The Association Between Payer Source and Traumatic Brain Injury Rehabilitation Outcomes: A TBI Model Systems Study

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Abstract

Objective: To examine the relationship between payer source for acute rehabilitation, residential median household income, and outcomes at rehabilitation discharge after traumatic brain injury (TBI).

Setting: Acute Inpatient Rehabilitation Facilities

Participants: 8,558 individuals enrolled in the Traumatic Brain Injury Model Systems (TBIMS) National Database who were admitted to inpatient rehabilitation between 2006 and 2019 and under the age of 64.

Design: Secondary data analysis from a multicenter longitudinal cohort study.

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Main Measures: Payer source was divided into four categories: uninsured, public insurance, private insurance, and worker's compensation/auto. Relationships between payer source with residential median household income (MHI), rehabilitation length of stay (RLOS), and the FIM® Instrument at discharge were examined. Covariates included age, injury severity, FIM® at admission, and a number of sociodemographic characteristics including minority status, pre-injury limitations, education level, and employment status.

Results: Individuals with worker's compensation/auto or private insurance had longer RLOS compared with uninsured individuals or those with public insurance after controlling for demographics and injury characteristics. An adjusted model controlling for demographics and injury characteristics showed a significant main effect of payer source on FIM® scores at discharge with the highest scores noted among those with worker's compensation/auto insurance. The main effect of payer source on FIM® at discharge became non-significant after RLOS was added to the model as a covariate, suggesting a mediating effect of RLOS.

Conclusion: Payer source was associated with pre-injury residential MHI and predicted RLOS. While prior studies have demonstrated the effect of payer source on long-term outcomes due to lack of inpatient rehabilitation or quality follow-up care, this study demonstrated that individuals with TBI who are uninsured or have public insurance may be at risk for poorer functional status at the point of rehabilitation discharge compared to those with private insurance, particularly compared to those with worker's compensation/auto insurance. This effect may be largely driven by having a shorter length of stay in acute rehabilitation.

INTRODUCTION

Traumatic brain injury (TBI) is the leading cause of death from injury in the United States, with approximately 230,000 hospitalizations and approximately 61,000 deaths annually[1,2] Over half of TBI hospitalizations in the US occur in those under age 65[2].

Health insurance status remains a critical determinant of access to healthcare and health outcomes. According to the US Department of Health and Human Services, 30 million non-elderly people (under age 65) in the US were uninsured in the first half of 2020, a slight increase from 2019[3]. Although the number of uninsured decreased from 48 million in 2010 to 30 million in 2020, 10.8% of the non-elderly population remains uninsured, demonstrating the continued need to study disparities related to health insurance and various health outcomes[3].

Several studies have shown disparities in TBI outcomes associated with payer source. Uninsured trauma patients tend to have higher mortality rates than those with medical insurance[4]. This effect of being uninsured was found to be more salient among individuals with more severe injuries[5]. In addition, those with public insurance were shown to have higher rates of mortality compared with individuals with private insurance[4,6,7]. Those with severe TBI who are uninsured are also less likely to receive computed tomography

(CT) than those who are insured[8]. Uninsured patients[9,10] and those with public insurance are less likely to be to be discharged to rehabilitation compared with those with private insurance[6,7,11]. Among those who do attend acute rehabilitation, public payer source has been found to negatively impact trajectories of functional change over time[12,13].

With most of the research examining the effect of insurance on mortality, access to rehabilitation, or long-term outcomes, there are fewer studies examining the effect of payer source on acute rehabilitation outcomes. In a recent study that examined children with acquired brain injury, those with public insurance had lower functional status at discharge even after controlling for a number of confounding variables including functional status at admission[14]. This and other studies showing similar findings suggest that insurance status may be indicative of other pre-morbid factors that may influence acute rehabilitation outcomes. While research has used insurance status as a proxy for individual socioeconomic status[15], there is less research looking into the correlates of payer source and the effect on immediate rehabilitation outcomes after TBI.

The purpose of the present study is to better understand the relationship between payer source and immediate rehabilitation outcomes after TBI. It was hypothesized that those without insurance or with public insurance would have shorter lengths of stay in rehabilitation and have poorer functional status at discharge compared with individuals who had private insurance. Adjusted models were examined to determine whether rehabilitation length of stay would contribute to disparities in functional outcomes above and beyond injury characteristics (injury severity, functional status at admission) and pre-injury social determinants of health including age, pre-injury limitations, pre-injury employment, education, minority status, and residential median household income.

METHODS

Participants

This study included participants enrolled in the Traumatic Brain Injury Model Systems (TBIMS) National Database[16,17]. Informed consent procedures in accordance with each participating center's institutional review board were followed at enrollment. National Database (NDB) enrollment criteria include age at least 16 years at time of injury, moderate to severe TBI (as defined by at least one of the following: posttraumatic amnesia > 24 hours, trauma-related intracranial neuroimaging abnormalities, loss of consciousness exceeding 30 minutes, or the Glasgow Coma Scale score of < 13 in the emergency department), and received acute care hospitalization within 72 hours, followed by inpatient rehabilitation at a TBIMS of care. The present analysis included individuals who were admitted to inpatient rehabilitation between 2006 and 2019. The earliest time of injury was limited in order to make use of location data from the American Community Survey 5-year estimates for median household income by zip code. Similar to prior research on payer source, older individuals were excluded from analysis to avoid disproportionate age effects on functional outcomes for individuals with Medicare[11]. To be conservative, the sample retained those under age 64 at the time of injury in order to minimize the number of individuals becoming Medicare-eligible due to age within the period of acute care and rehabilitation hospitalization. Of the 12,159 cases in the TBIMS NDB between 2006 and

2019, there were 9,641 individuals under the age of 64. Cases were excluded if they were missing key variables such as payer source, zip code, duration of posttraumatic amnesia, and demographic characteristics such as employment and level of education at the time of injury, race/ethnicity, and history of pre-injury limitations. The flow chart in Figure 1 illustrates how the analytic sample size of 8,558 was derived.

Measures

Payer source—Payer source was divided into four categories: uninsured, public insurance (Medicare, Medicaid), private insurance (health management organizations and preferred provider organizations), and worker's compensation/auto (representing coverage that was directly related to liability or the mechanism of injury). This information was extracted from medical records after enrollment in the TBIMS.

Injury severity—Injury severity was characterized by the duration of post-traumatic amnesia (Days in PTA). Emergence from PTA was determined through serial assessments using either the Orientation Log[18] or the Galveston Orientation and Amnesia Test[19]. For individuals who were still in PTA at the time of rehabilitation discharge, the total number of days of inpatient hospitalization + 1 day was imputed as has been described previously[20].

Aggregate Median Household Income—Aggregate Median Household Income (MHI) in inflation-adjusted dollars was extracted from data collected for the U.S. Census Bureau's American Community Survey. Five-year estimates by zip code were applied to estimate neighborhood income at the time of injury[21]. MHI estimates from 2007–2011 were applied to individuals who were injured between the years 2006 through 2012 and estimates from 2014–2018 were applied to those injured between 2013 through 2019. In order to analyze the entire sample using the same metric, residential incomes were categorized within their respective time period into lower, middle, and upper income groups. Resulting tertiles for MHI were lower < $42,461   middle $61,128 < upper for the 2006–2012 cohort, and lower < $48,749   middle $70,994 < upper for the 2013–2019 cohort.

Acute Care Length of Stay—Acute Care Length of Stay was calculated in days by subtracting the date of admission to the emergency room from the date of discharge from the acute facility.

Rehabilitation Length of Stay (RLOS)—Rehabilitation Length of Stay (RLOS) was calculated in days by subtracting inpatient rehabilitation admission date from rehabilitation discharge date. If a patient has any inpatient rehabilitation interruptions, the number of days off of the rehabilitation service is subtracted from the length of stay.

The FIM® Instrument—The FIM® Instrument is an 18-item functional independence measure, consisting of a 13-item motor subscale and 5-item cognition subscale (Corrigan, Smith-Knapp, & Granger, 1997; Ottenbacher, Hsu, Granger, & Fiedler, 1996; Uniform Data System for Medical Rehabilitation, 2012). Each item is rated based on the individual's need for assistance with item scores ranging from 1 (total assistance needed) to 7 (complete

independence), producing a total score that ranges from 18 to 126. FIM® scores were assessed at rehabilitation admission and discharge by trained rehabilitation staff.

Pre-injury education level, employment status, limitations, and race/ethnicity were collected as part of a pre-injury history interview conducted after enrollment with either the participant or a designated surrogate if the participant was unable to provide the information due to medical status or cognitive impairment. *Pre-injury education level* was coded to three levels based on the highest educational attainment (less than high school, high school graduate, college graduate). *Pre-injury employment* was coded as a dichotomous variable defined as being competitively employed in a full-time or part-time job at the time of injury or not. *Pre-injury limitation* was defined as an affirmative response to any one of 7 questions in the initial interview asking about blindness or a severe vision impairment; deafness or a severe hearing impairment; a condition that substantially limited one or more of the following activities: walking, climbing stairs, reaching, lifting or carrying; dressing, bathing, or getting around inside the home; learning, remembering, or concentrating; going outside the home alone to shop or visit a doctor's office; and working at a job or business. *Racial/ethnic minority status* was coded as a dichotomous variable representing two groups: those representing racial/ethnic minorities (non-Hispanic Black, Hispanic, Asian, Native American, and Other) and those identifying as non-Hispanic White. Although the proportions of individuals identifying as Asian, non-Hispanic Black, Hispanic, and Native American were comparable to the relative proportions observed in the U.S.[25], the small number of individuals identifying as Asian, Native American, and Other precluded the possibility of making sound conclusions with appropriate generalizability for each racial/ ethnic category separately.

Analysis

All statistical analyses were conducted using IBM SPSS statistical software. Descriptive statistics were used to characterize the sample. A Pearson chi-square test was used to examine the relationship between payer source and MHI. Preliminary examination of the data showed that FIM® at discharge had a skewed distribution. While a square root transformation improved normality, results did not significantly differ from models with the untransformed variable. Therefore, a normal distribution was assumed for this variable. Because RLOS was more highly skewed, and a non-zero count variable, a Poisson distribution was assumed for this outcome with robust standard errors[26]. Generalized linear models were used to analyze the relationships between payer source and rehabilitation outcomes (RLOS and FIM® at discharge) controlling for a number of covariates. A partially adjusted model was first examined containing personal and injury characteristics (age, pre-injury limitations, injury severity, FIM® at Admission). A fully adjusted model was then fit to examine the addition of sociodemographic covariates (pre-injury employment, education, minority status, and MHI). A significance level of $\alpha = 0.05$ was used to determine statistical significance. Where omnibus tests showed a significant effect of payer source, pairwise comparisons among the 4 groups were performed using a Bonferroni correction to control for multiple comparisons ($\alpha = 0.05/6 = 0.0083$).

RESULTS

Description of the Sample

The sample was predominantly male (76%) and non-Hispanic White (64%) with a mean age at injury of 37 years. Nearly half the sample had private insurance (49%) and approximately 10% were uninsured. The majority of participants were employed at the time of injury (71%) and 18% of the sample endorsed at least one preinjury limitation. Additional demographics and sample characteristics are summarized in Table 1.

MHI and Payer Source

There was a statistically significant relationship between payer source and MHI (χ^2 (6) = 512.1, $p < 0.001$). As neighborhood income increased, decreasing proportions of uninsured and public insurance and increasing proportions of private and worker's compensation/auto insurance were observed (see Figure 2).

Rehabilitation Length of Stay and Payer Source

A partially adjusted generalized linear model for rehabilitation payer source controlling for personal and injury-related covariates (age, pre-injury limitations, injury severity, FIM® at Admission) indicated there was a statistically significant relationship between payer source and length of stay (χ^2 (3) = 138.8, $p < 0.001$). The trend was such that worker's compensation/auto insurance had the longest mean RLOS, followed by private and public insurance, and no insurance had the shortest mean RLOS. Pairwise comparisons showed significant differences in RLOS between all four insurance groups (all p's < 0.001) with the exception of public vs. private insurance ($p = 0.616$). When adjusting for sociodemographic variables (pre-injury employment, education, minority status, and MHI), the main effect of insurance type remained significant (χ^2 (3) = 109.1, $p < 0.001$). Again, all pairwise comparisons showed significant differences with the exception of public vs. private insurance ($p = 0.134$). The largest difference was noted between those with no insurance and those with worker's compensation/auto insurance (adjusted mean difference = 7.0; 95% CI = 5.4, 8.6). Adjusted mean RLOS by group from both models are illustrated in Figure 3.

Discharge FIM® and Payer Source

A partially adjusted generalized linear model (Model A) for FIM® at discharge controlling for personal and injury-related covariates (age, preinjury limitations, injury severity, FIM® at admission) indicated there was a statistically significant relationship between payer source and FIM® at Discharge [F(3, 8550) = 15.7, $p < 0.001$]. After adjusting for multiple comparisons, those with worker's compensation/auto insurance or private insurance had significantly higher FIM® scores than those with no insurance and public insurance (all p's 0.001). There was no significant difference between those with no insurance and those with public insurance ($p = 0.066$) or between private insurance and worker's compensation/ auto insurance ($p = 0.014$). The main effect of payer source on FIM® at discharge remained statistically significant after the addition of sociodemographic variables to the model (pre-injury employment, education, minority status, and MHI) [F(3, 8544) = 5.5, $p < 0.001$] (Model B). However, after adjusting for multiple comparisons the only group we

found exhibiting differences was worker's compensation/auto insurance having significantly higher FIM® discharge means than the other three groups (all p's $\leq$ 0.008); there were no differences among the no insurance, public, and private insurance groups (all p's > 0.010).

When RLOS was further added to the model (Model C), the relationship between payer source and FIM® at discharge was no longer statistically significant [F(3, 8543) = 2.2, p = 0.083]. Adjusted means for the three models are illustrated in Figure 3. All covariates were significantly associated with FIM® at Discharge ($p < 0.05$) with the exception of education level (p=0.121).

DISCUSSION

The present study examined the relationship between payer source and acute rehabilitation outcomes in adults with moderate to severe TBI. As prior studies have used insurance status as a proxy for socioeconomic status[15], it is not surprising that this study found a significant association between a neighborhood-level indicator of socioeconomic status (MHI) and payer source. Those with worker's compensation/auto insurance had longer RLOS compared with all other groups. In a partially adjusted model controlling for age, injury severity, and functional status at admission, those with worker's compensation/auto insurance had significantly better functional status at discharge compared with both public and uninsured groups. Controlling for sociodemographic factors resulted in a non-significant difference between private insurance and the public and uninsured groups while those with worker's compensation/auto insurance had significantly higher functional status at discharge compared with all other groups. However, the effect of payer source became non-significant in a fully adjusted model after RLOS was added as a covariate, suggesting a mediating effect of RLOS. These findings indicating significant relationships between payer source and rehabilitation outcomes are consistent with prior research[4–7].

In this study, like others[14,27], we found that payer source was significantly associated with RLOS. Furthermore, our findings suggest that RLOS *mediates* the relationship between payer source and acute rehabilitation outcomes. Taken together, this pattern of findings suggests that the better acute rehabilitation outcomes among individuals with private insurance, and particularly those with worker's compensation/auto insurance, may be explained by their greater time spent in inpatient rehabilitation. Longer length of stay has been associated with greater medical stability in prior research.[28]

The findings have implications for the impact of reduced lengths of stay on patient outcomes in inpatient rehabilitation. The less restricted lengths of stay under worker's compensation and auto insurance likely allow for increased services that may contribute to improved rehabilitation outcomes. It is possible that this relationship is due to leveraging of the spontaneous recovery that occurs over the initial weeks and months following TBI. Persons who are in rehabilitation for longer periods may benefit more from rehabilitation as they spontaneously improve, thereby increasing their ability to participate more fully in rehabilitation and to learn and transfer therapy lessons to the context of daily life. Persons with worker's compensation or auto insurance coverage may have flexibility to stay as long as needed to maximize independence and improve outcomes. Shorter lengths of stay,

associated with insurance limitations, may force rehabilitation team members to make more choices about which aspects of function to prioritize, which may leave some rehabilitation needs unaddressed. Of course, rehabilitation staff must be able to maximize therapy services and benefits for people with TBI, regardless of their insurance coverage and length of stay. Knowledge of approved length of stay as soon as possible after admission can assist the rehabilitation team with setting reasonable goals that will maximize outcomes. Algorithms for priorities may be developed based on insurance coverage and length of stay projections to help guide treatment plans for maximal success.

While previous studies have focused on the lack of rehabilitation services as a result of payer source, this study confirms that despite having access to inpatient rehabilitation, certain individuals are discharged with greater functional needs resulting in potentially greater family or caregiver burden and poorer quality of life following injury. How to best optimize rehabilitation services and provide community-based support for uninsured persons with TBI remains a challenge.

Limitations and Future Directions

While this study presents valuable implications for payer source for individuals with moderate to severe TBI, some limitations exist. There are notable differences in proportions for several variables, e.g., higher proportion of men, Non-Hispanic White, and privately insured individuals. Although this sample is representative of participants enrolled in the TBI Model Systems, which has been shown to be representative of individuals with TBI receiving rehabilitation throughout the United States[29], the findings may not generalize to individuals with moderate to severe TBI who do not receive specialized TBI care in the inpatient rehabilitation setting. This study did not stratify or exclude individuals based on discharge destination. There was a small percentage of individuals (2%) who were discharged to acute care but did not return to rehabilitation within a 30-day period. While these individuals did not have a shorter length of rehabilitation stay than any other discharge destination cohort, it is unclear whether they completed their rehabilitation. Future studies may wish to look at this group and collect additional information to determine the possible reasons why they did not return to rehabilitation.

There are also a few considerations regarding the payer source variable. For example, one's insurance status may change during the course of their hospitalization (i.e., expanded coverage or loss of coverage). While every effort is made to include the most up-to-date information in the TBIMS NDB, claim payers are likely to change if there is a denial or billing error, and these changes may be missed if there is a delay in payment resolution beyond the deadlines for quarterly data submission. Another potential limitation is that the payer source variable has changed over the course of the study period due to changes in public policy. In addition, the public insurance category combines those who may be enrolled in the Medicare Fee-for-Service, Medicaid, Medicare-Medicaid dual-eligible, or Medicare Advantage programs. Further research is needed to determine whether there are differences in outcomes within each of these programs for individuals with TBI.

Another potential limitation with regard to location data is that within the TBIMS National Database, zip code is the most granular location variable collected at the time of enrollment

in the study with more specific address information requested at follow-up after discharge. Although there have been numerous studies showing zip code to be influential on outcomes following TBI[30,31], research has shown that bias inherent in many aggregate location-based variables becomes reduced with smaller geographic units[32]. Future prospective studies requiring more granular geographic information should consider collecting address information at enrollment to allow for more fine-grained analysis regarding pre-injury neighborhood characteristics.

Changes in insurance are not uncommon after TBI, especially among those who are unable to return to their pre-injury place of employment, and thus those with the most severe injuries tend to experience this change to a greater degree[33]. Future studies should consider exploring how changes in payer sources may influence long-term outcomes after TBI. Although this study showed that individuals with worker's compensation or auto insurance had greater length of stay and higher discharge functional status than individuals with other payer sources, it is unclear how long this coverage may last. Future research may consider examining how changes in coverage within this group may affect long-term outcomes. Further exploration within various racial/ethnic subgroups should also be examined, perhaps with a qualitative component, to better understand the specific challenges that may be faced by diverse communities with regard to health insurance.Further studies may also consider examining regional variation and exploring methods to adequately capture facility factors that may be of particular importance in determining length of stay and functional outcomes. A better understanding of neighborhood and facility factors can inform quality improvement initiatives and changes at the policy level to maximize rehabilitation outcomes. Given that we excluded adults aged 65 and older, future studies should explore whether the relationships between patient and clinical factors with rehabilitation and post-hospitalization outcomes vary based on the type of insurance coverage among older adults including Medicare beneficiaries. Future studies should also explore whether policy changes, such as the passage of the Patient Protection and Affordable Care Act and Medicaid expansion, influence access, care receipt, and post-hospital outcomes following TBI.

Conflicts of Interest and Source of Funding:

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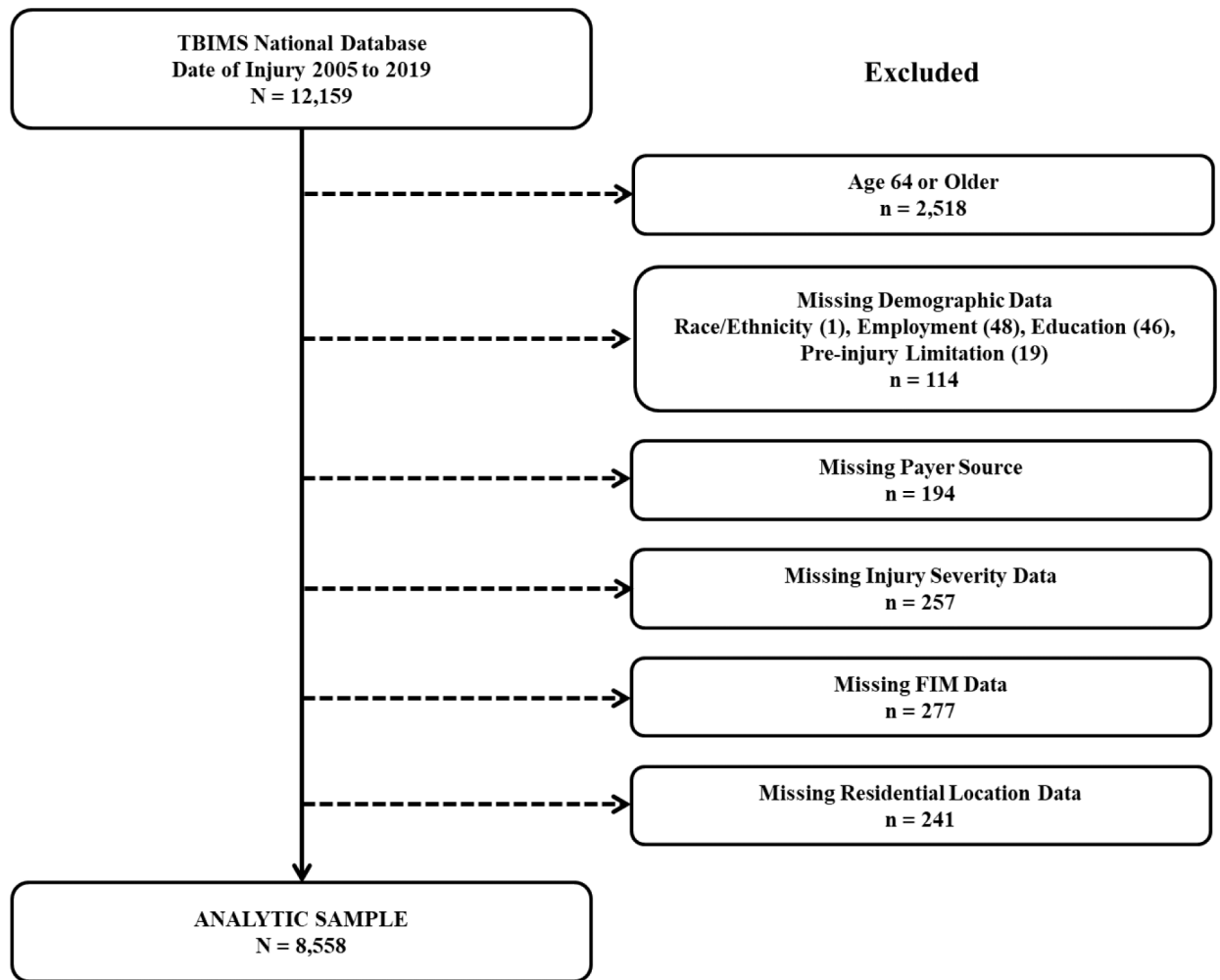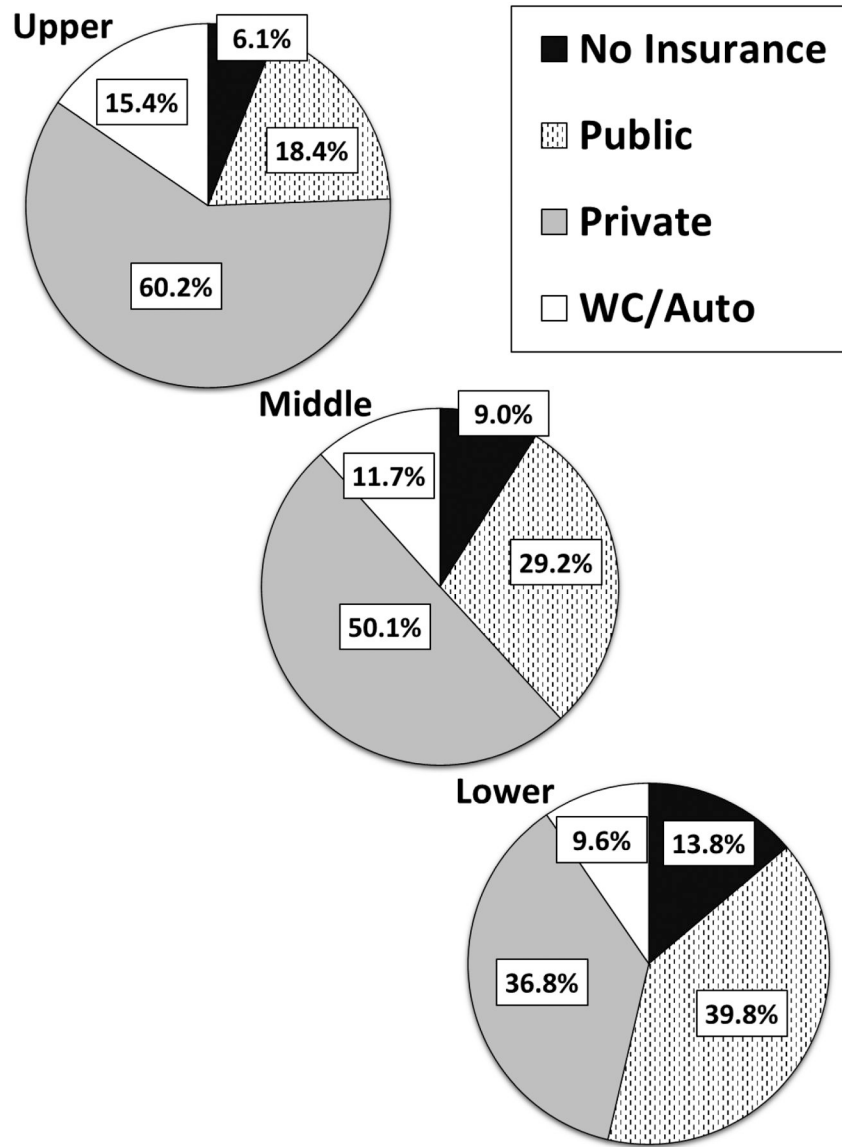
Figure 1.
Sample Derivation Flowchart

Figure 2.
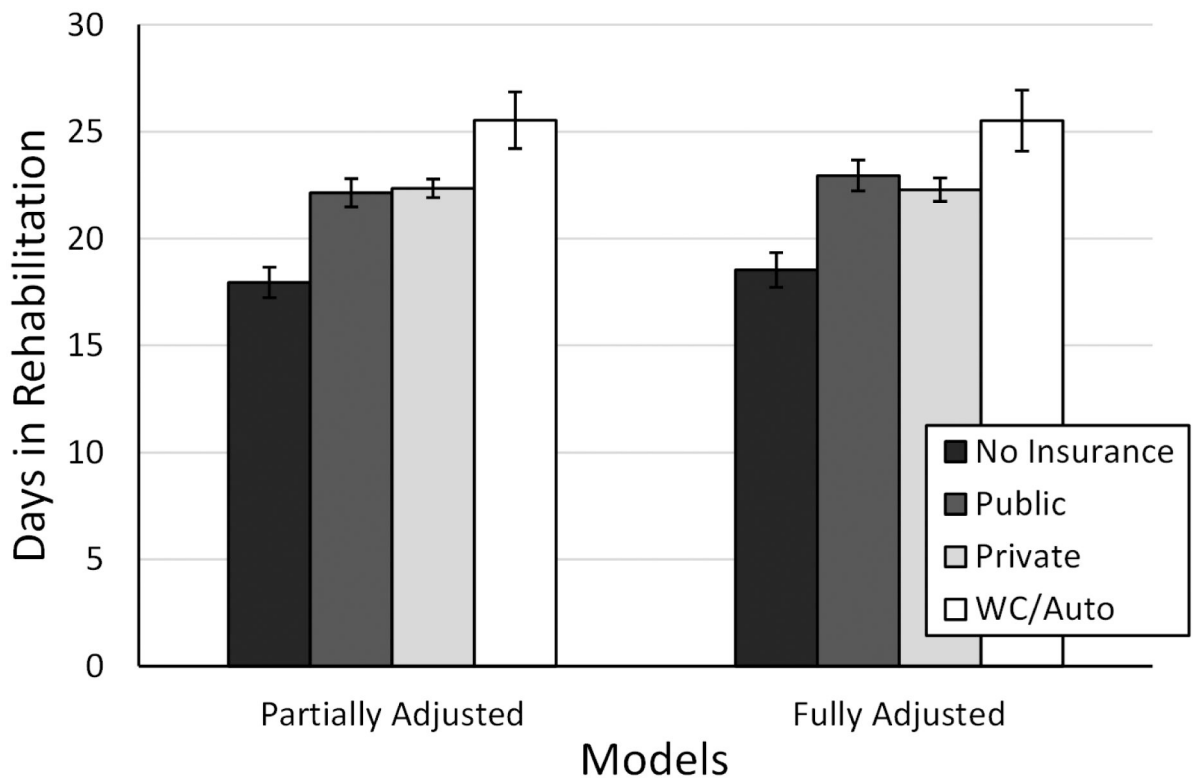Insurance Status by Residential Median Household Income

Figure 3.

Mean Rehabilitation Length of Stay versus Payer source

Note: Partially adjusted model covariates included age, pre-injury limitations, injury severity, FIM® at Admission; Fully adjusted model included pre-injury employment, education, minority status, and MHI; Error bars represent 95% confidence intervals; WC=worker's compensation
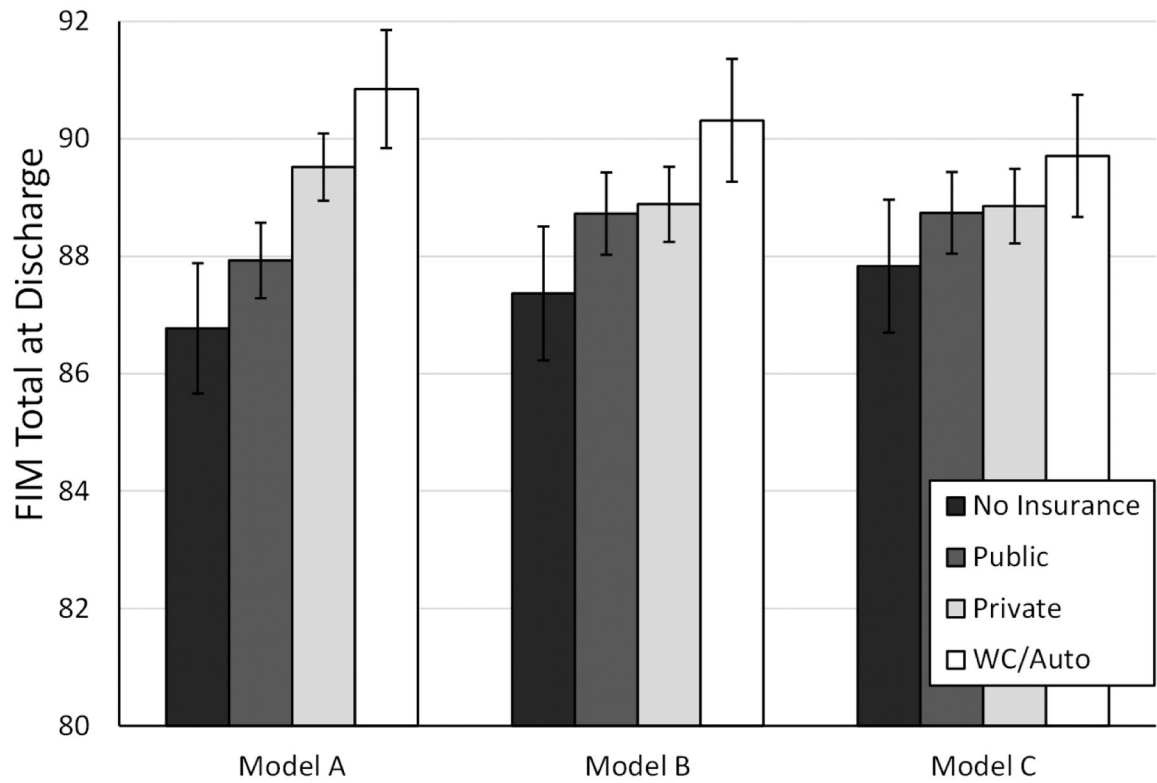
Figure 4.
Adjusted means and confidence intervals for FIM® at Discharge for the three models
Note: Model A covariates included personal and injury-related covariates (age, preinjury limitations, injury severity, FIM® at admission); Model B added sociodemographic variables (pre-injury employment, education, minority status, and MHI); Model C added RLOS; Error bars represent 95% confidence intervals; WC=worker's compensation

Table 1.

Demographics and Sample Characteristics

Sample Characteristics	Count	%
Sex		
Female	2060	24.1
Male	6498	75.9
Race/ethnicity		
Non-Hispanic White	5451	63.7
Minority Status	3107	36.3
Non-Hispanic Black	1476	17.2
Hispanic Origin	1324	15.5
Asian/Pacific Islander	207	2.4
American Indian/Alaska Native	50	0.6
Other	50	0.6
Education		
Less than High School	1815	21.2
High School Graduate/GED	5372	62.8
College Graduate	1371	16.0
Employment at Time of Injury		
Not Employed	2512	29.4
Employed	6046	70.6
Pre-injury Limitations		
Any Endorsement	1510	17.6
Blindness or Deafness	380	4.4
Limited Physical Activities	561	6.6
Interferes with Learning	725	8.5
Interferes with Dressing	113	1.3
Interferes with Going Outside the Home	199	2.3
Interferes with Working	551	6.4
Did Not Endorse Any of the Above	7048	82.4
Cause of Injury		
Vehicular	5335	62.3
Fall	1899	22.2
Assault	958	11.2
Sports or hit by falling/flying object	322	3.8
Other/Unknown	44	0.5
Payer Source		
Uninsured	825	9.6
Public Insurance	2494	29.1
Private Insurance	4193	49.0
Worker's Compensation/Auto Insurance	1046	12.2
Age (Mean, SD)	36.7	14.2

Sample Characteristics	Count	%
FIM® Total at Admission (Mean, SD)	50.3	22.7
FIM® Total at Discharge (Mean, SD)	90.0	22.2
Length of Stay in Acute Care (Median, IQR)	18	10–28
Length of Stay in Rehabilitation (Median, IQR)	18	11–30
Days in Posttraumatic Amnesia (Median, IQR)	22	9–41

SD = Standard deviation, IQR = Interquartile range