Pre-Fracture Individual Characteristics Associated with High Total Health Care Costs after Hip Fracture

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Abstract

Purpose—To estimate the associations of individual pre-fracture characteristics with total health care costs after hip fracture, using Study of Osteoporotic Fractures (SOF) cohort data linked to Medicare claims.

Methods—Our study population was 738 women age 70 and older enrolled in Medicare Fee for Service (FFS) who experienced an incident hip fracture between 1/1/1992 and 12/31/2009. We assessed pre-fracture individual characteristics at SOF study visits, and estimated costs of hospitalizations, skilled nursing facility and inpatient rehabilitation stays, home health care visits, and outpatient utilization from Medicare FFS claims. We used generalized linear models to estimate the associations of predictor variables with total health care costs (2010 U.S. Dollars) after hip fracture.

Results—Median total health care costs for one year after hip fracture were $35,536 (inter-quartile range $24,830 to $50,903). Multi-variable adjusted total health care costs for one year after hip fracture were 14% higher ($5,256, 95% C.I. $156 to $10,356) in those with walk speed <0.6 meter/sec compared to ≥1.0 meter/sec; 25% higher ($9,601, 95% C.I. $3,314 to $16,069) in those with body mass index ≥30 kg/m^2 compared to 20 to 24.9 mg/kg^2; and 21% higher ($7,936, 95% C.I. $346 to $15,526) for those with 7 or more compared to no comorbid medical conditions.

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Conclusions—Pre-fracture poor mobility, obesity, and multiple comorbidities are associated with higher total health care costs after hip fracture in older women. Studies to investigate if targeted health care interventions for these individuals can reduce the costs of hip fractures are warranted.

Keywords

Hip fracture costs; total health care costs; walk speed; obesity; multimorbidity

INTRODUCTION

Osteoporotic fractures cause substantial morbidity among older persons, and are projected to cost $25 billion in the United States by 2025.[1] Hip fractures account for 50% to 70% of fracture costs,[1, 2] but these costs are highly variable at the individual level. Reducing the incidence, morbidity, *and* costs of hip fractures remain important health policy goals. A necessary step in making progress toward these goals is to identify individual patient characteristics that are associated with higher hip fracture costs.

Studies of hip fracture costs thus far have focused primarily on the associations of post-acute care use,[3–6] post-fracture rehabilitation intensity,[7, 8] or identified health care structural characteristics that influence post-acute care use after hip fracture.[3, 9] These studies, based on claims data, have limited ascertainment of individual patient characteristics such as age, sex, location of residence, and claims-based estimates of co-morbidity. Prospective epidemiologic studies have assessed unique patient characteristics that predict incident hip fracture[10], and many of these patient attributes may be related to aspects of health care utilization. In particular, slow walk speed[11] predicts higher hospital[12] and nursing home utilization[13, 14] among community-dwelling adults but its association with total health care costs in the general or selected subsets of the aged population has not been assessed.

Identification of characteristics associated with high health care costs after hip fracture is important for several reasons. Pre-fracture characteristics that predict high health care costs after hip fracture may help direct the design, and improve the cost-effectiveness, of various health care interventions. For example, pharmacologic treatments to reduce risk of hip fracture may be particularly cost-effective for osteoporotic individuals with characteristics that predict high health care costs after hip fracture; this may be an important consideration for newer but more expensive pharmacologic fracture prevention therapies. If pre-fracture characteristics that are potentially modifiable (such as slower walk speed and greater depressive symptoms)[15] are associated with both a higher incidence of hip fracture *and* higher post-fracture costs, then interventions that improve these risk factors are even more likely to be cost-effective. Finally, even non-modifiable risk factors that aid identification of individuals with high post-fracture costs could help target programs to coordinate and improve the efficiency of health care for these individuals, ultimately reducing their health care burden and costs if a hip fracture occurs.

Our primary objective was to estimate the associations of pre-fracture characteristics, (including measures of physical performance, depressive symptoms, cognitive function, body mass index (BMI), and comorbidity burden) with total health care costs for the year

after hip fracture among older women. Our secondary objective was to estimate the associations of pre-fracture characteristics with component costs, specifically acute hospital costs, skilled nursing facility costs, and outpatient costs.

METHODS

The Study of Osteoporotic Fractures (SOF) recruited 9,704 community-dwelling Caucasian women age 65 or older between 1986 and 1988 from population based listings in four geographic regions of the United States; Baltimore, MD; Minneapolis, MN; Portland, OR; and a rural area (Monongahela Valley) near Pittsburgh, PA.[16] SOF study visits were carried out every 2–5 years through 2010. At the sixth SOF study visit between 1996 and 1998, 662 African-American women age 65 and older were also recruited.[17] Using validated methods detailed in previous publications,[18, 19] successful matches to Medicare claims were achieved for 92% (n=9,228) of women enrolled in SOF as of January 1, 1991, when outpatient Medicare claims first became available. Since the far majority of all individuals who have a hip fracture are admitted to hospital for surgical treatment, we used the U.S. Medicare Provider Analysis and Review (MedPAR) file to identify SOF participants with an incident hip fracture between January 1, 1992 and December 31, 2009 by the following criteria; a) a discharge diagnosis of hip fracture (ICD-9 code 820.0x or 733.14); b) a hip fracture surgical treatment code (ICD-9 codes 78.55, 79.15, 79.35, 81.51, 81.52); and c) *not* having a treatment code indicating surgical removal of hardware or revision arthroplasty (78.65 or 81.53). The date of the hip fracture was the admission date for the hospital stay during which their hip fracture was surgically treated. Of the 1170 women who met these criteria, 738 (63%) were enrolled in Medicare Fee for Service parts A and B for the year before and year after their hip fracture, and this subset comprised our analytic cohort (figure 1). The remaining 432 participants were enrolled in Medicare Advantage during part or all of the first year before or year after their hip fracture, and therefore their claims were not available to us.

Total Health Care Costs Year Before and Year after Hip Fracture

Because it is very difficult to accurately ascertain which items of health care utilization after hip fracture are attributable to that fracture,[20] our analytic strategy was to use total healthcare costs the year after hip fracture as our dependent variable and to adjust for pre-fracture total health care costs the year prior to hip fracture. Since health care utilization attributable to hip fracture can occur for at least a year after the event, we defined the episode of care for hip fracture as one year. Total health care costs were calculated as the sum of costs for all acute hospital stays (including the stay during which the hip fracture was surgically treated), skilled nursing facility (SNF) stays paid by Medicare, inpatient rehabilitation facility (IRF) stays, outpatient care, and home health care for one year after and before the hip fracture date. Medication costs were not included. All acute hospital stays, Medicare paid SNF stays, and IRF stays during the year before and year after hip fracture were identified in the MedPAR file. Outpatient utilization was identified in the Carrier and Outpatient Medicare claims files, and home health care visits were identified in the Home Health Care file.

The U.S. Medicare system is a government-administered health insurance system that sets reimbursement payment rates to both inpatient and outpatient providers on behalf of Medicare beneficiaries (U.S. citizens age 65 and older). Medicare tries to base payments for hospital, SNF, IRF and outpatient care providers on the intensity of and true resource costs for those services required for the patient's medical and surgical acuity.[21] Medicare adjusts final payments to providers for geographic variation in labor and capital price inputs into the costs of delivering health care services. As our aim was to assess impact of individual characteristics on health care costs that were generalizable to the United States as a whole, we used Medicare payments with the geographic price input adjustments removed. Our methods of doing so for acute hospital inpatient stays and outpatient utilization are described fully in previous publications.[19, 22]

In the case of SNF and IRF payments, Medicare uses the health care wage index (WI) to adjust payments for local price inputs. For SNF stays, the local input price adjustment can be removed from the Medicare payment values in the MedPAR file using the following equation:

$$\text{SNF\_ Cost} = (\text{SNF MedPAR Payment})/(\text{WI}*\text{Prop}_{\text{LABOR- SNF}} + [1 - \text{Prop}_{\text{LABOR- SNF}}])$$

where $\text{Prop}_{\text{LABOR-SNF}}$ is the proportion of SNF care costs attributable to SNF worker wages and WI is the hospital wage index for that geographic locality.

Similarly for IRF stays, the local input price adjustments can be removed from the Medicare payment values in the MedPAR file using the following equation:

$$\text{IRF\_ Cost} = (\text{IRF MedPAR Payment})/(\text{WI}*\text{Prop}_{\text{LABOR- IRF}} + [1 - \text{Prop}_{\text{LABOR- IRF}}])$$

where $\text{Prop}_{\text{LABOR-IRF}}$ is the proportion of IRF care costs attributable to IRF worker wages and WI is the health care wage index for that geographic locality. The proportions of SNF and IRF costs estimated to be attributable to worker wages are published for each fiscal year in the U.S. Federal Register, and the WI for each local geographic location in the U.S. for each fiscal year are available on the U.S. Medicare website.

Costs were calculated and adjusted for health care cost inflation to U.S. 2010 dollars by methods described in detail in prior publications,[19] using Medicare payments to providers and resource intensity weights that reflect the true monetary resources required to deliver each type of health care.

Patient Characteristics

Age, race, and educational status were recorded at the baseline visit. Femoral neck bone mineral density (BMD) was measured in participants at the second (1989 to 1990), fourth (1992 to 1994), sixth (1996 to 1998), eighth (2002 to 2004) and ninth (2006 to 2008) study visits, with quality control methods described in previous publications.[23, 24] Self-reported health status (recorded as a single question survey item), impairment of instrumental activities of daily living (IADLs), smoking status, whether the participant had a fall during

the previous 12 months, and whether or not the participant walked for exercise were ascertained at each study visit. Grip strength,[25] the ability and time to complete 5 chair stands,[26] and 6 meter walk speed at usual pace were measured at each study visit. Depressive symptoms were measured using the 15-item Geriatric Depression Scale (GDS) [27] score at the second, fourth, sixth, eighth, and ninth study visits, and categorized as none or minimal (GDS score of 0 or 1), mild (2, 3, 4, or 5), or moderate to severe (GDS scale score of 6). Cognitive function was assessed using a modification of the Mini-Mental State Examination (MMSE)[28] at all visits except the 2nd and 3rd, and scored from 0 to 26. Height (measured with a Harpenden stadiometer) and weight were assessed at each study visit.

Participant comorbidity burden at the time of the hip fracture was ascertained by the Elixhauser method that takes into account 31 specific medical conditions (summary score range 0–31) using Medicare inpatient and outpatient claims data for the year prior to the hip fracture.[29] We ascertained if participants were already residing in a nursing facility at the time of their hip fracture using a previously validated algorithm[30] with outpatient Medicare claims.

Hospital Characteristics

We used Centers for Medicare and Medicaid Provider of Service (CMS POS) files and Medicare Cost Reports files to ascertain characteristics of the hospitals in which patients' hip fractures were surgically treated that might influence utilization and cost of care after hip fractures. These characteristics, included as covariates in our analytic models, were hospital size (defined as the number of Medicare certified acute care beds), the number of prospective payment (PPS) exempt rehabilitation beds in the hospital, and hospital ownership of a SNF and/or a home health care agency.[31]

Local Supply of Health Care Providers

Since the presence of SNFs close to the woman's residence may increase the likelihood of SNF utilization for post-acute care following any hospitalization[31] (and therefore health care costs), the addresses of all SNFs within the patient's county of residence and adjacent counties were identified in CMS POS files. Because the local supply of hospital beds has been associated with length of stay and intensity of inpatient utilization,[32] and the supply of primary care providers has also been inversely associated with health care costs,[33] we also adjusted for these factors in our analytic models. We used CMS POS files and the Area Health Resource File to estimate the numbers of Medicare certified acute hospital beds and primary care providers per capita within the patient's county of residence, and to also to estimate the numbers of orthopedic surgeons, occupational therapists, and physical therapists per capita within the patient's county of residence.

Statistical Analysis

Predictor variables that represented continuous phenomena were modeled as continuous variables unless their distribution was highly skewed or their association with total health care costs was non-linear. In that case, they were modeled as ordinal variables. The most recent SOF visit proximally preceding the hip fracture occurred a median 1.6 years (IQR 0.8

to 2.7) before the hip fracture. If the participant did not attend that particular study visit, predictor values were imputed for that participant at that visit with imputation models using data for all predictors from prior visits for that individual and all visits for all 10,336 SOF study participants. The missing values were imputed 50 times with the multiple chained regression equations method using the *ice* command of Stata 13.1.

We performed both single-level models and multilevel models with random intercepts for both hospitals in which the hip fractures were surgically treated and counties of residence. However, likelihood ratio tests comparing the multilevel models to single-level models showed no difference between them, hence we included only analyses from single-level generalized linear models with a gamma variance function and identity link. Models were run using the *mi estimate* command of Stata, in order to compute robust parameter coefficients and standard errors. Initial models were run to assess the association of each individual patient predictor with costs after hip fractures, adjusted only for study enrollment site and the year in which the hip fracture occurred. Those predictor variables with a p-value of association < 0.1 with total health care costs were then included in full multivariable models; variables with a multi-variable adjusted p-value of association > 0.2 with costs were then eliminated in a stepwise fashion.

Our secondary goal was to estimate the associations of the individual predictor variables with each of three major components of health care costs after hip fracture (acute hospital costs, outpatient care costs, and Medicare paid SNF costs). Each of these separate generalized linear models had the same predictor variables as the final multivariable model for total health care costs after hip fracture. Twenty five percent of participants did not have any Medicare paid SNF claims during the year after their hip fracture. Hence, we estimated the associations of predictor variables with any Medicare paid SNF utilization (any SNF costs versus none) using logistic regression, and then the associations of predictor variables with total Medicare paid SNF costs for the subset of participants with non-zero costs using a generalized linear model.

Hip fracture is associated with a 20% or more cumulative mortality within several months of the fracture,[34] and health care costs tend to be very high in the year preceding death.[35] Therefore, all of the above analyses were repeated after excluding participants who did not survive for 1 year after hip fracture.

Finally, in order to explore whether certain key comorbid conditions were important predictors of total health care costs after hip fracture, we adjusted for the presence or absence of five key comorbid conditions (diabetes mellitus, cardiovascular disease (CVD), dementia depression, and chronic obstructive pulmonary disease [COPD]) in place of the overall comorbidity score.

RESULTS

The 738 women with hip fracture in our cohort had a mean age of 83.7 years (range 70 to 99 years) and were overwhelmingly Caucasian (Table 1). Over 50% of participants had three or more comorbid conditions, and 65% had at least one IADL impairment before experiencing

their hip fracture. Five hundred sixty five (77%) survived the entire first year after their hip fracture, and among those who did not survive, 173 (23%) died a mean 4.1 months after hip fracture.

The median (inter-quartile range [IQR]) total costs of care for the year after and year before hip fracture were, respectively, \$35,536 (\$24,830 to \$50,903) and \$4,465 (\$1,120 to \$14,066). Major components of total health care costs during the year after hip fracture were acute hospital stays (median \$12,236, IQR 10,248 to 18,725), Medicare paid SNF stays (median \$9,587, IQR 0 to 24,416), and outpatient costs (median \$5,807, IQR 3,843 to 8,625). Only 13.8% of the cohort had an IRF stay during the year after their hip fracture, and 52% incurred home health care costs that on average were modest in magnitude (Table 2).

With adjustment only for study enrollment site and the year during which the hip fracture occurred, pre-fracture characteristics associated with higher total health care costs after hip fracture included poorer self-rated health, 5 or more comorbid conditions, younger age, IADL impairment, obesity (BMI $\geq$ 30 kg/m^2), depressive symptoms, and slower walk speed (Table 1). Pre-fracture global cognitive function, BMD, self-reported walking for exercise, grip strength, chair stand speed, current smoking, and pre-fracture nursing home residence were not significantly associated with total health care costs after hip fracture.

After further multi-variable adjustment for pre-fracture comorbidity, health care costs the year before hip fracture, size of the hospital in which the hip fracture was surgically treated, and per capita supply of primary care physicians, women with walk speed <0.6 meters/sec and those with walk speed 0.6 to <0.8 meters/sec both had a 1.14-fold higher total health care costs after hip fracture compared to those with walk speed $\geq$ 1.0 meter/sec (Table 3). Obese women with BMI $\geq$ 30 kg/m^2 compared to normal weight women with BMI 20 to 24.9 kg/m^2 had a 1.25-fold increase in total health care costs the year after hip fracture. Compared to those with no pre-fracture comorbid conditions, those with 5 or 6 or $\geq$ 7 more comorbid conditions had 1.21-fold higher total health care costs after hip fracture. Age, self-reported health, depressive symptoms, and IADL impairment were no longer associated with total health care costs after hip fracture in the multivariable model.

When indicator variables for diabetes mellitus, CVD, depression, dementia and COPD were included in the multivariable models in place of the overall comorbidity score, only pre-existing CVD was significantly associated with total health care costs after hip fracture (incremental cost compared to those with compared to those without CVD \$5,168, 95% C.I. 1026 to 9310). Notably, the associations of walk speed and BMI with total health care costs after hip fracture were unchanged (data not shown).

The effects of the individual patient characteristics differed for the major components of post-fracture health care costs. The multivariable-adjusted association between slow walk speed and total health care costs was primarily due to its association with Medicare paid SNF costs the year after hip fracture (Table 4); associations of walk speed with acute hospital costs (Table 5) or outpatient costs (Table 5) the year after hip fracture appeared smaller in magnitude and did not reach significance. These results were unchanged in analyses limited to the women who survived for at least 1 year after hip fracture. In contrast,

obesity was associated with increases in all major components (adjusted acute hospital care costs, outpatient costs (Table 5), and Medicare paid SNF costs (Table 4) of total health care costs\ for the year after hip fracture. Among the subset of women who survived for at least 1 year after hip fracture, patterns were similar but the association of obesity with increased costs reached the level of significance only for outpatient costs. Finally, the association of pre-fracture comorbidity with higher total health costs appeared to be primarily driven by increases in both acute hospital and Medicare paid SNF costs, though the association was significant only for acute hospital costs among the subset of women who survived at least 1 year after hip fracture.

DISCUSSION

Total health care costs after hip fracture are highly variable, and individual characteristics that may predict these costs have not been previously explored. Our results indicate that pre-fracture slow walk speed, pre-fracture obesity (BMI $\geq$ 30 kg/m^2), and greater comorbidity burden are independently associated with higher total health care costs after hip fracture, adjusted for health care utilization before the hip fracture. The association of walk speed with total health costs after hip fracture is primarily driven by its association with Medicare paid SNF costs after hip fracture. These findings suggest that those with higher pre-fracture lower extremity physical performance have more reserve to withstand the effects of hip fracture such that they may require less intense rehabilitation afterward. In contrast, obesity is associated more broadly with increases in all of the major components of health care utilization after hip fracture.

One previous study reported an association of self-reported ability to walk ¼ mile with total health care costs,[36] but our investigation is the first to show any association between objectively measured walk speed and total health care costs. In addition, other studies have reported that objectively assessed impaired mobility is associated with a higher risk of inpatient hospitalization[12] and nursing home admission,[13, 14] but our investigation expands on these findings by showing the incremental effect of slow walk speed on total health care costs. Slow walk speed is associated with a higher incidence of hip fracture,[10] and is amenable to interventions designed to improve physical mobility and activity in older individuals.[37, 38] Improving mobility may reduce health care costs not only by reducing risk of incident hip fracture but also by reducing cost of care following hip fracture should it occur. Future research studies to evaluate whether or not interventions to improve mobility reduce hip fracture incidence *and* health care costs after hip fracture clearly are warranted. If interventions that improve mobility result in some health care cost savings that at least partially offset the intervention cost, then routine periodic assessment of lower extremity performance (such as walk speed) in clinical practice settings as some have advocated[11] may be reasonable, particularly in frail older persons at higher hip fracture risk.

Although only an estimated 12.3% of our hip fracture cases were obese, the effect of obesity on health care costs attributable to hip fracture was particularly striking; costs were 25% higher in obese individuals compared to those with normal body weight. Higher body weight is associated with a lower incidence of hip fracture up to a BMI of 30 kg/m^2, but further increases in BMI are associated with little or no further reductions in fracture incidence.[39,

40] The effects of interventions to reduce obesity on hip fracture costs are therefore likely to be complex. Hip fracture incidence increases with weight loss irrespective of body weight or intention to lose weight[41] but this may be offset by lower costs of hip fracture should they occur.

There has been recent strong interest in identifying those with clusters of comorbid conditions with very high health care costs,[42] who then may be appropriate candidates for care management programs to improve the efficiency of their health care.[43] Our results support such efforts, but also show that measured characteristics such as walk speed and body mass index can be combined with comorbidity to identify high risk older adults. Moreover, pharmacologic fracture prevention therapies may be particularly cost-effective for those individuals with these characteristics who also have osteoporosis.

An important limitation of our study is that pre-fracture characteristics were assessed a median 1.6 years before the occurrence of the hip fracture, and we had to impute predictor variable values for a minority of these hip fracture patients because they did not attend the most recent SOF visit preceding the date of their hip fracture. Thus, our estimated associations of pre-fracture characteristics may be biased toward the null hypothesis of no association, and we may have missed some associations of predictors that may change over time, including factors such as depressive symptoms, cognitive impairment, and IADL impairment. However, our findings of significant associations of walk speed, obesity, and comorbidity with total health care costs after hip fracture are robust to this limitation. In addition, The SOF study did not include men, and other cohort studies would be required to investigate whether or not our findings are also true for older men. Our results are not applicable to the small minority of hip fracture patients who do not have surgical fixation of their fractures. We did not have a contemporaneous non-fracture control group, but that is mitigated since we adjusted for pre-fracture total health care costs; using pre-fracture health care costs as a control yields similar estimates of hip fracture attributable costs as does using a contemporaneous control group.[44] Other limitations of our study are that we did not include costs of long-term nursing home care in our calculations of total health care costs, the dearth of minority beneficiaries, the lack of claims data on participants with hip fracture that were enrolled in Medicare Advantage plans, and data from only four geographic sites in the United States.

In conclusion, slower walk speed, obesity, and a greater comorbidity burden are associated with higher total health care costs after hip fracture, after adjustment for each other and for pre-fracture health care costs, hospital characteristics, and local supply of health care providers. Improvement of mobility among older women at high risk of hip fracture may reduce costs of care, should a hip fracture occur. Further studies of the effect of interventions to improve physical performance capability among elderly persons at high risk of hip fractures are warranted.

Acknowledgments

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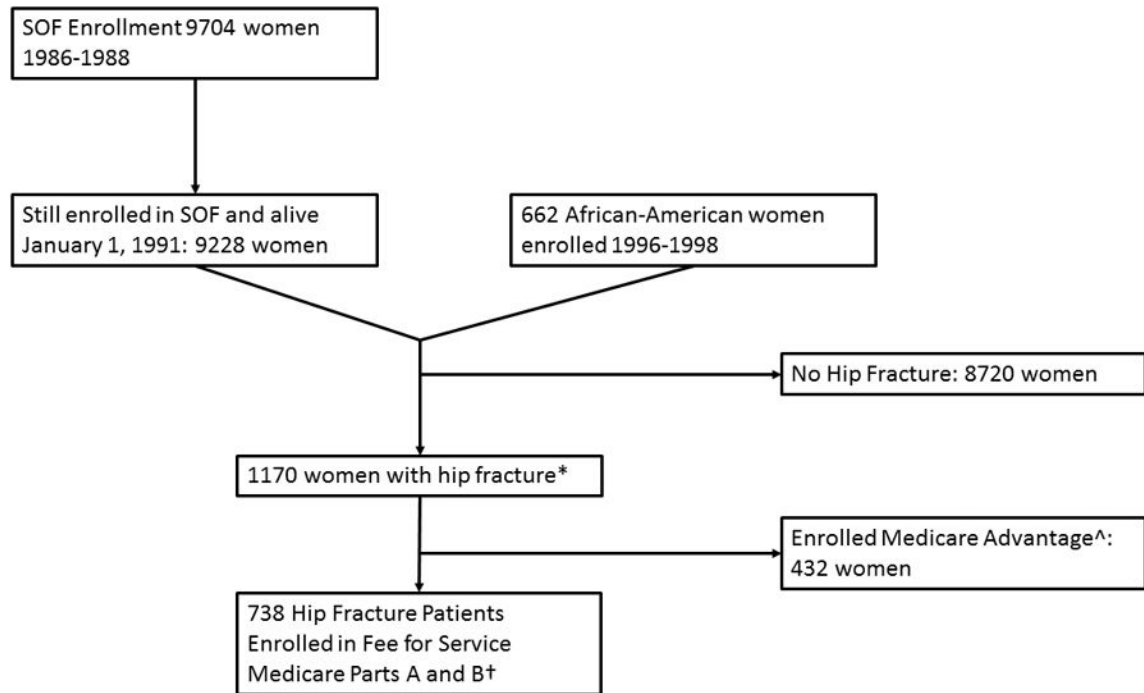
Figure 1. Flow Diagram of Identification of Study Population

*Hip fracture date between January 1, 1992 and December 31, 2009 inclusive. Identified by self-report to the SOF cohort *or* by Medicare Claims (required primary discharge diagnosis of hip fracture and hip fracture surgical treatment code and absence of code for surgical removal of hardware)

^Enrolled in Medicare Advantage for part or all of the year before hip fracture date and the year after hip fracture (or until death, whichever came first)

†Enrolled in Medicare Fee for Service Parts A and B for entire year before hip fracture date and the year after hip fracture (or until death, whichever came first)

Table 1

Characteristics of 738 Hip Fracture Patients and Associations with Total Health Care Costs after Hip Fracture, Base Model[a]

Parameter	Mean (SD) or Frequency (%)	Incremental Cost[b] (95% CI)[c]
Age, years (per 5 year increase)[d]	83.7 (5.5)	**−$1,816 (−3,395 to −236)**
Race/Ethnicity		
Caucasian	726 (98.4%)	Reference
African American	12 (1.6%)	−$7,778 (−18,706 to 3,149)
Education		
Less than high school	231 (24.8%)	Reference
High school	343 (36.9%)	−$2,363 (−6,558 to 1,832)
Less than 4 years college	176 (18.9%)	$3,689 (−2,280 to 9,657)
4 or more years college	180 (19.3%)	−$2,046 (−6,609 to 2,516)
Number of comorbidities[d]		
None	174 (18.7%)	Reference
1 or 2	259 (27.8%)	$2,171 (−3,014 to 7,356)
3 or 4	215 (23.1%)	$5,281 (−205 to 10,767)
5 or 6	139 (15.0%)	**$13,485 (6,971 to 19,999)**
7	143 (15.4%)	**$14,185 (7,741 to 20,630)**
Self-rated health[d]		
Good or excellent	669 (71.9%)	Reference
Fair, poor, or very poor	261 (28.1%)	**$5,648 (1,551 to 9,746)**
Walks for exercise[d]		
No	540 (73.2%)	Reference
Yes	198 (26.8%)	−$3,003 (−6,663 to 656)
IADLs impaired[d]		
None	326 (35.0%)	Reference
1	239 (60.7%)	**$5,914 (796 to 11,032)**
2 or 3	232 (25.0%)	**$6,100 (1,473 to 10,727)**
4	133 (14.3%)	$5,028 (−367 to 10,422)
Self-Reported Falls Prior 12 months		
None		Reference
One or more		$2,071 (−1267 to 5410)
Body mass index[d], kg/m^2		
<20	97 (13.1%)	$1,083 (−4,428 to 6,595)
20 to 24.9	312 (42.3%)	Reference
25 to 29.9	238 (32.2%)	$3,146 (−1,333 to 7,625)
30	91 (12.3%)	**$11,669 (4,862 to 18,476)**
Femoral neck BMD, g/cm^2	0.548 (0.098)	$1,533 (−529 to 3,596)[e]
Mini-Mental State Exam score (0–30)		
26	127 (17.3%)	Reference

Parameter	Mean (SD) or Frequency (%)	Incremental Cost[b] (95% CI)[c]
25	149 (20.1%)	$3,139 (−3,106 to 9,384)
23 or 24	245 (33.2%)	$1,413 (−3,905 to 6,733)
22	217 (29.4%)	$−1,951 (−7,897 to 3,994)
GDS-15 score[d]		
0 or 1	232 (31.5%)	Reference
2 to 5	368 (49.8%)	$3,925 (−78 to 7,929)
6	138 (18.7%)	**$5,764 (383 to 11,145)**
Grip strength, kg	15.2 (4.85)	−$1,526 (−3,474 to 422)[e]
Chair stand speed[d], stands/sec	3.11 (1.28)	$2,237 (−28 to 4,502)[e]
Walk speed[d], m/s		
1.0	112 (15.1%)	Reference
0.8 to 0.99	220 (29.8%)	$4,520 (−1,031 to 10,072)
0.6 to 0.79	202 (27.4%)	**$6,546 (908 to 12,184)**
<0.6	204 (27.6%)	**$7,472 (1,781 to 13,163)**
Permanent nursing home resident before hip fracture		
No	551 (74.7%)	Reference
Yes	187 (25.3%)	$−3,025 (−6,794 to 744)

[a] Adjusted for study site and year of hip fracture

[b] 2010 U.S. Dollars

[c] Associations with p-value <0.05 are in **bold**

[d] Selected for multivariable models based on p-value <0.1

[e] per SD increase

Table 2

Standardized Costs of Health Care Year After and Year Before Hip Fracture

Parameter	Costs *After* Hip Fracture, Median (IQR)	Costs *Before* Hip Fracture, Median (IQR)
Total	$35,536 (24,830 to 50,903)	$4,465 (1,120 to 14,066)
Acute hospital costs	$12,236 (10,248 to 18,725)	$0 (0 to 5,766)[d]
SNF costs	$9,587 (0 to 20,416)[a]	$0 (0 to 0)[e]
IRF costs	$0 (0 to 0)[b]	$0 (0 to 0)[f]
Outpatient costs	$5,807 (3,843 to 8,625)	$2,500 (1,066 to 5,037)
Home health care	$442 (0 to 4,310)[c]	$0 (0 to 0)[g]

[a] 553 (74.9%) had positive part A paid SNF costs after hip fracture (mean $13,718 across all 738 individuals)

[b] 102 (13.8%) had positive IRF costs after hip fracture (mean $1,790 across all 738 individuals)

[c] 384 (52.0%) has positive Home Health Care costs after hip fracture (mean $2,692 across all 738 individuals)

[d] 286 (38.3%) had non-zero acute hospital costs year before hip fracture (mean $4,422 across all 738 individuals)

[e] 96 (13.0%) had non-zero SNF costs year before hip fracture (mean $1,606 across all 738 individuals)

[f] 10 (1.4%) had non-zero IRF costs year before hip fracture (mean $204 across all 738 individuals)

[g] 163 (22.1%) had non-zero Home Health Care costs year before hip fracture (mean $942 across all 738 individuals)

Table 3

Multivariable-Adjusted Incremental Change of Total Health Care Costs after Hip Fracture with Change of Predictor Variable Level Compared to Reference Category

| Predictor | Change of Total Health Care Costs (95% CI)[a,b] | |
	Model 1 (n = 738)	Model 2[c] (n = 565)
Total health care costs before hip fracture		
Quintile 1	Reference	Reference
Quintile 2	$937 (–3,328 to 5,203)	$351 (–3,921 to 4,625)
Quintile 3	–$298 (–5,039 to 4,442)	–$1,011 (–5,849 to 3,826)
Quintile 4	$4,803 (–770 to 10,377)	$3,468 (–2,218 to 9,153)
Quintile 5	**$8,234 (1,938 to 1,530)**	**$8,964 (1,922 to 16,006)**
Comorbidities		
None	Reference	Reference
1 or 2	$848 (–4,268 to 5,964)	$1,523 (–3,440 to 6,486)
3 or 4	$2,262 (–3,497 to 8,022)	$2,920 (–2,608 to 8,449)
5 or 6	**$7,859 (769 to 14,949)**	**$10,210 (2,667 to 17,752)**
7 or more	**$7,936 (346 to 15,526)**	**$13,763 (5,311 to 22,214)**
Walk speed, m/s		
1.0	Reference	Reference
0.8 to 0.99	$3,891 (–1057 to 8839)	$2,902 (–1921 to 7724)
0.6 to 0.79	**$5,142 (104 to 10,180)**	**$5,637 (482 to 10,792)**
<0.6	**$5,256 (156 to 10,356)**	**$7,523 (1,809 to 13,236)**
Body mass index, kg/m^2		
<20	$75 (–5,149 to 5,300)	–$1,473 (–7,107 to 4,160)
20 to 24.9	Reference	Reference
25 to 29.9	$2,003 (–2,237 to 6,242)	$751 (–3,533 to 5,034)
30	**$9,601 (3,134 to 16,069)**	**$7,233 (506 to 13,959)**

[a] Adjusted for study enrollment site, year of hip fracture, size of hospital in which hip fracture was treated, and primary care providers per 10,000 inhabitants in county of residence at the time of hip fracture

[b] Model predicted costs for reference level, and incremental costs for other levels compared to reference level; statistically significant values at p-value <0.05 are in **bold**

[c] Model 2 restricted to those who survived at least 12 months post hip fracture

Table 4

Associations of Predictors with Use of SNF During First Year Post Hip Fracture and SNF Costs

Predictor	Odds Ratio (95% CI)	Incremental Cost (95% CI)[a,b]	
	SNF use[c] (n=738)	Model 1[d] (n=533)	Model 2[d,e] (n=420)
Total health care costs before hip fracture			
Quintile 1	Reference	Reference	Reference
Quintile 2	0.92 (0.49 to 1.73)	$−762 (−4,150 to 2,625)	$−619 (−4,017 to 2,780)
Quintile 3	1.08 (0.52 to 2.24)	$−3147 (−6,772 to 479)	$−3,438 (−7,115 to 238)
Quintile 4	1.17 (0.59 to 2.31)	$−721 (−4,847 to 3,406)	$−352 (−4,736 to 4,033)
Highest Quintile	1.12 (0.54 to 2.33)	$−394 (−5,049 to 4,260)	$−1,174 (−6,075 to 3,727)
Comorbidities			
None	Reference	Reference	Reference
1 or 2	0.86 (0.43 to 2.12)	$−2,476 (−6,612 to 1,661)	$−2,211 (−6,627 to 2,206)
3 or 4	1.24 (0.53 to 2.92)	$−1,467 (−6,019 to 3,084)	$−1,404 (−6,193 to 3,386)
5 or 6	**2.67 (1.09 to 6.57)**	$905 (−4,520 to 6,331)	$4,044 (−1,788 to 9,876)
7 or more	1.08 (0.42 to 2.80)	$4,329 (−1,622 to 10,101)	$5,371 (−883 to 11,626)
Walk speed, m/s			
1.0	Reference	Reference	Reference
0.8 to 0.99	1.04 (0.56 to 1.92)	$3,035 (−507 to 6,577)	$2,167 (−1,602 to 5,936)
0.6 to 0.79	0.99 (0.47 to 2.10)	$2,049 (−2,050 to 6,147)	$1,992 (−2,375 to 6,359)
<0.6	1.05 (0.50 to 2.21)	**$4,646 (690 to 8,601)**	**$5,371 (947 to 9975)**
Body mass index, kg/m²			
<20	1.23 (0.60 to 2.58)	$−504 (−4,272 to 3,264)	$−1,164 (−5,298 to 2,971)
20 to 24.9	Reference	Reference	Reference
25 to 29.9	1.08 (0.60 to 1.94)	$1,113 (−2251 to 4,477)	$80 (−3,288 to 3,449)
30	1.61 (0.74 to 3.48)	**$4,802 (441 to 9,165)**	$3,889 (−938 to 8,715)

[a] Model predicted costs for reference level, and incremental costs for other levels compared to reference level; statistically significant values at p-value <0.05 are in **bold**

[b] Adjusted for study enrollment site, year of hip fracture, size of hospital in which hip fracture was treated, and primary care providers per 10000 inhabitants in county of residence at the time of hip fracture

[c] Defined as any non-zero SNF costs for the year after hip fracture vs. no SNF costs

[d] Regression limited to those with non-zero part A paid SNF costs post hip fracture

[e]Model 2 restricted to those who survived at least 12 months post hip fracture

Table 5

Multivariable-Adjusted Incremental Change of Acute Hospital and Outpatient Costs after Hip Fracture with Change of Predictor Variable Level Compared to Reference Category

Predictor	Change of Acute Hospital Costs (95% CI)[a,b]		Change of Outpatient Costs (95% CI)	
	Model 1 (n = 738)	Model 2[c] (n = 565)	Model 1[b] (n = 738)	Model 2[c] (n = 565)
Total health care costs before hip fracture				
Quintile 1	Reference	Reference	Reference	Reference
Quintile 2	$−82 (−2,085 to 1,921)	$61 (−2,055 to 2,177)	$861 (−33 to 1,755)	**$958 (39 to 1,877)**
Quintile 3	$−279 (−2,474 to 1,916)	$−487 (−2,827 to 1,853)	**$1,267 (176 to 2,357)**	**$1,334 (170 to 2,498)**
Quintile 4	$878 (−1,599 to 3,354)	$218 (−2,459 to 2,895)	**$2,360 (1,168 to 3,551)**	**$2,423 (1,157 to 3,710)**
Highest Quintile	$1,852 (−914 to 4,619)	$2,026 (−1,169 to 5,221)	**$4,093 (2,650 to 5,536)**	**$5,191 (3,423 to 6,959)**
Comorbidities				
None	Reference	Reference	Reference	Reference
1 or 2	$694 (−1,703 to 3,091)	$1,256 (−1,138 to 3,650)	$−329 (−1,438 to 780)	$−179 (−1,259 to 902)
3 or 4	$1,517 (−1,201 to 4,234)	$2,090 (−665 to 4,845)	$−363 (−1,668 to 943)	$−186 (−1,452 to 1,080)
5 or 6	$2,749 (−330 to 5,828)	$2,667 (−682 to 6,016)	$−444 (−1,940 to 1,052)	$−158 (−1,773 to 1,458)
7 or more	$2,907 (−446 to 6,260)	**$5,601 (1,707 to 9,495)**	$−36 (−1,726 to 1,653)	$937 (−1,027 to 2,902)
Walk speed, m/s				
1.0	Reference	Reference	Reference	Reference
0.8 to 0.99	$666 (−1,578 to 2,890)	$95 (−2,224 to 2,414)	$570 (−509 to 1,649)	$457 (−610 to 1,524)
0.6 to 0.79	$1,304 (−1,074 to 3,682)	$1,068 (−1,426 to 3,563)	$742 (−381 to 1,864)	$772 (−381 to 1,925)
<0.6	$991 (−1,367 to 3,349)	$1,543 (−1,099 to 4,186)	$483 (−648 to 1,614)	$892 (−359 to 2,142)
Body mass index, kg/m^2				
<20	$269 (−2,037 to 2,575)	$−583 (−3,264 to 2,098)	$36 (−1,032 to 1,105)	$−29 (−1,244 to 1,184)
20 to 24.9	Reference	Reference	Reference	Reference
25 to 29.9	$1,092 (−707 to 2,892)	$859 (−1,082 to 2,799)	$458 (−419 to 1,335)	$360 (−569 to 1,290)
30	**$2,949 (173 to 5,724)**	$2213 (−687 to 5,114)	**$1,849 (471 to 3,228)**	**$1,608 (178 to 3,088)**

[a] Adjusted for study enrollment site, year of hip fracture, size of hospital in which hip fracture was treated, and primary care providers per 10,000 inhabitants in county of residence at the time of hip fracture

[b] Model predicted costs for reference level, and incremental costs for other levels compared to reference level; statistically significant values at p-value <0.05 are in **bold**

[c] Model 2 restricted to those who survived at least 12 months post hip fracture