

Mini-abstract

The study used quasi-experimental regression discontinuity models to assess for changes in uninsured rates among trauma patients at age 64 versus 65y and associated changes in rehabilitation. The results reveal the magnitude of gains in rehabilitation associated with changes in insurance coverage, enabling an additional 1-in-10 patients to access rehabilitative care.

Abstract

Objectives: To assess for changes in uninsured rates among trauma patients at age 64 versus 65y and whether there are associated changes in post-discharge rehabilitation; determine whether changes are driven by rehabilitation provided at home, skilled-nursing facilities (SNFs), or acute inpatient facilities; and determine whether changes vary among stratified subgroups of trauma-related ‘best-practice’ factors

Summary background data: Rehabilitation is an important component of high-quality trauma systems with access heavily influenced by insurance status. In the wake of policy changes affecting insurance coverage, it remains unknown the extent to which insurance changes associate with variations in rehabilitation access/use among otherwise similar patients.

Methods: Regression discontinuity models were used to assess for changes in insurance status and rehabilitation at age 64 versus 65y among adults aged 54-75y (± 10 y age-related Medicare eligibility). Data were extracted from the 2007-2012 National Trauma Data Bank.

Results: A total of 305,198 patients were included; 40.1% were discharged to rehabilitation. Medicare eligibility associated with an abrupt 6.4 (95%CI:5.8-7.0) percentage-point decline in uninsured and a 9.6 (95%CI:6.5-12.6) percentage-point increase in rehabilitation at age 64 versus 65y, enabling an additional 1-in-10 patients to access rehabilitation. Differences were driven by SNF use and were greatest among patients with less-severe clinical presentations. Restriction based on Medicare-payment eligibility to patients with LOS ≥ 3 days (SNF requirement) and ≥ 1 ‘presumptive diagnosis codes’ (inpatient facilities’ 60 percent rule) demonstrated abrupt gains in both SNF and inpatient care.

Conclusions: The results reveal the magnitude of changes in access to rehabilitation associated with changes in insurance coverage at age 65y. Use of quasi-experimental models enabled meaningful consideration of health-policy change.

Key words: Medicare; insurance; rehabilitation; skilled nursing facility; inpatient rehabilitation facility; regression discontinuity; trauma.

The Association Between Medicare Eligibility and Gains in Access to Rehabilitative Care: A National Regression Discontinuity Assessment of Patients Aged 64 versus 65 Years

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Introduction

In the United States (US), traumatic injuries account for nearly one-third of all life-years lost.(1) As the third highest cause of death and the leading cause of death for adults aged 18-46y, trauma accounts for >192,000 deaths, 2.3 million hospital admissions, and 41 million Emergency Department (ED) visits each year.(1) Among patients who survive, the long-term consequences can be devastating. Access to rehabilitation after acute traumatic injury is considered an essential component of high-quality trauma care.(2,3) Recommended by national and international organizations for the management of older adult patients, including the Eastern Association for the Surgery of Trauma(2) and World Health Organization,(3) rehabilitation following hospital discharge is associated with both improved functional outcomes and health-related quality-of-life reported by patients.(4–6)

Nevertheless, despite widespread recognition of the benefits of appropriate post-discharge care, access to this important component of trauma systems may not be available to all patients.(6,7) Studies have demonstrated an association between rehabilitation and patients' primary insurance payer.(8,9) As a driving component of disparities in healthcare access among trauma(10) and surgical(11,12) patients, variations in patients' ability to afford and, thereby, utilize rehabilitation are thought to have a direct effect on long-term outcomes following inpatient care.(6,7,13) Efforts to promote enhanced insurance coverage, such as establishment of public insurance programs through the Centers for Medicare & Medicaid Services (CMS), are intended to improve access to care, yet despite documented gains in insurance coverage, the success of these programs in promoting use of high-quality care, including the use of appropriate rehabilitation following acute traumatic injury, has not been extensively explored. Little is

known about the degree to which insurance changes affect rehabilitation access and use among otherwise similar patients.

Introduction of quasi-experimental models: Regression discontinuity

A set of quasi-experimental techniques developed in educational psychology and economics offer a novel means by which to determine whether changes in access to insurance associate with variations in post-discharge rehabilitation.(14–16) Designed to mimic the results of randomized, controlled trials, regression discontinuity (RD) models enable pragmatic assessment of how changes in insurance affect patients' post-discharge rehabilitation use based on an established insurance mechanism measured along a continuum of age with eligibility determined by a set threshold of age. They remain underutilized in epidemiologic and clinical literature and have largely not been considered among surgical patients.(14–16) RD uses 'regression' modeling with local higher-order (n^x) polynomials to fit a (curving) line to data on either side of a cut-point (*e.g.* to compare the percentage of patients discharged to rehabilitation at age 64 versus 65y) and determine whether there is an abrupt change—'discontinuity'—in use beyond that expected for an additional year of age, among patients of similar age.

What it means for surgical patients and health insurance coverage

In order to use these techniques to ascertain the extent to which changes in insurance policy affect rehabilitation use among trauma patients, the study considered three populations. First, it examined changes among adults overall (regardless of insurance status) within 10 age-years of universal Medicare eligibility due to age (54-75y). As beneficiaries of an established health insurance model, Medicare-sponsored patients reflect long-standing policy at work within the US population. Patients of this age are also among the most likely to suffer traumatic injuries expected to benefit from rehabilitative care.(17,18) The second population consisted of similarly-

aged patients with a minimum length of stay (LOS) ≥ 3 days—a requirement for Medicare coverage of skilled-nursing facility (SNF) care.(19) The final population consisted of trauma patients aged 54-75y with ≥ 1 of 1,390 different ‘presumptive diagnosis codes’ defined by Medicare as a requirement for financial support of patients managed in inpatient rehabilitation facilities (Supplemental Table 1).(20) As of 2006, eligible facilities are required to support a case-mix comprising $\geq 60\%$ of patients with these diagnoses—‘60 percent rule’.(20)

The objectives of the study were to: (1) assess for systematic changes in uninsured rates among trauma patients at age 64 versus 65y and ascertain whether there are associated changes in post-discharge rehabilitation; (2) determine whether changes are driven by rehabilitation provided at home, SNFs, or acute inpatient facilities; and (3) determine whether changes vary among stratified subgroups of trauma-related ‘best-practice’ factors.(21)

Methods

Data source and study population

Six years of data (2007-2012) from the American College of Surgeons’ (ACS) National Trauma Data Bank (NTDB) were queried for patients with primary diagnoses of trauma (ICD-9-CM:800-959). NTDB is the largest trauma registry in the world with clinical information collected in accordance with the US National Trauma Data Standard.(22) It contains information from >900 Level I-IV (and non-trauma) trauma centers throughout the US.

Patients with primary diagnoses of superficial injuries (910-924.9), foreign-body injuries (930-939.9), and late effects of injury (905-909.9) were excluded,(22) as were patients missing information on insurance or post-discharge rehabilitation. In order to focus on a group of patients managed by major trauma centers who could, theoretically, be discharged to rehabilitation and account for potential biases inherent to the voluntary nature of centers’ inclusion in NTDB,

patients were required to have a LOS ≥ 1 day, survive their inpatient ED/hospital stay, present to a Level I or II ACS-verified trauma center with an annual trauma volume ≥ 500 cases, and fall within the age criteria of the study's populations. A schematic of inclusion/exclusion criteria is presented in Figure 1.

NTDB 'best practice' demographic and clinical factors

Included demographic and clinical characteristics were chosen based on previous work, which identified a series of mortality-related 'best practice' factors that are important to consider when studying trauma outcomes in large databases.(21) The study was conducted in and designed for use with NTDB.(21) In addition to age and primary insurance status (categorized as Medicare, uninsured, private, other public [non-Medicare], other), extracted characteristics included: gender, race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, non-Hispanic other), ACS trauma-center level, mechanism of injury (stab, fall, gunshot, motor vehicle collision, pedestrian, struck, other), means of hospital transport (ground ambulance, helicopter ambulance, fixed-wing ambulance, walk-in/private vehicle, police escort, other), Glasgow Coma Scale (1-3, 4-5, 6-8, 9-12, 13-15), Injury Severity Score (1-8, 9-15, 16-24, 25-75), severe head injury (AIS >3), ventilator dependency, ICU use, presence of hypotension on admission (SBP <90 mmHg), median pulse, and median respiratory rate.

Statistical analysis

Differences in demographic and clinical factors were compared between patients discharged to rehabilitation and those discharged without rehabilitation using descriptive statistics: Chi-squared tests for binary/categorical variables and Kruskal-Wallis tests for non-normally distributed continuous variables.

Quasi-experimental RD techniques were employed to assess absolute and relative changes in patients' primary insurance coverage; probability of discharge to rehabilitation; and probability of discharge to specific types of rehabilitation—home care, SNFs, acute inpatient facilities—at ages 64 versus 65y. A 'sharp' RD design (which assumes a treatment effect of zero prior to threshold, *i.e.* that policy eligibility does not have an effect prior to age 65y) was used to assess changes in insurance status. For rehabilitation access, a 'fuzzy' RD design was employed. This technique accounts for some patients being Medicare eligible prior to age 65y for non-age-related reasons. In order to provide an estimate of gains in rehabilitation among patients not covered by Medicare prior to age 65y or, alternatively, an estimate of gains that would have been observed within the entire population had some patients not already been eligible, fuzzy RD divides changes in rehabilitation by underlying changes in Medicare coverage, as depicted in Figure 2. Analogous assessment was conducted stratifying by 'best practice' factors and restricting inclusion, in an *a priori* sensitivity analysis, to patients aged 60-69y.

Statistical analyses were conducted using Stata Statistical Software: Release 14.0 (College Station, TX). Two-sided p-values <0.05 were considered significant. The Partners Human Research Ethics Committee, the Institutional Review Board of Brigham & Women's Hospital and Massachusetts General Hospital, approved the study.

Results

Study population and rehabilitation use throughout the lifespan

A total of 305,198 trauma patients aged 54-75y (± 10 y of Medicare eligibility due to age) were included in the RD analyses (Figure 1). Prior to age-based exclusion, 1,464,713 patients met criteria. Differences in their probability of being discharged to rehabilitation from ages 0-100y are presented in Figure 3. Use of post-discharge rehabilitation increased non-linearly

throughout patients' life-course, spiking around ages 16-21y before increasing slowly from ages 22-48y. Usage began to increase more rapidly from ages 50-90y, plateauing around 83% for patients aged 90-100y. These changes—corresponding to a sigmoidal distribution from ages 22-100y—speak to a complex relationship between rehabilitation utilization and age that is likely to be due, at least in part, to increased SNF use among patients of more advanced age.

Differences in rehabilitation at age 64 versus 65y

Among patients aged 54-75y, 40.1% ($n=122,492$) were discharged to rehabilitation. These patients were more likely to be older (median age 65 versus 61y; $p<0.001$) and sponsored by Medicare (47.8 versus 28.4%). They were less likely to be uninsured (4.0 versus 11.7%; $p<0.001$). Differences in best-practice factors are shown in Supplemental Table 2.

RD results comparing differences in access to rehabilitation and insurance coverage among trauma patients before and after age 65y are presented in Table 1. Beyond the change in insurance anticipated by an additional year of age (64 versus 65y), the results demonstrate an abrupt absolute jump in Medicare coverage of +38.1 (95%CI: 37.0-39.2) percentage-points and a corresponding abrupt absolute decline in the proportion of uninsured by -6.4 (95%CI: 5.8-6.7) percentage-points. These 1y-age differences correspond to relative changes in insurance status of +194.9 and -65.3%, respectively. Significant changes in rehabilitation were also detected. As shown in Figure 2, between ages 64-65y, there was an abrupt overall absolute increase (beyond that expected for an additional year of age) in rehabilitation use of +3.6 percentage-points. After accounting for the underlying change in Medicare coverage that began for some patients prior to age 65y (Figure 2), the resultant change in rehabilitation use increased by an absolute 'discontinuity' of +9.6 (95%CI: 6.5-12.6) percentage-points as a result of the Medicare program as a whole. Corresponding to a relative 23.4% increase in the percentage of patients discharged

to rehabilitative care, an absolute jump of 10 percentage-points means that for every 10 trauma patients sponsored by Medicare, an additional patient is able to access this ‘essential component’ of high-quality care.(2,3)

Differences in rehabilitation were primarily driven by changes in SNF use (+6.2; 95%CI: 4.0-8.4 percentage-points) and were consistent when considered in a sensitivity analysis restricted to patients within ± 5 y of age 65y (Table 2). Stratification by best-practice factors (Table 3) revealed that, while reductions in uninsured and gains in rehabilitation were significant across the board, the greatest increases in rehabilitation occurred among ‘marginal patients’ with less-severe clinical presentations. For example, while patients with ISS>15 jumped in usage by a relative 24.0%, patients with ISS<9 increased by 48.9%. Differences in ED arrival (walk-in/private vehicle: 55.2 versus ground ambulance: 20.2%), ventilator dependency (no: 30.0 versus yes: 14.2%), and ICU use (no: 28.2 versus yes: 19.8%) exhibited similar patterns.

Restriction to patients with LOS ≥ 3 days (SNF eligibility)

Among patients with LOS ≥ 3 days, 50.6% ($n=115,083$) were discharged to rehabilitation (Supplemental Table 3). They were less likely to be uninsured (25.2 versus 74.7%; $p<0.001$) and were, correspondingly, more likely to be sponsored by Medicare (62.9 versus 37.2%) They were also more likely to be older ($p<0.001$). When considered using RD to look for abrupt changes in insurance and rehabilitation (Table 4), significant differences were found. The percentage of uninsured trauma patients decreased (-5.8; 95%CI: 5.2-6.5 percentage-points), while the percentage of Medicare-sponsored patients increased (+37.3; 95%CI: 36.1-38.6 percentage-points), beyond expectations for changes anticipated over the same age-year. Consistent with expectations for increased Medicare eligibility for SNF care, changes in rehabilitation (+10.2; 95%CI: 6.5-13.9 percentage-points) were again driven by abrupt gains in SNF use (+12.2; 8.2-

16.2 percentage-points) larger than those observed for the overall population. Among patients with LOS 1-2 days (Supplemental Table 4), significant gains were observed in the use of home care.

Restriction to patients with ≥ 1 presumptive diagnosis codes (inpatient facilities' 60 percent rule)

Slightly more than half, 51.9% ($n=63,235$), of patients with ≥ 1 presumptive diagnosis codes were discharged to rehabilitation (Supplemental Table 3). As with the other study populations, they were more likely to be older and were less likely to be uninsured ($p<0.001$). RD analyses presented in Table 4 demonstrated consistent abrupt changes in insurance status corresponding to an overall abrupt increase in access to post-discharge rehabilitation of +8.2 (95%CI: 3.1-13.2) percentage-points. Discontinuity differences in SNF use were significant (+7.3; 95%CI: 1.9-12.7 percentage-points) as were gains in access to acute inpatient facilities (+4.4; 95%CI: 0.3-8.8 percentage-points).

Discussion

This study of changes in access to post-discharge rehabilitation following acute traumatic injury associated with changes in insurance at age 65y demonstrated significant increases in rehabilitation use among patients sponsored by Medicare. Relative to otherwise similar patients aged 64y, surviving trauma patients aged 65y were more than 10 percent more likely to access rehabilitative care. The magnitude of this abrupt change among physiologically comparable patients within 1y of age, save differences in insurance status, underscores the need for clinicians to carefully consider how access to care influences the outcomes that patients experience.(10–12)

In the era of the Patient Protection and Affordable Care Act, signed into law on March 23, 2010, discussions about healthcare reform and related insurance changes have risen to prominence in the US. The conversation is not new. Debate surrounding methods of healthcare

provision and payment have long been a part of the national discourse with publically-sponsored civilian programs dating as far back as July 30, 1965, when President Lyndon B. Johnson signed into law a bill that led to the establishment of the CMS Medicare (and Medicaid) programs. Despite their tumultuous political history, the clinical impact of such programs remains poorly understood, particularly among surgical patients.

Compared to trauma patients aged 54-75y who, overall, demonstrated a significant 23.4% relative increase (absolute +10.2 percentage-points) in access to post-discharge rehabilitation on becoming eligible for an established insurance plan, restriction to Medicare SNF eligibility (LOS ≥ 3 days) and inpatient facilities' 60 percent rule (≥ 1 presumptive diagnosis codes) revealed similar trends with significant abrupt relative gains of 20.1 and 15.8%, respectively. Prior work has shown that post-discharge rehabilitation is an important component of trauma care(2,3) and that access to such care strongly associates with variations in insurance.(9) Our work also demonstrated significant associations, revealing that variations in patients' primary payer were associated with their probability of discharge to rehabilitation ($p < 0.001$; Supplemental Tables 2-3). The magnitude of such gains for newly eligible patients, further demonstrated in this study, reveals a striking contrast in the care that patients within 1 age-year (64 versus 65y) can expect to receive.

Gains in post-discharge rehabilitation use among trauma patients (beyond those otherwise anticipated due to an additional year of age) were principally driven by increases in SNF use—a service that Medicare covers(19,23,24)—among a population expected to require some form of post-discharge care (higher prevalence of severe injuries related to falls such as TBI and hip fracture).(17,18) Smaller abrupt increases in the use of home care and inpatient facilities did not reach significance overall but did emerge when restricted to subsets of the trauma population

expected *or able* to benefit from the respective modalities of care: home care – patients with LOS 1-2 days and inpatient facilities – restriction to Medicare eligibility based on the 60 percent rule. While rehabilitation has been demonstrated to be important in improving functional outcomes after trauma, the literature offers conflicting data on the benefits of SNF use.(25,26) There are differences in the types of physical and occupational therapy offered by SNFs relative to inpatient facilities.(27) Further studies are needed to determine the comparative quality of rehabilitative care that Medicare patients receive and, given their increased use of SNFs, to ensure that gains in rehabilitation as a result of increased insurance coverage are not being offset by the provision of inappropriate or low-quality care.

Stratification by trauma-related ‘best practice’ factors(21) revealed significant increases in rehabilitation among the majority of older patients. Groups with the largest abrupt gains were those with the least severe presentations, including ED walk-ins/private vehicle, injuries with ISS<9, and patients with non-severe head injuries. Part of this larger relative (and absolute) increase can be explained by lower baseline levels of rehabilitation use among less-severely injured patients prior to age 65y. For example, among patients with severe head injuries, 47.8% were discharged to rehabilitation at age 64y compared to 38.8% among patients with non-severe head injuries. Use of rehabilitation increased significantly among patients without severe head injuries, while remaining statistically unchanged in patients with more severe presentations. Such a finding is consistent with a ceiling-effect wherein patients who unequivocally need post-discharge care may be more likely to receive it, regardless of insurance status, than ‘marginal patients’ for whom clinical decision-making and payment considerations could tip the decision either way. Whether opting out or being denied access for such injuries prior to age 65y, the results reveal that increased insurance coverage allowed an additional 1-in-10 trauma patients to

utilize recommended post-discharge care. Given the variable nature of trauma cases, clinical discernment remains essential to determine the appropriateness of and need for various modalities of rehabilitation. Among less severely-injured patients, abrupt jumps in post-discharge rehabilitation use could reflect some amount of inappropriate use or overuse in certain cases. However, when viewed on the aggregate, as quasi-experimental population-based models are intended to be,(14–16) the results provide compelling evidence of gains in access to this ‘essential component’ of high-quality care.(2,3) On a national scale, changes in access to rehabilitation at age 65y were associated with increased insurance coverage as a result of Medicare, allowing identified groups of ‘marginal patients’ to benefit from post-discharge services that may otherwise have been unavailable to optimize their recovery.

The study is not without limitations, the majority of which stem from its reliance on a retrospective database of trauma patients where limitations of available variables, missing/miscoded data, and the voluntary nature of centers’ inclusion can be of concern. Use of the NTDB as the largest trauma registry in the world inclusive of clinical information collected in accordance with the US National Trauma Data Standard(22) helps to allay many of them. In order to address the issue of the voluntary nature of centers’ inclusion and the tendency for the database to be more representative of larger trauma centers, we limited our assessment to ACS-verified Level I and II trauma centers with an annual trauma volume ≥ 500 cases, which are likely to report cases consistently and submit high-quality data. Clinical information included in the study was collected prospectively by trained reviewers using complete patient records.(22) The study lacked information on the quality of post-discharge care and on functional and post-discharge outcomes. While prior studies have shown that improved longer-term outcomes are associated with post-discharge care,(17,18) additional work is warranted to understand the

experiences of Medicare patients discharged to rehabilitation and, in particular, SNF care. How the results may differ among other medical and surgical subpopulations as well as among other groups of newly insured, such as patients with Medicaid or employer-sponsored/purchased private insurance plans, also need to be studied, as do rehabilitation use's potential implications on readmissions among injured patients.

As the US continues to experience health-reform-related changes and ongoing efforts to increase and modify insurance coverage in the coming years, it will be important to consider the clinical implications of health-policy change. Trauma represents a leading cause of death and disability, the outcomes of which, literature and management guidelines suggest, can be greatly enhanced by access to appropriate post-discharge care. Our results reveal the magnitude of changes in access to post-discharge rehabilitation associated with changes in insurance coverage at age 64 versus 65y. Among trauma patients, where Medicare eligibility was found to have an effect, use of quasi-experimental models enabled meaningful consideration of health-policy change. In the wake of ongoing debate surrounding such change, clinical vigilance and continued evidence-based assessment of implications on outcomes for patients across surgical disciplines are necessary to understand the true meaning of insurance coverage.

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Table 1. Regression discontinuity results comparing differences in access to rehabilitation and insurance coverage among trauma patients before and after age 65y

Change in access to rehabilitation among trauma patients aged 54-75y (10y on either side)				
	Percent Discharged to Rehabilitation at 64y	Relative Change in Percent Discharged to Rehabilitation	Absolute Change in Percent Discharged to Rehabilitation (95%CI)	
Any form of rehabilitation	40.89%	23.40%	9.57%	6.50-12.64% **
Restricted to specific types of rehabilitation				
Home Care	7.31%	--	1.00%	-0.65 to 2.64%
Skilled Nursing Facility	13.87%	44.56%	6.18%	3.96-8.40% **
Inpatient Facility	5.06%	--	3.19%	-1.06 to 1.69%
Rehabilitation (<i>type other or unspecified</i>)	13.76%	15.12%	2.08%	0.01-4.26% *
Change in primary insurance coverage				
	Percent by Insurance Type at 64y	Relative Change in Insurance Type Coverage	Absolute Change in Insurance Type Coverage (95%CI)	
Medicare	19.55%	194.94%	38.11%	37.02-39.18% **
Uninsured	9.78%	-65.34%	-6.39%	-5.81-6.97% **
Privately-Insured	44.84%	-15.41%	-6.91%	-6.25-7.55% **

*Denotes a two-sided p-value<0.05 **Denotes a two-sided p-value<0.001
The results show (absolute and relative) changes in the percent of trauma patients discharged to rehabilitation and with various primary insurance payers immediately before and after age 65y. Results for insurance coverage were calculated using a sharp regression discontinuity (RD) design. Results for rehabilitation were calculated using a fuzzy RD design to account for trauma patients with Medicare coverage for non-age-related reasons prior to age 65y (Social Security Disability Insurance >24 months, End-Stage Renal Disease, Amyotrophic Lateral Sclerosis, disabled railroad worker status).

Table 2. Sensitivity analysis (restricting the population to ± 5 y of age 65y): regression discontinuity results comparing differences in access to rehabilitation among trauma patients before and after age 65y

Sensitivity Analysis: Change in access to rehabilitation among trauma patients aged 60-69y (5y on either side)				
	Percent Discharged to Rehabilitation at 64y	Relative Change in Percent Discharged to Rehabilitation	Absolute Change in Percent Discharged to Rehabilitation (95%CI)	
Any form of rehabilitation	40.89%	23.26%	9.51%	6.41-12.59% **
Restricted to specific types of rehabilitation				
Home Care	7.31%	--	1.04%	-0.62 to 2.69%
Skilled Nursing Facility	13.87%	43.33%	6.01%	3.76-8.24% **
Inpatient Facility	5.06%	--	0.29%	-1.10 to 1.67%
Rehabilitation (<i>type other or unspecified</i>)	13.76%	15.77%	2.17%	0.00-4.37% *

*Denotes a two-sided p-value<0.05 **Denotes a two-sided p-value<0.001
The results show (absolute and relative) changes in the percent of trauma patients discharged to rehabilitation immediately before and after age 65y. Results for rehabilitation were calculated using a fuzzy RD design to account for trauma patients with Medicare coverage for non-age-related reasons prior to age 65y (Social Security Disability Insurance >24 months, End-Stage Renal Disease, Amyotrophic Lateral Sclerosis, disabled railroad worker status).

Table 3. Stratification by National Trauma Data Bank (NTDB) trauma-related ‘best practice’ factors. Regression discontinuity results comparing differences in access to rehabilitation and uninsured rates among trauma patients before and after age 65y

	Percent Uninsured at 64y	Relative Change in Uninsured Rate	Absolute Change in Uninsured Rate (95%CI)		Percent Discharged to Rehabilitation at 64y	Relative Change in Percent Discharged to Rehabilitation	Absolute Change in Percent Discharged to Rehabilitation (95%CI)	
Injury Severity Score (ISS)								
1-8	10.43%	-67.50%	-7.04%	-6.10-7.97% **	25.85%	48.86%	12.63%	8.26-16.99% **
9-15	9.36%	-63.03%	-5.90%	-4.06-6.83% **	46.40%	14.66%	6.80%	1.80-11.80% **
16-24	9.65%	-65.70%	-6.34%	-4.82-7.87% **	48.02%	23.99%	11.52%	3.23-19.80% **
≥25	8.33%	-63.87%	-5.32%	-3.18-7.46% **	71.60%	--	5.14%	-16.85 to 27.14%
Gender								
Female	8.63%	-68.83%	-5.94%	-5.11-6.78% **	44.84%	25.96%	11.64%	6.85-16.43% **
Male	10.58%	-63.14%	-6.68%	-5.88-7.48% **	36.51%	21.91%	8.00%	3.97-12.03% **
Race/Ethnicity								
Non-Hispanic White	8.21%	-69.18%	-5.68%	-5.08-6.28% **	41.25%	20.12%	8.30%	4.89-11.70% **
Non-Hispanic Black	14.21%	-64.11%	-9.11%	-6.68-11.54% **	37.80%	--	19.51%	-0.86 to 39.91%
Hispanic	20.73%	-58.27%	-12.08%	-5.74-18.42% **	28.45%	59.72%	16.99%	3.48-30.50% *
ACS trauma center level								
Level I	10.59%	-62.61%	-6.63%	-5.85-7.41% **	39.50%	23.54%	9.30%	5.37-13.23% **
Level II	8.49%	-70.44%	-5.98%	-5.12-6.84% **	40.83%	23.95%	9.78%	4.77-14.79% **
Mechanism of injury								
Stab	15.08%	-77.79%	-11.73%	-1.72-21.74% *	17.13%	--	12.33%	-20.96 to 45.63%
Fall	8.44%	-71.68%	-6.05%	-5.33-6.77% **	44.80%	19.89%	8.91%	5.05-12.76% **
Gunshot wound	22.30%	-85.29%	-19.02%	-3.44-34.59% *	35.37%	--	19.41%	-25.25 to 64.08%
Motor vehicle collision	10.81%	-56.52%	-6.11%	-4.86-7.35% **	39.24%	35.07%	13.76%	5.37-22.15% **
Pedestrian	5.30%	-57.55%	-3.05%	-0.03-6.07% *	32.09%	--	-25.00%	-62.04 to 12.02%
Struck	15.61%	-54.26%	-8.47%	-0.87-16.06% *	21.69%	--	10.23%	-11.45 to 31.90%
Transport to the hospital								
Ground ambulance	9.36%	-65.17%	-6.10%	-5.41-6.78% **	42.62%	20.20%	8.61%	4.79-12.41% **
Helicopter ambulance	9.54%	-61.95%	-5.91%	-4.15-7.66% **	46.33%	--	6.07%	-5.95 to 18.09%

Walk-in/Private vehicle	10.32%	-67.54%	-6.97%	-5.37-8.58% **	22.84%	55.21%	12.61%	5.91-19.31% **
Severe head injury (AIS>3)								
No	10.05%	-62.09%	-6.24%	-5.61-6.88% **	38.83%	25.80%	10.02%	6.63-13.39% **
Yes	9.73%	-76.16%	-7.41%	-5.86-8.96% **	47.79%	--	7.67%	-0.27 to 15.62%
Ventilator use								
No	9.27%	-64.19%	-5.95%	-5.30-6.60% **	36.07%	29.97%	10.81%	7.46-14.17% **
Yes	10.43%	-70.66%	-7.37%	-5.51-9.23% **	73.12%	14.22%	10.40%	7.59-20.05% *
Intensive Care Unit use								
No	9.58%	-65.87%	-6.31%	-5.57-7.04% **	34.48%	28.19%	9.72%	5.96-13.48% **
Yes	9.76%	-66.50%	-6.49%	-5.45-7.53% **	52.56%	19.81%	10.41%	4.75-16.07% **

*Denotes a two-sided p-value<0.05 **Denotes a two-sided p-value<0.001

The results show (absolute and relative) changes in the percent of patients discharged to rehabilitation and the percent of patients who were uninsured immediately before and after age 65y. Results for insurance coverage were calculated using a sharp regression discontinuity (RD) design. Results for rehabilitation were calculated using a fuzzy RD design to account for trauma patients with Medicare coverage for non-age-related reasons prior to age 65y (Social Security Disability Insurance >24 months, End-Stage Renal Disease, Amyotrophic Lateral Sclerosis, disabled railroad worker status).

Table 4. Regression discontinuity results comparing differences in access to rehabilitation and insurance coverage among trauma patients with a length of stay ≥ 3 days ($n=227,637$) and with ≥ 1 presumptive diagnosis codes for inpatient rehabilitation ($n=121,762$) before and after age 65y

Change in access to rehabilitation among trauma patients aged 54-75y with LOS ≥ 3 days				
	Percent Discharged to Rehabilitation at 64y	Relative Change in Percent Discharged to Rehabilitation	Absolute Change in Percent Discharged to Rehabilitation (95%CI)	
Any form of rehabilitation	50.81%	20.11%	10.22%	6.53-13.91% **
Restricted to specific types of rehabilitation				
Home Care	8.98%	--	3.05%	-0.37 to 6.47%
Skilled Nursing Facility	18.07%	67.29%	12.16%	8.15-16.16% **
Inpatient Facility	5.73%	--	2.64%	-0.43 to 5.73%
Rehabilitation (<i>type other or unspecified</i>)	18.04%	34.81%	6.28%	2.43-10.14% *
Change in primary insurance coverage				
	Percent by Insurance Type at 64y	Relative Change in Insurance Type Coverage	Absolute Change in Insurance Type Coverage (95%CI)	
Medicare	21.11%	176.84%	37.33%	36.07-38.58% **
Uninsured	8.96%	-65.18%	-5.84%	-5.19-6.50% **
Privately-Insured	43.46%	-47.91%	-20.82%	-19.55-22.09% **
Change in access to rehabilitation among trauma patients aged 54-75y with ≥ 1 presumptive diagnosis codes				
	Percent Discharged to Rehabilitation at 64y	Relative Change in Percent Discharged to Rehabilitation	Absolute Change in Percent Discharged to Rehabilitation (95%CI)	
Any form of rehabilitation	51.52%	15.80%	8.14%	3.11-13.16% *
Restricted to specific types of rehabilitation				
Home Care	7.69%	--	2.64%	-1.85 to 7.14%
Skilled Nursing Facility	17.23%	42.37%	7.30%	1.86-12.73% *
Inpatient Facility	6.74%	64.39%	4.34%	0.26-8.81% *
Rehabilitation (<i>type other or unspecified</i>)	19.86%	29.31%	5.82%	0.58-11.06% *
Change in primary insurance coverage				
	Percent by Insurance Type at 64y	Relative Change in Insurance Type Coverage	Absolute Change in Insurance Type Coverage (95%CI)	
Medicare	21.32%	175.52%	37.42%	35.70-39.13% **
Uninsured	9.49%	-61.96%	-5.88%	-4.95-6.80% **

Privately-Insured

43.32%

-47.55%

-20.60%

-18.87-22.32%**

*Denotes a two-sided p-value<0.05 **Denotes a two-sided p-value<0.001

The results show (absolute and relative) changes in the percent of trauma patients discharged to rehabilitation and with various primary insurance payers immediately before and after age 65y. Results for insurance coverage were calculated using a sharp regression discontinuity (RD) design. Results for rehabilitation were calculated using a fuzzy RD design to account for trauma patients with Medicare coverage for non-age-related reasons prior to age 65y (Social Security Disability Insurance >24 months, End-Stage Renal Disease, Amyotrophic Lateral Sclerosis, disabled railroad worker status).

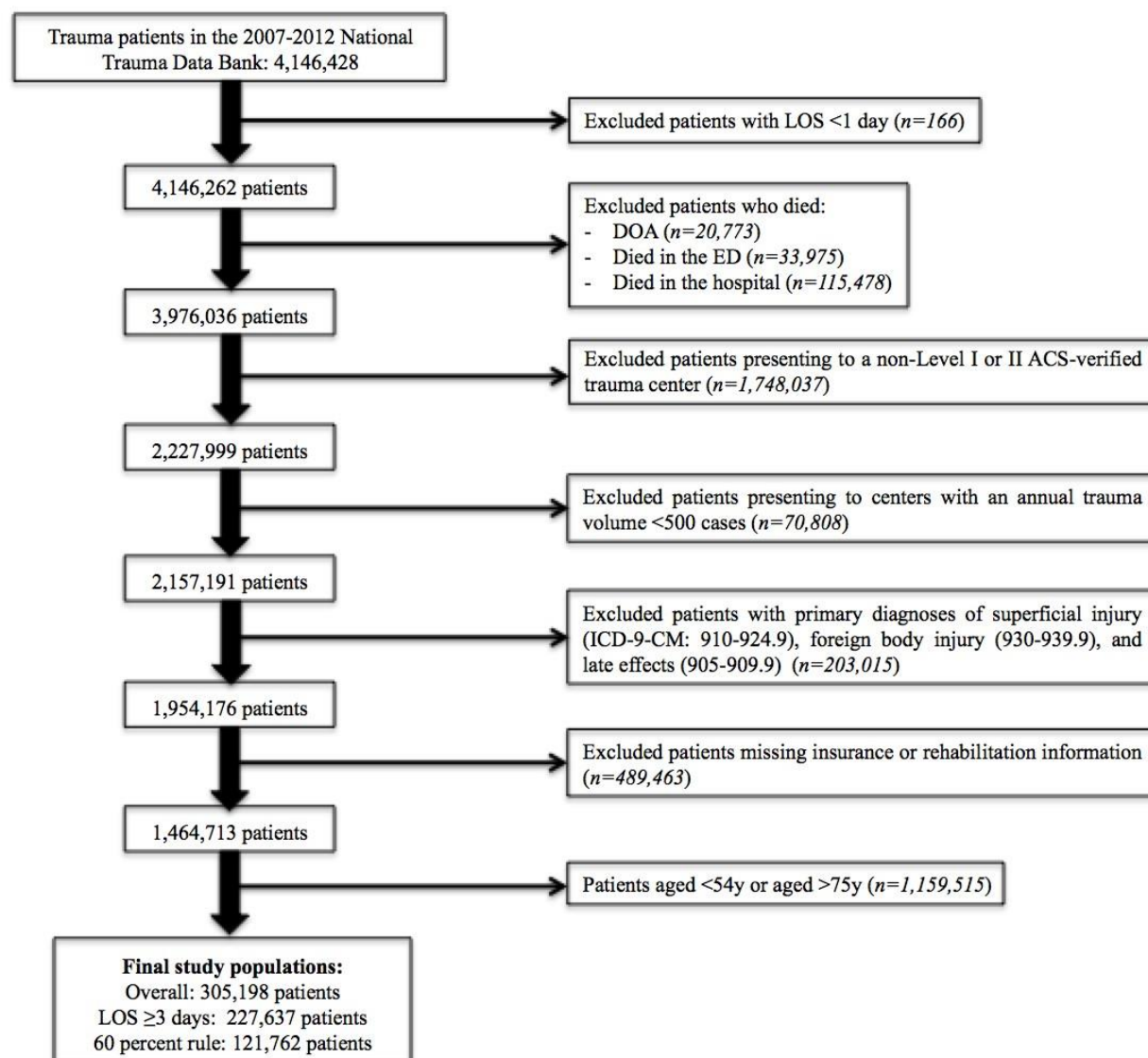


Figure 1. Schematic of inclusion and exclusion criteria

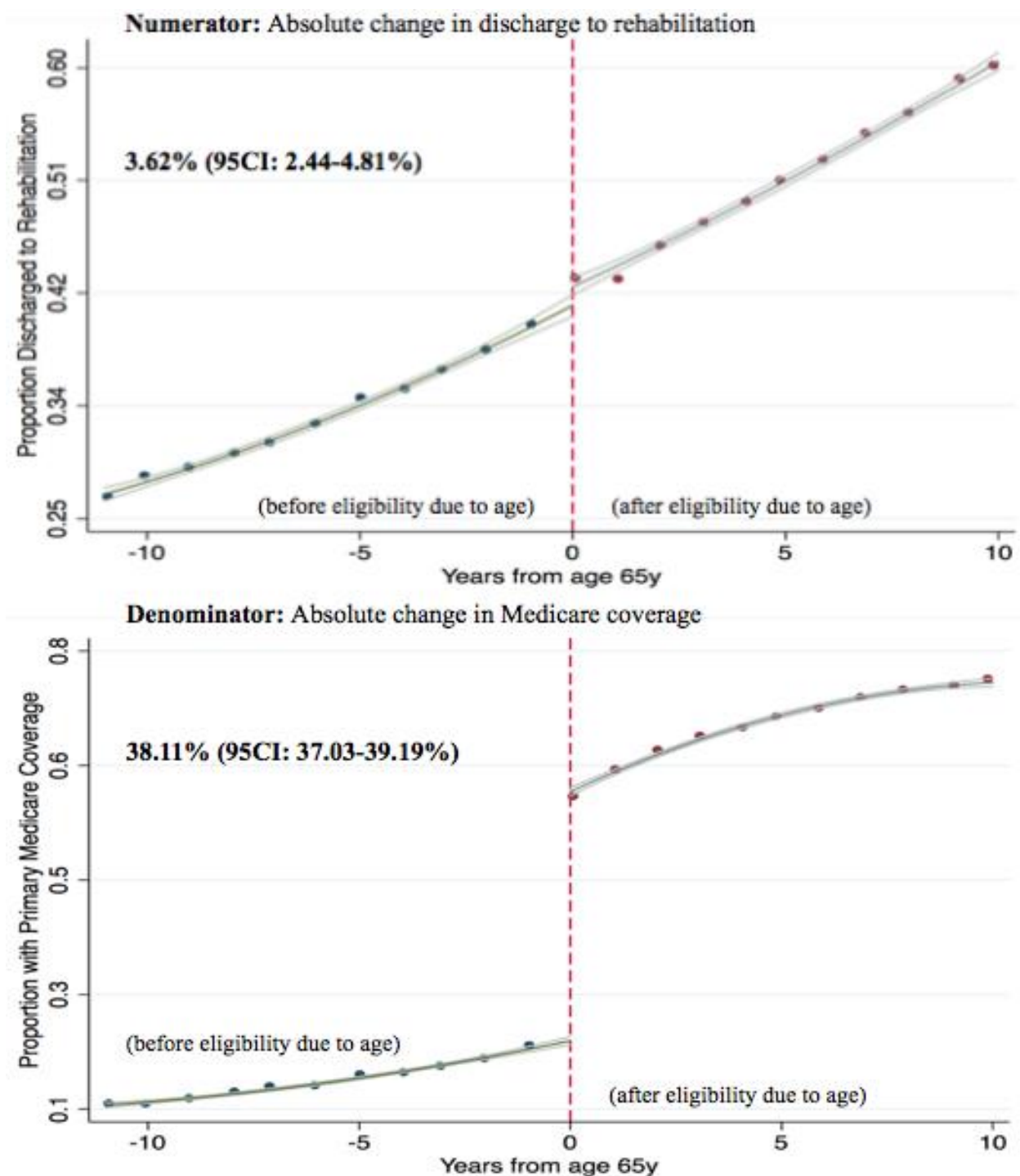


Figure 2. Components of fuzzy regression discontinuity. Grey lines show local polynomials and 95% confidence intervals. **Numerator (a):** gain in discharge to rehabilitation within the entire population (significant jump in anticipated increase of 3.6 percentage-points over 1 age-year, age 64 vs. 65y). **Denominator (b):** gain in primary Medicare coverage (significant jump in anticipated increase of 38.1 percentage-points over 1 age-year, age 64 vs. 65y). **Result is the quotient (0.0362/0.3811) or a 9.5 percentage-point absolute increase** beyond anticipated age-related increases in rehabilitation use as a result of Medicare coverage overall (assuming that no-one had access at a younger age) or, more directly, among trauma patients not already sponsored by Medicare.

Figure 3

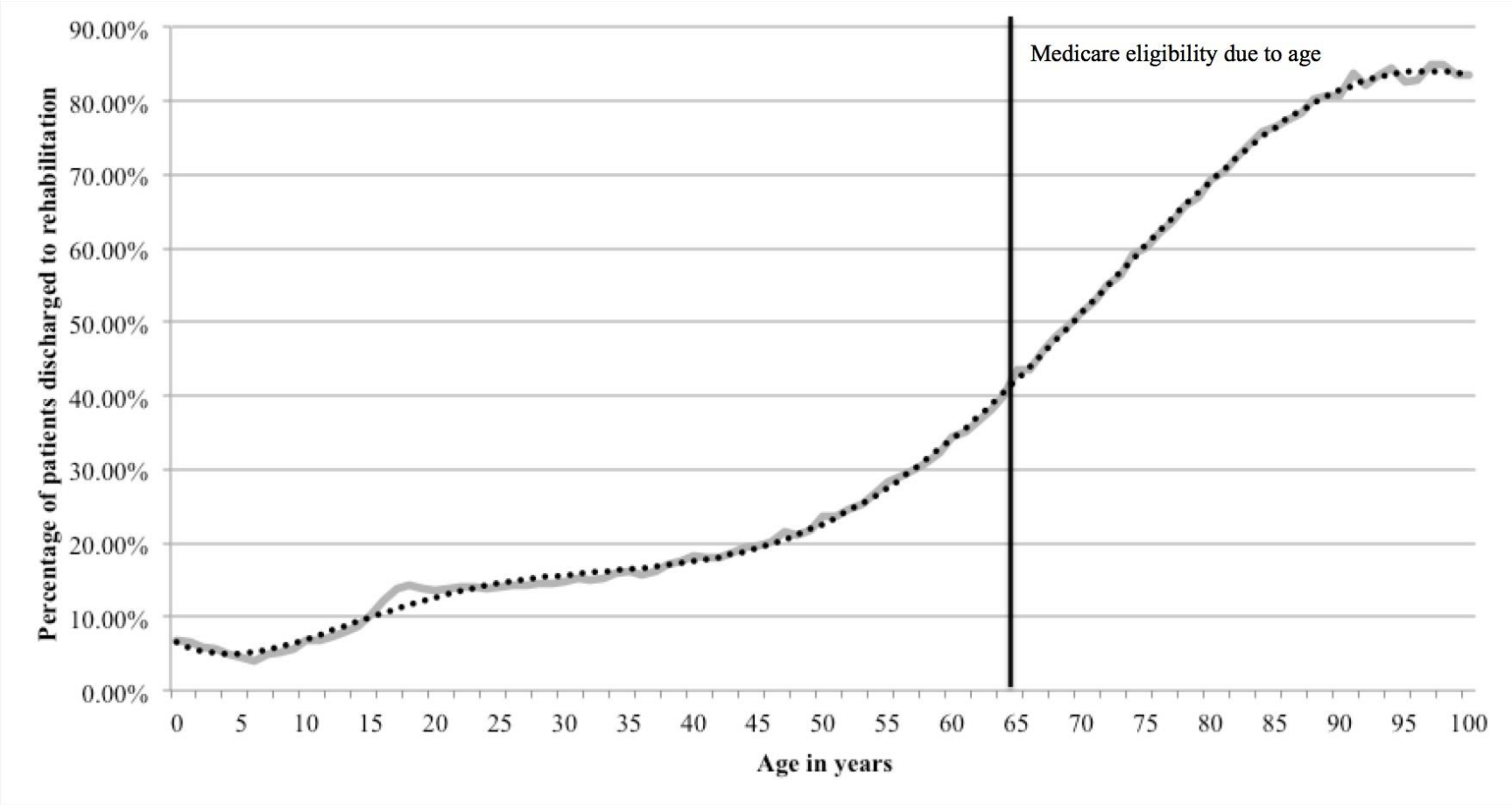


Figure 3. Percentage of trauma patients discharged to rehabilitation by age (0-100y). The grey line shows observed percentages for each age-year; the dotted black line shows the smoothed fit of a higher-order (n^6) polynomial. Universal Medicare eligibility due to age (>64y) was established for all years included, 2007-2012 (black solid line).

