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Association Between Treatment or Usual Care Region and Hospitalization for Fall-Related Traumatic Brain Injury in the Connecticut Collaboration for Fall Prevention

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Abstract

BACKGROUND—Most traumatic brain injuries among older persons in the U.S. are attributed to falls. Efforts to prevent falls may also plausibly reduce the incidence of TBIs and resultant costs.

OBJECTIVES—To evaluate the association between the treatment or usual care region of the Connecticut Collaboration for Fall Prevention (CCFP), a clinical intervention for prevention of falls, and the rate of hospitalization for fall-related traumatic brain injury (FR-TBI) among persons 70 years. The Medicare charges of FR-TBI hospitalizations are also described.

DESIGN—Using a quasi-experimental design, rates of hospitalization for FR-TBI were recorded over an eight year period (2000–2007) in two distinct geographic regions (treatment and usual care) chosen for their similarity in characteristics associated with occurrence of falls.

SETTING/PARTICIPANTS—Over 200,000 persons, 70 years and older, residing in two geographical regions in Connecticut.

INTERVENTION—Clinicians in the treatment region translated research protocols from Yale FICSIT, a successful fall prevention randomized clinical trial, into discipline- and site-specific fall prevention procedures for integration into their clinical practices.

MEASUREMENTS—The rate of hospitalization for fall-related traumatic brain injury among persons 70 years and older

RESULTS—Relative to the usual care region, CCFP's treatment region exhibited lower rates of hospitalization for FR-TBI; RR= 0.84 with 95% credible interval (0.72 – 0.99).

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CONCLUSION—The significantly lower rate of hospitalization for FR-TBI in CCFP's treatment region suggests that the engagement of practicing clinicians in the implementation of evidence-based fall-prevention practices may reduce hospitalizations for FR-TBI.

Keywords

Connecticut Collaboration for Fall Prevention; fall-related traumatic brain injury; hospitalization; Bayesian; spatial model

INTRODUCTION

Relative to other age groups, adults aged 75 years and older have the highest incidence of hospitalization for traumatic brain injury (TBI).^{1,2} Although there is a paucity of information regarding prevention of TBI among older persons,³ it is generally acknowledged that falls are responsible for most TBI among older persons.^{4,5} For this reason fall prevention may offer a viable option for averting some proportion of these expensive and potentially life-altering injuries in the burgeoning geriatric population.

Many randomized controlled trials have demonstrated the efficacy of various fall-prevention efforts among older persons.^{6,7} One of these, the Yale FICSIT trial⁸, reduced falls among older adults by 30% among community dwelling older adults. It was followed by a successful translational fall prevention dissemination and implementation effort, that was carried out in a defined region of CT.⁹

In this article we report the association between the treatment region (TR) or usual care region (UCR) and the rate of hospitalization for fall related traumatic brain injury (FR-TBI) among persons of age 70 years. Secondary objectives were the reporting of related Medicare charges for both study regions and the frequency distribution of the aggregated diagnoses documenting these hospitalizations.

METHODS

Study Design

The Connecticut Collaboration for Fall Prevention (CCFP) used a non-randomized quasi-experimental design to compare the rates of emergency room and hospital services for fall related injury among community-dwelling persons age 70 and older in two geographically distinct regions of CT.¹⁰ Previous CCFP reports detail efforts in the treatment region (TR) to embed evidence-based fall prevention screenings and interventions into clinical practice in emergency departments, home care agencies,¹¹ primary care practices,¹² rehabilitation facilities,¹³ and senior centers.¹⁴ Briefly, workgroups comprised of rehabilitation therapists, nurses, physicians, and pharmacists were tasked with translating research protocols into site- and discipline-specific assessment and intervention protocols and integrating them into their practices.¹⁵ The interventions targeted impairments in balance, gait, transfers, medications, postural hypotension, sensory deficits, and environmental hazards, including unsafe use of footwear or assistive devices.¹⁶

To evaluate the effectiveness of CCFP, the TR was compared with a matched usual care region (UCR). Obtaining individual informed consent was not feasible in this community-based intervention. Therefore zip code tabulation regions (ZCTAs), i.e., bounded regions corresponding to zip codes, were defined to comprise the TR and UCR. Each study region consisted of groupings of ZCTAs based on participating hospital catchment areas. There was no known contamination between the regions, either from formally networked health systems or otherwise, that might have influenced the uptake of the intervention. Selected

aggregate characteristics of the two regions were compared with a chi-square test. These characteristics included proportional makeup by gender, education, race/ethnicity, income, medical resources, and living in an institution. The TR consisted of 58 ZCTAs in the greater Hartford region while the UCR was a discontinuous stretch of 53 ZCTAs along the southern coastline.⁹ As has been described elsewhere,¹⁵ data were collected over eight years; 2 years of pre-intervention, 3 years of intervention, and 3 years of evaluation. The CCFP study was approved by the Human Investigation Committee at the Yale University School of Medicine, and dissemination activities are ongoing.¹⁵ In comparing the outcome rates of the TR relative to the UCR, and temporally referencing the evaluation period to the intervention period, the following adjusted rate ratios (RR) and 95% Bayesian credible intervals were reported: emergency department and hospital admissions for serious fall-related injury RR=0.91 (0.88–0.94) and fall-related injury RR=0.89 (0.86–0.92).⁹

This article documents a secondary analysis of the CCFP data that is restricted to hospitalizations resulting from fall-related traumatic brain injury (FR-TBI) and includes annual Medicare charges for FR-TBI hospitalizations.

Outcome Data

Hospital related outcome data were obtained from the Connecticut Health Information Management (CHIME) database,¹⁷ managed by the Connecticut Hospital Association (CHA),¹⁸ and indexed by E-codes from the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM).¹⁹ CHIME is the most comprehensive hospital database in Connecticut, with over 31 million patient encounters. Outcome data regarding discharge diagnoses and hospital charges were obtained for the 14 acute care hospitals in the TR and UCR. These data were believed to be representative of the state FR-TBI data in that they include both of CT's Level 1 trauma centers and seven of the 13 state trauma centers. Because residential street addresses are confidential, CHIME ensured that hospital data were provided only for residential zip codes corresponding to ZCTAs in the TR and UCR. Hospitalization for fall-related TBI was defined as any assigned a fall-related E-code by CHIME (817, 824, 880–888, or 927) and at least one of the following ICD-9-CM codes specific to TBI (800 – 801, 803–804, 850–854, or 959.01). These ICD-9-CM codes are the same used by members of the Traumatic Brain Injury Surveillance Working Group of the Centers for Disease Control and Prevention (CDC).²⁰

Population Data

The study population consisted of all persons 70 years and older residing within the treatment or usual care geographic regions. Data were obtained from Medicare denominator files²¹ and all charges are reported in U.S. dollars from 2007. The covariate data for each ZCTA are for persons 65 years or older and were obtained from the weighted 2000 U.S. Census Sample Tables,²² in which the closest cutoff to 70 years or older was 65 years or older.

Statistical Analysis

The observed, annual rates of hospitalization for FR-TBI in each study region were plotted across the eight year period. Because the analytical units are bounded areas (ZCTAs) rather than persons, the association between the CCFP intervention and rate of hospitalization for FR-TBI was evaluated with a spatial model. A spatial model adjusts for spatial correlation between neighboring ZCTAs because those adjacent to each other tend to be more similar than those further away. A spatial model is also adjusted for characteristics that are aggregate of the entire ZCTA and which are obtained from U.S. census data. This spatial analysis used a Bayesian Poisson model that included ZCTA-specific random effects for spatial and non-spatial correlation, adjustment for study period (evaluation versus

intervention), an interaction between treatment type and study period, time in years, and covariates. The covariates included ZCTA-based proportional estimates of the following characteristics among residents 65 years of age: nonwhite race, institutional residents, community-residing with disability, income < \$15,000, and income > \$75,000. Finally, the model included the following ZCTA-based adjustments for the important confounders of age and sex: proportion of males 65 years of age and proportion of persons of age 80 years in the population 65 years of age. The evaluation model included two levels of comparison. The first was geographic, i.e., the TR relative to the UCR, whereas the second was temporal, i.e., evaluation period relative to intervention period. We used WinBUGS Version 1.4 and statistical significance was interpreted as a 95% credible interval for a risk ratio that excluded zero.²³ Length of stay and Medicare charges (in 2007 U.S. dollars) were tabulated by year. The ICD-9-CM codes used to define FR-TBI were also aggregated over the 8 years and examined for relative frequency.

RESULTS

The demographic characteristics of the study regions are presented as the mean proportion across the ZCTAs within each study region (Table 1) and are similar for both regions with few exceptions. The proportion of black residents in the UCR is significantly higher whereas the TR has a significantly higher proportion of residents living in institutions, emphasizing the need to adjust for these covariates in the evaluation model.

The observed rates of hospitalization for FR-TBI in each of the study regions over the eight year period, which account for the number of admissions as well as the population at risk, are similar and fairly static in the first five years when the intervention was being developed and implemented (Figure 1). Although rates subsequently rise in both regions during the three year evaluation period, rates in the UCR rise more quickly.

As calculated from the Bayesian Poisson model, the rate ratio (RR) and 95% credible interval for the CCFP treatment region were RR = 0.84 (0.72 – 0.99).

Because our model evaluated only the rate of hospitalization for FR-TBI, it did not incorporate information from the hospital stays in each region. In Table 2 several important characteristics of the hospital stays in each study region are presented for the eight year period. These include median length of stay (LOS) in days, median charges per day and per hospital stay, and total charges from all hospital stays attributed to FR-TBI. All charges were filed to Medicare and are reported in U.S. dollars from 2007. While it is beyond the scope of this brief report to analyze the regional differences of the hospital stays, this table provides broad estimates of the expenditures related to FR-TBI hospitalizations among older persons in CT (Table 2). The UCR consistently exhibits a higher number of admissions, due in part to its larger population. Rows 3 and 4 present a median LOS that is longitudinally stable in both regions with stays in the UCR that are typically one day longer. The median charges per day in the UCR are higher except for FY07 when charges in the TR increased abruptly. The median charge per stay in the UCR is higher, reflecting its longer LOS and typically greater cost per day. Overall charges for all hospital stays attributed to FR-TBI are substantially higher in the UCR than in the TR.

The last results reported describe the frequency distribution of the ICD-9-CM codes aggregated by region over the eight years. For the UCR, the most frequent ICD-9-CM code reported for FR-TBI over the eight years was code 852 (intracranial hemorrhage; subarachnoid, subdural, and extradural) accounting for 45.5% of admissions. Other codes were: 851 (cerebral laceration and contusion); 959.01 (head injury not otherwise specified); 850 (concussion); 801 (fracture of base of skull); and 853 (other and unspecified intracranial

hemorrhage). These codes accounted for 13.2%, 11.5%, 9.2%, 8.5%, and 8.1% respectively, totaling 96% of all FR-TBI codes. Similarly in the TR, code 852 accounted for 44.9% of all FR-TBI codes and the other codes, listed in the same order as for the UCR, accounted for the following percentages: 14.6%, 10.6%, 10.5%, 7.6%, and 8.2%, respectively. As observed above for the UCR, these codes accounted for a total of 96% of all FR-TBI codes in the TR.

DISCUSSION

The significantly lower rate of hospitalization for FR-TBI in CCFP's treatment region suggests that the engagement of practicing clinicians in the implementation of evidence-based fall-prevention practices may reduce hospitalizations for FR-TBI. The rates of hospitalization for FR-TBI were similar in both study regions prior to the evaluation period (Figure 1), at which time rates rose in both regions, with the UCR outpacing the TR. No specific explanation has been uncovered for this temporal change in rates in both regions of Connecticut. However national data indicate that between 2002 and 2006 the rate of hospitalization for FR-TBI rose by 34%.²⁴ Between 2002 and 2006, the number of admissions in our reference group (UCR) rose by 33%, closely reflecting the national trend.

The compelling public health challenge is to identify the driving force behind the rising rate and health care expenditures for hospitalization for FR-TBI among older persons. A recent study from Australia concluded that the increase in national rates of TBI (8% per year over 13 years) was due to an increase in the number of adults living beyond age 85 and a higher rate of falls among this age group.⁵ They further noted that falls among this age group increasingly result in the serious injury of intra-cranial hemorrhage.⁵ To explore the plausibility of this hypothetical explanation, we examined the U.S. census data for CT from 2000 and 2010. These data revealed the state's population of age 85 years had grown by 32.1%. This rate of growth contrasted sharply with that of the state population of age 65 years, which only grew by 7.7%.²⁵ Other studies speculate whether the widespread use of anti-coagulant therapies among older persons raises the risk of intracranial hemorrhage among those who do fall.^{3,26,27} The Australian study posits that, given the high incidence of FR-TBI among the oldest old, risk-benefit analysis of anti-coagulant therapy is warranted.⁵ Consistent with the conjecture of the Australian investigators, the CCFP data showed that ICD-9-CM codes for intracranial hemorrhage accounted for more than half of all codes reported over the study period.

There are several limitations to our study that warrant mention. Because of the small number of FR-TBI outcome events, we were not able to stratify the analysis on age and sex as was done in earlier analyses of CCFP outcomes.²⁸ We subsequently used ZCTA-based measures representing the proportions of persons of age 80 years and of males to adjust for the two confounding factors of age and sex. The other ZCTA-specific covariates provided similar, limited adjustment for the outcome and, owing to limitations of census data, do not adjust for comorbidity, functional impairment, or impairments of vision or hearing. Because CCFP is based on a non-randomized design, the authors make no claims of causality.

There are, however, two reasons why CCFP may have accounted for the observed change in rates during the evaluation period. First, we could identify no secular trends that might account for the observed differences. Second, the divergence in rates transpired, as would be expected, during the evaluation period. This divergence in rates suggests that clinical interventions designed to prevent falls among older persons may prevent some FR-TBI events. The 632 FR-TBI admissions to the 14 participating CT hospitals in 2007 potentially cost the Medicare program \$23 million for acute care only. Acute care is only the first stage of caring for an older adult who sustains a TBI. Additional costs are incurred from

rehabilitation and long term care. To prevent suffering and reduce healthcare costs, it is essential to examine every potential means of prevention.

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Observed Rates of Hospitalization^a for Fall-Related Traumatic Brain Injury Connecticut Collaboration for Fall Prevention^b

Figure 1.

Observed Annual Rates of Hospitalization per 100,000 Persons by Study Region for Fall Related Traumatic Brain Injury ^a in the Connecticut Collaboration for Fall Prevention^b (2000 –2007)

Footnotes:

^a hospitalization for fall-related traumatic brain injury defined as admissions assigned a fall-related E-code by CHIME (817, 824, 880–888, or 927) and at least one of the following ICD-9-CM codes specific to traumatic brain injury (800 – 801, 803–804, 850–854, or 959.01).

^b national data indicate that between 2002 and 2006 the rate of hospitalization for FR-TBI rose by 34%. Because rates adjust for population growth, this reflects an increasing trend in the occurrence of FR-TBI among older persons. (Faul M, Xu L, Wald MM, VG C. Traumatic brain injury in the United States: emergency department visits, hospitalizations and deaths 2002–2006. *Centers for Disease Control and Prevention*. 2010; National Center for Injury Prevention and Control 43.)

Table 1

Baseline Aggregate Characteristics of the Treatment and Usual Care Regions in the Connecticut Collaboration for Fall Prevention (2000 – 2007)

Population Characteristics ^a	Treatment Region (53 ZCTAs) N = 95,433 persons age ≥ 70 years	Usual Care Region (58 ZCTAs) N = 109,413 age ≥ 70 years
	Percent of Regional Population	
Female	61.3	61.4
Race		
White	91.8	92.3
Black ^b	5.2	5.8
Other	2.5	2.4
Hispanic or Latino	2.2	2.2
Education level ^c		
High school graduate or less	66.9	63.8
Some college or more	33.1	36.2
Annual Household income ^c		
<\$15,000	23.3	22.9
>\$75,000	14.3	18.2
Below Poverty Level	7.6	7.2
Living in an institution ^{b,c}	7.4	5.3
Non-institutionalized persons with physical disability [†]	24.0	24.0
Data on Hospitals and Emergency departments ^d		
Number of hospitals (number of beds)	7 (2303)	7 (2505)
Mean number of beds/hospital	329	358
Total adult discharges, 2003	70,084	77,230
Mean number of discharges/hospital	10,012	11,033
Total adult ED visits, 2000	351,515	356,847
Mean number of ED visits/hospital	50,216	50,978

ZCTA = zip code tabulation area

^aPopulation data were obtained from the 2000 U.S. Census. Unless stated otherwise, the data refer to the persons who were 70 years of age or older

^bValues are significantly different for P-value = 0.05 based on a chi-square test

^cData are for persons 65 years of age or older and were obtained from the weighted 2000 Census Sample Tables, in which the closest age cutoff to 70 years or older was 65 years or older

^dHospital and emergency department data and counts of fall-related healthcare utilization are from CHIME (Connecticut Health Information Management database)

Table 2

Characteristics of Hospital Admissions for Fall Related Traumatic Brain Injury (FR-TBI) in the Connecticut Collaboration for Fall Prevention (2000 – 2007)

Characteristics of Hospitalizations for FR-TBI		Pre-Intervention		Intervention			Evaluation		
		FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07
Number of Admissions	UCR	214	227	227	208	230	262	302	363
	TR	166	175	191	193	210	205	232	269
Median Length of Stay (Days)	UCR	6	5	5	5	5	5	4	5
	TR	5	4	4	4	4	4	4	4
Median Charge per Day (USD) ^a	UCR	2,822	2,903	3,717	4,077	3,924	4,650	4,997	5,273
	TR	2,513	2,667	2,863	3,002	3,475	3,775	4,505	5,644
Median Charge per Stay (USD) ^a	UCR	16,832	14,824	16,642	18,485	17,188	18,655	21,027	24,046
	TR	10,349	11,215	11,704	12,743	13,276	16,497	18,495	21,166
Total Charges for All Stays in Millions (USD) ^a	UCR	6.34	6.24	6.18	6.40	6.60	8.85	10.08	14.83
	TR	2.85	3.50	3.29	3.78	4.56	5.09	7.04	8.89

FR-TBI = fall-related traumatic brain injury

FY00 = fiscal year 2000 where fiscal year runs from October of calendar year 1999 through September of 2000

UCR = usual care region

TR = treatment region

^a2007 U.S. Dollars