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How Are the Costs of Care for Medical Falls Distributed? The Costs of Medical Falls by Component of Cost, Timing, and Injury Severity

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Purpose of the Study: To examine the components of cost that drive increased total costs after a medical fall over time, stratified by injury severity. ***Design and Methods:*** We used 2004–2007 cost and utilization data for persons enrolled in an integrated care delivery system. We used a longitudinal cohort study design, where each individual provides 2–3 years of administrative data grouped into 3-month intervals relative to an index date. We identified 8,969 medical fallers through International Classification of Diseases, 9th Revision, codes and E-Codes and used 8,956 nonfaller controls, identified through age and gender frequency matching. Total costs were partitioned into 7 components: inpatient, outpatient, emergency, radiology, pharmacy, postacute care, and "other." ***Results:*** The large increase in costs after a hospitalized fall is mainly associated with inpatient and postacute care components. The spike in costs after a nonhospitalized fall is attributable to outpatient and "other" (e.g., ambulatory surgery or community health services) components. Hospitalized fallers' inpatient, emergency, postacute care, outpatient, and radiology costs are not always greater than those for nonhospitalized fallers. ***Implications:*** Components associated with increased costs after a medical fall vary over time and by injury severity. Future studies should compare if delivering certain acute and postacute health services improve health and reduce cost trajectories after a medical fall more than others. Additionally, since the older adult population and the problem of falls are growing, health care delivery systems should develop standardized methodology to monitor medical fall rates.

Key Words: Economics, Medicaid/Medicare, Longitudinal analysis

Falls among the community-dwelling older adults are a growing public health concern (Sleet, Moffett, & Stevens, 2008). An estimated 6 million (Shumway-Cook et al., 2009) to 12 million (Stevens, Mack, Paulozzi, & Ballesteros, 2008) Medicare-eligible community-dwelling older adults fall each year. At least 20% of the older adults who fall seek medical attention to address suspected injury (Hausdorff, Rios, & Edelberg, 2001; Hornbrook et al., 1994; Tinetti, Speechley, & Ginter, 1988), and roughly 10% of those who fall sustain an injury that is serious enough to require hospitalization (Masud

& Morris, 2001). Such falls that lead to medical attention are referred to as "medical falls" (Tinetti et al., 1994) and can be thought of as the treated prevalence of fall-related injuries. Direct annual medical care costs resulting from fatal and nonfatal medical falls are estimated at $19.2 billion (in 2000 U.S. dollars; Stevens, Corso, Finkelstein, & Miller, 2006). Although evidence suggests that multifactorial fall prevention programs have decreased medical fall rates on a population level (Tinetti et al., 2008) and can reduce health care costs (Rizzo, Baker, McAvay, & Tinetti, 1996), integrating prevention services into routine clinical and public health practice remains a challenge (Wenger et al., 2003).

The Affordable Care Act mandates coverage of select preventive services, including fall risk screening and management (American Medical Association, 2011), and this policy is certain to impact health care expenditures. By extension, economic evaluations of this policy change will need estimates of component cost increases resulting from a medical fall in order to estimate whether there are savings from prevention. This manuscript provides researchers and policy makers with the information needed to estimate this impact.

Previous research has shown that health care costs increase in the year following a medical fall (Rizzo et al., 1998; Roudsari, Ebel, Corso, Molinari, & Koepsell, 2005; Stevens et al., 2006). We extended this literature by describing changes in total health care costs over discrete time intervals (quarters) in the year following a medical fall (Bohl et al., 2010). We found significantly greater direct medical costs attributable to falling in the year after a medical fall. The bulk of these costs was incurred within the first quarter, but costs remained elevated throughout the year. Furthermore, individuals hospitalized for a medical fall (hereafter referred to as "hospitalized fallers") had higher total costs in all 3-month intervals in the year after the fall compared with those who were not hospitalized ("nonhospitalized fallers"; Bohl et al., 2010).

Although it is now well-established that total costs increase after a medical fall, relatively few studies have described these increases over three important dimensions: (a) components of total costs (e.g., inpatient, outpatient, pharmacy, and emergency), (b) timing of component costs (e.g., first quarter after vs. subsequent quarters after a medical fall), and (c) component costs by injury severity (e.g., hospitalized vs. nonhospitalized falls). Although several studies (Rizzo et al., 1998; Roudsari et al., 2005; Stevens et al., 2006) examined differences in component costs after a medical fall, all described either how total expenditures change over time or how components costs increase in the year after a fall, but none examined both simultaneously within a single population or data set. One study examined how total and component Medicare fee-for-service (FFS) expenditures changed after an injury; however, this analysis focused on any injury and was not specific to fall-related injuries (Carter & Porell, 2011). The present manuscript provides important new information on the three aforementioned dimensions from a distinct population-based data source.

We note that the present manuscript is unique from our total costs manuscript (Bohl et al, 2010) in that it drills down to describe the key cost drivers underlying total costs. This information, to the best of our knowledge, has been previously unavailable in the published medical and health services literature. In addition, by stratifying medical falls into those that require hospitalization and those that do not, the present study enhances understanding of the impact of greater injury severity on the distribution of component costs.

Thus, in this paper, we present findings that address these gaps in the literature. Specifically, we answered three research questions directly related to the three dimensions of component costs mentioned earlier: (a) what components of health services are associated with increased costs in the quarter after a medical fall, (b) do these components change over time, and if so, (c) how are all component costs higher for hospitalized fallers compared with nonhospitalized fallers in all quarters after a medical fall? To our knowledge, longitudinal assessments of component costs for these two subgroups have not been explored as part of economic evaluations of medical falls.

Design and Methods

This analysis used cost information from 17,925 Medicare Advantage enrollees from Group Health. Details of the methodology used to select this sample have been published previously (Bohl et al., 2010). For the present analyses, we modeled costs over three dimensions: (a) components of total costs (e.g., inpatient, outpatient, pharmacy, emergency), (b) timing of component costs (by quarter following a fall-related injury), and (c) component costs by injury severity (e.g., hospitalized vs. nonhospitalized falls). This approach allowed us to test for differences in component costs between and within groups over time. We estimated the cost attributable to falling on a quarterly basis for the year immediately following a medical fall for each medical faller subgroup. The Group Health Research Institute's Institutional Review Board approved all study procedures.

Study Setting

The setting for this research was Group Health, an integrated health care delivery system headquartered in Seattle, Washington. Group Health provides comprehensive health and preventive services as well as insurance to approximately 50,000 older adults through a Medicare Advantage program available in Washington and Idaho. Group Health's Medicare Advantage enrollees are primarily persons who had a commercial plan at Group Health and aged into Medicare. Individuals eligible for this study received care through the Western Washington component of Group Health's Integrated Group Practice, which operates 20 primary care clinics and three specialty centers in the Puget Sound region and served more than 40,000 older adults between January 1, 2004, and December 31, 2006.

Study Sample

We identified older adults enrolled in Group Health's Medicare Advantage plan ("enrollees") who experienced an incident (first) fall requiring medical attention ("medical fall") and frequency-matched controls for comparison. Using a previously established methodology (Bohl et al., 2010; Roudsari et al., 2005), we identified medical falls using International Classification of Diseases, 9th Revision (ICD-9), codes of 800–848 (fractures, dislocations, and sprains and strains), 850–854 (intracranial injuries), and 920–924 (contusions with intact skin surfaces) and E-Codes 880, 881, 884, 885, and 888 (accidental fall injuries). Medical falls were detected as the presence of at least one fall-related ICD-9 diagnosis code or E-Code on a claim. For inclusion in the study, enrollees had to (a) have 2 years of continuous enrollment without record of a medical fall prior to the date of the first medical fall (the index date), (b) have at least one year of continuous enrollment (or enrollment until death) after the index date (to avoid right censoring of costs around death), (c) have no record of any postacute or long-term care utilization within two years preindex (to exclude those not living in the community), and (d) be at least 67 years or older at the index date, to ensure that, prior to the index date, they had had access to the same Medicare Advantage benefits. Persons with a diagnosis for non–fall-related injuries are included in the pool of nonfallers. This is consistent with prior approaches (Roudsari et al., 2005).

The data set included at least 9 and up to 12 (depending on time of death) repeated measures on all individuals in the study sample. Each measure represents quarter-year costs relative to an index date. For incident medical fallers, the index date was the date of the first medical fall on record. A time series analysis needs to index costs to an event. Since nonfallers by definition have no event, some assignment of an event must be used. Therefore, frequency matching was used to assign index dates. For nonfallers, we used age and gender in a frequency-matching procedure to randomly assign index dates, a procedure used in previous time series analyses (Fishman, Thompson, Merikle, & Curry, 2006). Details on the frequency-matching procedure are included in our prior manuscript (Bohl et al., 2010). The age and gender distributions for nonfallers were determined by the frequency-matching procedure.

We classified fallers based on our previously published methodology (Bohl et al., 2010). To distinguish between levels of injury severity, we divided fallers into two groups: hospitalized and nonhospitalized fallers. Hospitalized fallers were persons with a record of a hospital admission within the first 3 days after a fall; we classified all other fallers as nonhospitalized fallers. Hospitalized falls were differentiated from in-hospital falls by verifying that the relevant fall-related codes were contained in the set of admitting diagnosis codes. We divided fallers into these two groups in the anticipation of differences in follow-up care that would affect component costs.

Variable Definitions

Dependent Variable: Component Costs.—The health service utilization and cost data used in this study were derived from Group Health's clinical and administrative databases. Cost data reflect the actual cost of providing health services (as opposed to charges) from Group Health's perspective (Fishman, Von Korff, Lozano, & Hecht, 1997). Group Health provides health care almost entirely through capitated contracts and therefore does not generate claims in the way that FFS providers do. To monitor resource use, Group

Health developed a cost allocation model to capture information on true resource use from 15 different systems on a monthly basis, calculating the precise cost for each unit of service delivered and assigning costs to patients based on the units of service used. Key characteristics of the cost methodology are that actual costs from the general ledger are reported; overhead costs are fully allocated to patient care departments; total costs are assigned to the unit of service; and automated data are systematically verified (Fishman & Wagner, 1998).

Health care costs are categorized within the Group Health costing system into seven categories or components: (a) emergency, (b) inpatient, (c) outpatient, (d) pharmacy, (e) radiology, (f) postacute care, and (g) "other." The first six components represent 80% of total costs. All services received in the hospital, including mental health hospitalizations, are bundled within inpatient costs. Outpatient costs encompass primary and specialty care from physicians and nurses as well as mental health services costs. Pharmacy costs include medications received from outpatient settings only; all medications received during hospitalization are included as inpatient costs. Radiology costs include supplies, materials, and labor to produce and interpret imaging studies. Postacute care costs include skilled nursing facility stays, skilled nursing services, home health visits, and physical therapy. As contractually required by all Medicare Advantage Plans, Group Health pays only for postacute care costs covered under traditional Medicare FFS Parts A and B, which excludes long-term care stays. Postacute care costs exclude copayments made by patients, which are often substantial. The "other" category includes an array of heterogeneous services not fitting into a traditional classification, including, for example, renal dialysis, ambulatory surgery, community health services, and contact lenses. All costs are reported in 2008 U.S. dollars.

We followed an approach that is fairly conventional in the health economics literature (Baser, Crown, & Pollicino, 2006; Fishman et al., 2006) for handling costs after death, which is the assignment of missing values to these costs. Sensitivity analyses to examine the validity of this approach had been conducted previously (Bohl et al., 2010); these analyses demonstrated that this approach was empirically justified, as results from the model assuming costs as $0 after death and with an indicator variable for dead/alive produced strikingly similar results to the model with costs set to missing.

Independent Variables.—To account for factors influencing health care costs and fall risk, we adjusted for age, gender, and comorbidity. We adjusted for comorbidity using the RxRisk score (Fishman et al., 2003). The RxRisk score is well validated (e.g., with Health Maintenance Organization, Veterans Administration, and Medicaid samples) and risk adjusts for future costs from prior pharmacy use, for a range of comorbidities, including some associated with falling, such as hypotension ("Summary of the Updated American Geriatrics Society/British Geriatrics Society clinical practice guideline for prevention of falls in older persons," 2011). For each subject, we calculated an RxRisk score at the beginning of each quarter using pharmacy data from the previous year. The RxRisk score has units of 2008 U.S. dollars.

Analysis

There are a number of methods available for estimating the cost of illness (Honeycutt, Segel, Hoerger, & Finkelstein, 2009), and Finkelstein, Chen, Miller, Corso, and Stevens, (2005) have discussed alternative approaches in the context of medical falls. In this study, our approach used recycled coefficient estimates with the study sample's characteristics to answer the counterfactual question: what might costs look like for each faller cohort had they not experienced their index medical fall? This quantity represents the cost burden of medical falls over a given time period. This quantity should be interpreted with caution because regression-based methods tend to produce the largest estimate of attributable costs compared with accounting-based approaches, wherein specific procedures would be attributed to a medical fall by reviewing claims or chart records.

We used regression analysis to test for differences in component costs between and within groups over time and to estimate the cost attributable to falling at each time period postfall (Honeycutt et al., 2009). The cost attributable to falling represents the cost over-and-above what would have been observed had the medical fall not occurred, adjusting for trends in costs before the index date. To address the skewness, kurtosis, and intertemporal (i.e., repeated measures) correlation typical of longitudinal health care cost data, we used a Generalized Estimating Equations (GEE) model (Diggle, Heagerty, Liang, & Zeger, 2002; Fitzmaurice, Laird, & Ware, 2004; Hardin & Hilbe, 2003) with a log link and gamma distribution (Blough, Madden, &

Hornbrook, 1999). Although GEE models produce robust variance estimates (Hardin & Hilbe, 2003), standard error estimates for highly skewed outcomes using this model specification are typically imprecise (Manning & Mullahy, 2001). Therefore, we generated bootstrapped 95% confidence intervals (CIs) using 1,000 replications and a percentile-based estimate (Baser et al., 2006). In all models, we adjusted for index age, gender, an index age by gender interaction, comorbidity using the RxRisk score, dummy variables for time, faller status (hospitalized, nonhospitalized, or nonfaller), and time by faller status interactions. Detailed model information is available in our previously published work (Bohl et al., 2010).

Our models included costs before and after a fall. We labeled quarter-year periods as "quarters" with an integer denoting their position relative to the index date; negative integers represent quarters before index, quarter zero includes the index date, and positive quarters occur after index. We included costs prior to a fall as baseline costs; we included a control group to study the potential cost trajectory if the fall had been avoided. The same regression model was used to produce estimates for the component costs attributable to hospitalized and nonhospitalized falls. Guided by a sensitivity analysis performed in a previous analysis of total costs (Bohl et al., 2010), we coded costs after death as missing because this approach produced conservative results.

Separate models for each cost component were fit; each model included cost data on all cohorts at all observed time periods. We tested the main effects of cohort and time as well as the time-by-cohort interaction. This was done separately for each component. Statistical significance was considered at $\alpha = .05$ level. Exact dollar amounts, 95% CIs, and p values were obtained for each estimate of cost attributable to falling. Demographic characteristics between groups were analyzed using t tests for continuous variables and chi-square for categorical variables. To represent the cost attributable to falling in dollar amounts (as opposed to multiplicative effects derived from regression coefficients), we use recycled coefficient estimates through a least squares means process (Honeycutt et al., 2009).

Results

The analytic sample's demographic and death data were published previously (Bohl et al., 2010); we represent them in text for the reader's convenience. Most hospitalized fallers (66%), nonhospitalized fallers (61%), and nonfallers (62%) were female ($p < .01$). Hospitalized fallers were significantly older (mean age 82.0 years, *SD* 7.0) than nonhospitalized fallers (mean 78.0 years, *SD* 7.0) ($p < .001$). Comorbidity as of the index date, as measured by the RxRisk score, was higher for groups with higher injury severity ($p < .01$). Hospitalized fallers were more likely to die within one year of the index date than were nonhospitalized fallers and nonfallers (24% vs. 4% vs. 6%, $p < .001$). Figures on how total costs for each group change over time are summarized elsewhere (Bohl et al., 2010).

What Components of Health Services Drive Increased Costs in the Quarter After a Medical Fall?

Table 1 shows the unadjusted quarterly costs for each component for all 3 years of observation (2 years prior to and 1 year after index) for hospitalized and nonhospitalized fallers and nonfallers. Before the index date, all of the hospitalized fallers' component costs were higher than those for nonhospitalized fallers (all $p < .05$); all of the nonhospitalized fallers' component costs were, in turn, higher than for nonfallers (all $p < .05$). After the index date, the average quarterly cost for all components increased substantially for the hospitalized fallers, whereas emergency, inpatient, outpatient, and radiology costs increased substantially for the nonhospitalized fallers. Before the index date, hospitalized and nonhospitalized fallers' inpatient and pharmacy costs were the only two components to increase significantly over time ($p < .05$).

After adjusting for age, gender, and comorbidity, the cost attributable to hospitalized falls was significantly greater than zero (all $p < .001$) for all components in the index quarter (Table 2). Inpatient and postacute care components were the drivers of cost in the index quarter because they had the largest estimates for the cost attributable to hospitalized falls.

Adjusting for age, gender, and comorbidity, the cost attributable to nonhospitalized falls was significantly greater than zero (all $p < .001$) for all components except inpatient costs in the index quarter (Table 3). Outpatient, postacute care, and "other" costs were the drivers of cost in the index quarter because they had the largest estimates for the cost attributable to nonhospitalized falls. Full model results are available in the Supplementary Material. Of note, after adjusting for covariates, total costs

Table 1. Component Health Care Costs, Relative to Index Date, for the Study Cohort

		Average quarterly costs, 2008 U.S. dollars, M (SD)		
		Nonfallers	Fallers	
		All	Nonhospitalized	Hospitalized
Component	Years relative to the index date	N = 8,956	N = 7,993	N = 976
Emergency	2 years prior	32 (294)	41 (329)	62 (394)
	1 year prior	40 (353)	61 (453)	87 (488)
	1 year post	70 (488)	160 (719)	627 (1,472)
Inpatient	2 years prior	232 (2,412)	260 (2,596)	217 (1,939)
	1 year prior	280 (3,278)	363 (3,141)	541 (4,624)
	1 year post	708 (5,467)	920 (7,066)	5,947 (15,924)
Outpatient	2 years prior	347 (626)	457 (826)	490 (913)
	1 year prior	351 (628)	493 (937)	533 (927)
	1 year post	433 (814)	699 (980)	736 (1,115)
Pharmacy	2 years prior	200 (470)	253 (485)	318 (536)
	1 year prior	220 (611)	277 (594)	359 (699)
	1 year post	247 (608)	332 (598)	527 (853)
Radiology	2 years prior	48 (294)	66 (346)	76 (845)
	1 year prior	41 (228)	61 (345)	52 (247)
	1 year post	53 (391)	113 (545)	113 (326)
PAC[a]	1 year post	98 (1,171)	188 (1,629)	2,219 (5,398)
Other[b]	2 years prior	263 (1,303)	310 (1,461)	325 (1,355)
	1 year prior	337 (1,548)	417 (1,803)	521 (1,864)
	1 year post	507 (2,115)	716 (2,351)	1,734 (3,370)

Notes: [a]PAC costs were zero for all subjects prior to the index date due to study design; PAC includes skilled nursing rehabilitation, home health, and other services covered by Medicare. PAC = postacute care.
[b]"Other" costs include a heterogeneous group of services not classified into traditional categories (e.g., renal dialysis, ambulatory surgery, home health care, and contact lenses).

before the index date were greater for medical fallers compared with nonfallers (Bohl et al., 2010).

Do the Components That Drive Increased Costs Change Over Time, and If So, How?

The components driving increased costs appeared to change over time following the index date, especially for nonhospitalized fallers. For hospitalized fallers, as expected, the inpatient costs attributable to falling ($18,590; 95% CI: $14,543–$23,709) were the largest component in Quarter 0, followed by postacute care costs ($14,061; 95% CI: $8,632–$22,861; Table 2). In Quarter 0, inpatient and postacute care were 6.4 and 4.8 times greater, respectively, than the next largest component "other" ($2,903; 95% CI: $2,495–$3,369). Although inpatient and postacute care remained the largest components in the three subsequent quarters, both their absolute and relative costs declined with time (all $p < .05$, data not shown). In fact, by Quarter 3, postacute care costs surpassed inpatient costs and "other" costs were similar to inpatient costs.

For nonhospitalized fallers, outpatient ($482; 95% CI: $444–$582) and "other" ($422; 95% CI: $329–$524) costs had the largest cost attributable to falling in Quarter 0 (Table 3). Unlike trends for hospitalized fallers, the components driving nonhospitalized fallers' costs were not overwhelmingly larger than other components. In subsequent periods, outpatient costs remained a primary driver, and by Quarter 3, postacute care costs were similar to outpatient costs. The percentage change for each component cost is listed in the Supplementary Material.

Are All Component Costs Higher for Hospitalized Fallers Compared With Nonhospitalized Fallers in All Quarters After a Medical Fall?

The component costs attributable to hospitalized falls were not always greater than those for nonhospitalized falls (Table 4). In all quarters after index, hospitalized fallers' pharmacy and "other" costs were greater than nonhospitalized fallers' (all $p < .01$). For the first three quarters after index, hospitalized fallers' inpatient, emergency,

Table 2. Component Costs Attributable to Hospitalized Falls, for Quarter Years After the Index Fall Date

	Outpatient	Pharmacy	Emergency	Inpatient	Radiology	"Other"	Postacute care
Quarter 0							
Mean[a]	$431	$422	$1,906	$18,590	$138	$2,903	$14,061
95% CI[b]	$360 to $511	$348 to $503	$1,589 to $2,282	$14,543 to $23,709	$107 to $177	$2,495 to $3,369	$8,632 to $22,861
p value[c]	<.001	<.001	<.001	<.001	<.001	<.001	<.001
% of total[d]	1	1	5	48	0	8	37
Quarter 1							
Mean	$246	$192	$143	$1,165	$56	$806	$1,418
95% CI	$175 to $322	$136 to $256	$83 to $223	$587 to $1,988	$35 to $81	$560 to $1,095	$783 to $2,437
p value	<.001	<.001	<.001	<.001	<.001	<.001	<.001
% of total	6	5	4	29	1	20	35
Quarter 2							
Mean	$135	$235	$162	$891	$26	$308	$675
95% CI	$60 to $220	$162 to $316	$90 to $262	$409 to $1,563	$6 to $53	$118 to $544	$219 to $1,531
p value	<.001	<.001	<.001	<.001	.006	.001	<.001
% of total	6	10	7	37	1	13	28
Quarter 3							
Mean	$99	$311	$121	$498	$8	$489	$910
95% CI	$14 to $198	$207 to $430	$61 to $202	–$83 to $1387	–$12 to $33	$240 to $802	$153 to $2,828
p value	.021	<.001	<.01	.104	.459	<.001	.006
% of total	4	13	5	20	0	20	37

Notes: Regression model estimates are the differences in costs for hospitalized fallers had they not experienced a medical fall (in other words, compared to nonfallers). CI = confidence interval.

[a]All point estimates for means come from least squares means using the study sample.

[b]95% CIs were generated through bootstrapping.

[c]*p* value is a Wald test, where null hypothesis is that the cost attributable to falling is equal to zero. Standard errors were generated from bootstrapping.

[d]Reports the percentage of a given quarter's total cost attributable to falling explained by each component.

Table 3. Costs Attributable to Nonhospitalized Falls, for Quarter Years After the Index Fall Date

	Outpatient	Pharmacy	Emergency	Inpatient	Radiology	"Other"	Postacute care
Quarter 0							
Mean[a]	$482	$100	$214	$260	$131	$422	$143
95% CI[b]	$444 to $524	$79 to $121	$171 to $266	–$42 to $703	$101 to $166	$329 to $524	$58 to $288
p value[c]	<.001	<.001	<.001	.106	<.001	<.001	<.001
% of total[d]	28	6	12	15	7	24	8
Quarter 1							
Mean	$177	$38	$45	$111	$29	$158	$189
95% CI	$151 to $207	$15 to $64	$22 to $74	–$35 to $284	$16 to $45	$84 to $242	$77 to $365
p value	<.001	.002	<.001	.152	<.001	<.001	<.001
% of total	24	5	6	15	4	21	25
Quarter 2							
Mean	$139	$54	$34	$51	$42	$35	$64
95% CI	$112 to $170	$34 to $77	$13 to $60	–$96 to $236	$23 to $65	–$35 to $117	–$11 to $185
p value	<.001	<.001	.001	.53	<.001	.325	.106
% of total	33	13	8	12	10	8	15
Quarter 3							
Mean	$175	$66	$76	$88	$41	$116	$197
95% CI	$133 to $217	$39 to $97	$49 to $110	–$127 to $352	$21 to $65	$32 to $213	$64 to $412
p value	<.001	<.001	<.01	.46	<.001	.007	.001
% of total	23	9	10	12	5	15	26

Notes: Regression model estimates are the differences in costs for nonhospitalized fallers had they not experienced a medical fall (in other words, compared to nonfallers). CI = confidence interval.

[a]All point estimates for means come from least squares means using the study sample.

[b]95% CIs were generated through bootstrapping.

[c]*p* Value is a Wald test, where null hypothesis is that the cost attributable to falling is equal to zero. Standard errors were generated from bootstrapping.

[d]Reports the percentage of a given quarter's total cost attributable to falling explained by each component.

and postacute care costs were significantly greater (all $p < .05$) than nonhospitalized fallers' respective costs, but these differences were no longer significantly different by the fourth quarter after index (Quarter 3). Hospitalized fallers' outpatient and radiology costs were greater in the second quarter (Quarter 1) after the index date but lower than those of nonhospitalized fallers thereafter (all $p < .05$).

Discussion

Using the perspective of a health care delivery system, this study compared component costs for different cohorts after an incident medical fall in order to explain previously reported increased total health care costs in the year following a medical fall (Bohl et al., 2010). This analysis showed that several component costs increased after a medical fall and remained elevated for more than one quarter after the fall event and that component cost trajectories differed by severity of the medical fall. Specifically, the inpatient and postacute care components drove increased costs for hospitalized falls in all postfall quarters. Outpatient and "other" components drove increased costs in the index quarter for nonhospitalized fallers, and outpatient along with postacute care components predominated in subsequent quarters for nonhospitalized fallers. Component costs for hospitalized fallers were not always greater than those for nonhospitalized fallers, showing that increased medical fall severity does not necessarily result in persistently elevated inpatient, emergency, postacute care, outpatient, or radiology costs. Overall, these findings reinforce that medical falls increase costs for periods far beyond the acute injury period.

Of all types of falls, medical falls are most relevant to health care delivery systems, and our research findings can inform implementation of and research on medical fall treatment, rehabilitation, and prevention. First, our findings show that medical falls impact a diverse set of health services for at least 1 year after the index event, and other studies suggest that the impact on cost could last up to 2.5 years (Carter & Porell, 2011). Delivery systems—especially those experimenting with bundled payment for episodes of care—can compare their resource allocation to our estimates of the component costs attributable to medical falls in the index quarter and beyond.

Table 4. Cost Attributable to Increased Injury Severity (hospitalized vs. nonhospitalized), for Quarter Years After the Index Fall Date

	Outpatient	Pharmacy	Emergency	Inpatient	Radiology	"Other"	Postacute care
Quarter 0							
Mean[a]	–$80	$305	$1,630	$18,304	$14	$2,429	$13,789
95% CI[b]	–$160 to–$10	$232 to $387	$1,878 to $3,220	$12,251 to $25,567	–$5 to $37	$2,071 to $2,817	$9,645 to $19,648
p value[c]	.038	<.001	<.001	<.001	.174	<.001	<.001
% of total[d]	0	1	4	50	0	7	38
Quarter 1							
Mean	$48	$143	$82	$1,037	$27	$618	$1,023
95% CI	$21 to $123	$93 to $198	$24 to $159	$471 to $1,858	$10 to $47	$377 to $899	$408 to $2,008
p value	.165	<.001	.003	<.001	.001	<.001	<.001
% of total	2	5	3	35	1	21	34
Quarter 2							
Mean	–$22	$165	$115	$832	–$16	$266	$538
95% CI	–$110 to $66	$94 to $250	$49 to $211	$376 to $1,485	–$37 to $15	$77 to $497	$85 to $1,392
p value	.594	<.001	<.001	<.001	.278	.003	.012
% of total	–1	9	6	44	–1	14	29
Quarter 3							
Mean	–$100	$221	$13	$394	–$33	$346	$472
95% CI	–$191 to –$9	$117 to $344	–$49 to $101	–$172 to $1,267	–$52 to –$8	$94 to $655	–$263 to $2,252
p value	.034	<.001	.696	.198	.013	.005	.297
% of total	–8	17	1	30	–3	26	36

Notes: Regression model estimates are the differences in costs for hospitalized fallers had they experienced a nonhospitalized medical fall (in other words, hospitalized compared with nonhospitalized fallers). CI = confidence interval.

[a]All point estimates for means come from least squares means using the study sample.

[b]95% CIs were generated through bootstrapping.

[c]*p* Value is a Wald test, where null hypothesis is that the cost attributable to falling is equal to zero. Standard errors were generated from bootstrapping.

[d]Reports the percentage of a given quarter's total cost attributable to falling explained by each component.

Second, medical fall treatment and rehabilitation use a substantial amount of postacute and "other" care (e.g., ambulatory surgery or community health services), evidenced by their significant component cost attributable to falling in most time periods. Because there are substantial postacute care costs after a hospitalized fall, development of fall prevention interventions delivered upon discharge holds promise because knowledge of fall prevention for elderly inpatients is low (Hill et al., 2011). Third, our costs attributable to falling estimates come from a Medicare Advantage population, giving researchers interested in comparative health system evaluation estimates to compare with those from Medicare FFS populations. Fourth, our data show that many of the component costs remain increased throughout the first year after a medical fall, consistent with a study of Medicare FFS expenditures after a sentinel injury (Carter & Porell, 2011). Our finding suggests that future comparative- or cost-effectiveness analyses on geriatric injury prevention programs should use at least a 1-year follow-up, a recommendation that goes beyond the optimum 6-month timeframe for assessing mortality after geriatric injuries (Fleischman et al., 2010). Fifth, because both hospitalized and nonhospitalized medical falls have long-term cost consequences, health systems should establish how to best monitor the incidence of medical falls. Monitoring rates of medical falls over time is a relevant activity for delivery systems offering programs to prevent falls. Previous population-based studies have measured medical falls cared for at hospitals or emergency departments (Tinetti et al., 2008), but to date, national injury surveillance cannot track medical falls presenting in the outpatient setting only (Sleet et al., 2008), making it difficult to track costs across different providers and delivery systems. Sixth, more work is needed to explain why costs remain elevated after a medical fall. Possible explanations include rehabilitation, recurrent medical falls, or premature death because costs around the end of life are expensive (Fisher et al., 2003). Our findings suggest that some of the observed increase in component costs is likely to be caused by higher mortality rates experienced by faller groups compared with nonfallers.

Estimates from our analyses resemble those of previously published studies that focused exclusively on Medicare FFS populations. Roudsari and colleagues (2005) estimated that hospitalization for a medical fall totaled, on average, $20,511 (adjusted from 2004 to 2008 U.S. dollars) and emergency room and outpatient care totaled $277 and $483, respectively (adjusted from 2004 to 2008 U.S. dollars; Roudsari et al., 2005). Our estimates are similar: For the first 3 months after a fall, the inpatient cost attributable to hospitalized falls was $18,590 and the emergency and outpatient costs attributable to nonhospitalized falls were $214 and $482, respectively. Rizzo and colleagues (1998) found that compared with nonfallers, medical fallers had higher inpatient, nursing home, emergency room, and home health costs in the year after a fall. We also noted an increase in all component costs after a medical fall, but the size of these increases differed according to faller cohort over time. Stevens and colleagues (2006) produced an estimate on the cost burden of fall injuries at the population level. Pharmacy costs, however, were excluded from their study period because the data were pre-Medicare Part D implementation (Stevens et al., 2006). Combining our data on the average pharmacy cost per faller ($356) and the estimate of the average total cost per faller of Stevens and colleagues ($24,224 adjusted from 2000 to 2008 U.S. dollars), the economic burden of nonfatal fall injuries, from Medicare's perspective, increases by 1.5%, from $26.5 to $26.9 billion (2008 U.S. dollars). However, it is important to note that although our data augment previous studies, our analysis used data from a Medicare Advantage population in an integrated delivery system (as opposed to Medicare FFS) and defined cost from the system's perspective (instead of Medicare's).

Our results likely represent an underestimate of the costs attributable to falling, given that the full spectrum of long-term care costs—which include custodial care costs—was not contained within the postacute care cost component. Long-term care refers to both institutional nursing home care and home- and community-based services (HCBS). Given our analytic perspective of an integrated delivery system, we only included covered postacute care costs, such as Medicare-covered skilled nursing or home health. In the United States, integrated delivery systems, similar to the one we studied, do not pay for custodial care for their enrollees out of their Medicare funds; rather, this is a cost covered by Medicaid or paid out-of-pocket. Thus, these costs are not captured within Group Health's overall cost accounting system. However, because long-term care is costly (Kaiser Family Foundation Website, 2011) and not infrequent after a fall (Tinetti & Williams, 1997), it is important to remain cognizant of this particular component of long-term costs.

Our study has several limitations. First, we used ICD-9 and E-codes generated from automated administrative information systems to identify medical falls rather than through medical record review. Although most of the injuries for which an appropriate code was recorded were caused by falls (Masud & Morris, 2001), some may have been due to other causes; however, as demonstrated previously, cost estimates using this method tend to be conservative (Bohl et al., 2010; Roudsari et al., 2005). Second, our data did not allow us to identify which persons experienced a recurrent medical fall. Although validated approaches exist for tracking recurrent falls generally (Tinetti, Doucette, Claus, & Marottoli, 1995), tracking the subset of recurrent falls that presents for medical attention (i.e., "medical falls") has not been similarly worked out and, in particular, has not been worked out for studies relying solely on claims data, such as the present study. Third, although we adjusted for comorbidity among study subjects, we were unable to adjust for all potential confounders that might have contributed to the likelihood of falling and subsequent medical care use. Readers should interpret our results with caution because they are most likely biased upward due to the use of regression-based methods to attribute costs to medical falls. Our use of recycled coefficient estimates, however, attempts to address this issue. Fourth, our study data were derived from a Medicare Advantage program within a single integrated care delivery system, and as such, our results may not be generalizable to all other care settings. Although this is an important weakness, it is also a strength. Medicare Advantage populations are rarely the focus of costs of fall-related injuries studies. Furthermore, we believe our results are generalizable to most Medicare Advantage plans because all patients in this data set had access to benefit packages covered by traditional Medicare FFS, as is the case for patients covered by a Medicare Advantage plan. Future research should compare our results with those generated using data from different care settings.

This study has numerous strengths. First, it involved a large sample size, optimizing the statistical power for analysis. Second, it described costs over the dimensions of component, time, and injury severity. This approach is an incremental step toward identifying the services driving increased costs at varying points in time after a fall (Bohl et al., 2010; Stevens et al., 2006). Third, this study defined cost from the system's perspective (instead of society's, Medicare's, or the patient's). As such, out-of-pocket and other costs are not captured in the analysis. Previous studies took the perspective of allowable charges (Roudsari et al., 2005), Medicare (Rizzo et al., 1998; Stevens et al., 2006), or individuals (Carroll, Slattum, & Cox, 2005). Fourth, this study focused on medical falls, or the treated prevalence of fall-related injuries, and showed that preventing medical falls is not only a public health issue, it is also a health care system issue because medical falls result in health care utilization and are costly to treat. Fifth, the fact that nonfaller costs increase over time illustrates the importance of a control group for understanding the relative impact of medical falls on cost. Nonfaller costs increase because the study design restricts postacute care costs to $0 before the index date; additionally, health care costs tend to increase as persons age (Bird, Shugarman, & Lynn, 2002).

In summary, we found that the components driving increased costs after a medical fall vary over time and by injury severity. The large increase in costs after a hospitalized fall is mainly driven by inpatient and postacute care components. The spike in costs after a nonhospitalized fall is attributable to outpatient and "other" (e.g., ambulatory surgery) components. Inpatient, emergency, postacute care, outpatient, and radiology costs are not always greater for hospitalized compared with nonhospitalized fallers. Future studies should compare if delivering certain acute and postacute health services improve health and reduce cost trajectories after a medical fall more than others. Additionally, because the older adult population and the problem of falls are growing, health care delivery systems interested in tracking the cost of medical falls should first develop standardized methodology to monitor medical fall rates. Future studies should also determine the impact of differential timing of death on cost estimates of medical falls.

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Supplementary Material

Supplementary material can be found at: http://gerontologist.oxfordjournals.org.

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