cord Injury	Skull Fracture-No Spinal Cord Injury	TBI + SCI
Motorcycle Patients	N = 127	N = 90	N = 10
LOS Before Rehabilitation (Mean/ Standard Deviation)	21.31 (15.61)	22.92 (18.21)	20.80 (14.04)
LOS Rehabilitation (Mean/SD)	32.10 (24.15)	29.33 (27.32)	32.50 (20.77)
Charges Per Day – Acute Care (Mean, SD)	$5,507.24 (3,378.37)	$5,549.57 (2,775.69)	$6,279.46 (4,413.90)
Charges Per Day-Rehab (Mean, SD)	$1,408.52 (459.48)	$1,364.27 (382.51)	$1,488.55 (585.62)
Ratio Of Charges Per Day – Rehab/Charges Per Day – Acute Care (Mean, SD)	.3076 (.1424)	.3128 (.2041)	.2979 (.1200)
Ratio Of Charges Per Patient – Rehab/Charges Per Patient – Acute Care (Mean, SD)	.5602 (.4697)	.4704 (.6594)	.5520 (.3723)

Demographic Breakdowns for Motorcyclists

Table 3 shows that the LOS was nearly identical for ages 25–44 and 45–64. The LOS for patients aged 16–24 was higher (36 days compared to approximately 29 days). The data contains only three motorcyclists over age 65, too few cases to credibly report.

Table 3. LOS and Charges for People with TBI Incurred in Motorcycle Crashes, by Age Group

	16–24	25–44	45–64
Motorcycle Patients	N = 61	N = 116	N = 47
LOS Rehab (Mean/SD)	35.62 (27.42)	29.36 (26.31)	29.68 (19.04)
Charges Rehab – (Mean/SD)	$46,997.97 (36,390.29)	$40,482.72 (41,897.63)	$43,380.77 (30,753.98)
Ratio of Charges Per Day - Rehab/Charges Per Day - Acute Care (Mean, SD)	.3180 (.1948)	.2984 (.1689)	.3195 (.1165)
Ratio of Charges Per Patient – Rehab/ Charges per Patient – Acute Care (Mean, SD)	.5803 (.5251)	.4881 (.5829)	.5555 (.4882)

The rehabilitation charges for ages 16 to 64 range from $40,482 to $46,997. The ratio of charges per day for rehabilitation to acute care range from .30 to .32, and the ratio of charges per patient for rehabilitation to acute care range from .49 to .58.

As shown in Table 4, mean LOS for white patients was 32 days, compared to 28 for African American patients and 19 for Hispanic patients. The number of Hispanic cases (8) may be too small to be reliable. The observed differences could indicate a more rapid recovery, but differential access to payment for rehabilitation services seems a more likely explanation. The mean charges for rehabilitation range from a low of $25,394 for Hispanic patients to a high of $44,490 for white patients.

Table 4. LOS and Charges for People with TBI Incurred in Motorcycle Crashes, by Race/Ethnicity

	White	Black	Hispanic
Motorcycle Patients	N = 179	N = 39	N = 8
LOS rehab (Mean/SD)	32.10 (27.29)	28.41 (14.66)	19.38 (13.70)
Charges rehab (Mean/SD)	$44,490.64 (41,347.10)	$37,094.28 (20,696.84)	$25,394.63 (17,229.33)
Ratio of Charges Per Day – Rehab/ Charges Per Day – Acute Care (Mean, SD)	.3176 (.1738)	.2699 (.1202)	.2846 (.1750)
Ratio of Charges Per Patient – Rehab / Charges per Patient – Acute Care (Mean, SD)	.5326 (.5812)	.4773 (.3230)	.5986 (.4869)

Table 5 shows that there were no significant differences in LOS and charges by gender.

Table 5. LOS and Charges for People with TBI Incurred in Motorcycle Crashes, by Gender

	Male	Female
Motorcycle Patients	N = 207	N = 20
LOS rehab (Mean/SD)	31.15 (25.34)	29.47 (25.11)
Charges rehab (Mean/SD)	$42,874.26 (38,511.74)	$38,878.26 (34,191.44)
Ratio of Charges Per Day – Rehab/ Charges Per Day –Acute Care (Mean, SD)	.3077 (.1647)	.3232 (.1909)
Ratio of Charges Per Patient – Rehab / Charges per Patient – Acute Care (Mean, SD)	.5249 (.5570)	.5363 (.4105)

References

Bonczar, T. P., and Beck, A. J. (1997 March). *Special report: Lifetime likelihood of going to State or Federal prison* (NCJ-160092): U.S. Department of Justice, Office of Justice Programs, Bureau of Justice Statistics.

Brooks, A., Lindstrom, J., McCray, J. et al (1995) Cost of Medical Care for a Population-Based Sample of Persons Surviving Traumatic Brain Injury**.** *Journal of Head Trauma Rehabilitation*, 10(4): 1-13.

Carter, G. M., Relles, D. A., Wynn, B., Kawata, J., Paddock, S., Sood, N., and Totten, M. (2000). *Interim report on an inpatient rehabilitation facility prospective payment system*. (DRU-2309-HCFA): Health Care Financing Administration.

Christian, W. J., Carroll, M., Meyer, K., Vitaz, T. W., and Franklin, G. A. (2003). Motorcycle helmets and head injuries in Kentucky, 1995-2000. *The Journal of the Kentucky Medical Association, 10*(1), 21-26.

Dahmer, E. R., Shilling, M. A., Hamilton, B., Bontke, C., Englander, J., Kreutzer, J. S., and Rosenthal, M. (1993). A model of systems database for traumatic brain injury. *Journal of Head Trauma Rehabilitation, 8*(2), 12-25.

Department of Health and Human Services. (2001). Medicare program; Prospective payment system for inpatient rehabilitation facilities; Final rule. *Federal Register, 66*(152).

Hall, K., Karzmark, P., Stevens, M., Englander, J., O'Hare, P., and Wright, J. (1994). Family stressors in traumatic brain injury: a two-year follow-up. *Archives of Physical Medicine and Rehabilitation, 75*(8), 876-884.

Harrison-Felix, C., Newton, C. N., Hall, K. M., and Kreutzer, J. S. (1996). Descriptive findings from the traumatic brain injury model systems national database. *Journal of Head Trauma Rehabilitation, 11*(5), 1-14.

Kreutzer, J., Marwitz, J., High Jr., W. M., Englander, J., and Cifu, D. (2001, 08/30/2002). *Etiology and incidence of rehospitalizations*. The Traumatic Brain Injury National Data Center (TBINDC). Retrieved August 2003, from the Web at: www.tbindc.org/public/reg_projects/project_35.html

Lawrence, B. A., Max, W., and Miller, T. R. (2003 Feb). *Costs of injuries resulting from motorcycle crashes: A literature review* (DOT HS 809 242). Washington, DC: National Highway Traffic Safety Administration.

Lombard, L. A., Kelly, J. P., Heinemann, A., and Kychlik, K. (2003, March 26 - 29). *Motorcycle crash victims in the acute rehabilitation setting.* Paper presented at the 39th Annual AAP Educational Conference, Association of Academic Physiatrists, Fort Lauderdale, Florida.

Miller, T. R., Pindus, N. M., Douglass, J. B., and Rossman, S. B. (1995). *Databook on nonfatal injury: Incidence, costs, and consequences.* Washington, DC: The Urban Institute Press.

Miller, T. R., Spicer, R. S., Lestina, D. C., and Levy, D. T. (1999). Is it safest to travel by bicycle, car, or big truck? *Journal of Crash Prevention and Injury Control, 1*(1), 25–34.

National Highway Traffic Safety Administration. (2003). *Motor Cycle Safety Program*. Retrieved January 2003, from the Web at: www.nhtsa.dot.gov/people/injury/pedbimot/motorcycle/motorcycle03/recent.htm

Rivara, F. P., Dicker, B. G., Bergman, A. B., Dacey, R., and Herman, C. (1988). The public cost of motorcycle trauma. *Journal of the American Medical Association, 260*(2), 221-223.

Seel, R., Corrigan, J. D., Kreutzer, J. S., Rosenthal, M., and Hammond, F. M. (2003). *Prevalence, symptom rates, and associated factors of depression after TBI: A multi-center investigation of the U.S. NIDRR Model Systems.* Traumatic Brain Injury Research and Publications Registry. Retrieved August 2003, from the Web at: www.tbindc.org/registry/

Shankar, U. (2004, March 29, 2). *Motorcycle Fatalities: an Update.* Paper presented at the Lifesavers Conference 2004, San Diego, CA, March 28-30, 2004, NHTSA, Analyst: Shankar, U. G. Presenter: Williams, D. Washington, DC: National Center for Statistics and Analysis, National Highway Traffic Safety Administration.

Whiteneck, G. G., Charlifue, S. W., Gerhart, K. A., Overholser, J. D., and Richardson, G. N. (1992). Quantifying handicap: a new measure of long-term rehabilitation outcomes. *Archives of Physical Medicine and Rehabilitation, 73*, 519-526.

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