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A FRAILTY INDEX PREDICTS SOME BUT NOT ALL ADVERSE OUTCOMES IN OLDER ADULTS DISCHARGED FROM THE EMERGENCY DEPARTMENT

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Abstract

Object—The goal of this study was to determine whether frail older adults, based on a deficit accumulation index (DAI), are at increased risk of adverse outcomes following discharge from the emergency department (ED).

Design—Secondary analysis of data from the Medicare Current Beneficiary Survey

Participants—1851 community-dwelling, Medicare fee-for-service enrollees, ≥ 65 years old who were discharged from the ED between January 2000 and September 2002.

Measurements—Primary dependent variable was time to first adverse outcome, defined as repeat outpatient ED visit, hospital admission, nursing home admission or death within 30 days of the index ED visit.

Results—Time to first adverse outcome was shortest among individuals with the highest number of accumulated deficits. The most frail participants were at greater risk of adverse outcomes following ED discharge compared to those who were least frail (HR 1.44, CI 1.06, 1.96). The most frail individuals were also at higher risk of serious adverse outcomes defined as hospitalization, nursing home admission or death (HR 1.98, CI 1.29, 3.05). In contrast, no association was detected between degree of frailty and repeat outpatient ED visits within 30 days (HR 1.06, CI 0.73, 1.54).

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Conclusion—The DAI as a construct of frailty was a robust predictor of serious adverse outcomes in the first 30 days after ED discharge. Frailty was not found to be a major determinant of repeat outpatient ED visits; therefore, additional study is needed to investigate this particular type of health service use among older adults.

Keywords

emergency department; health services utilization; deficit accumulation index; frailty

INTRODUCTION

Frail older adults are increasingly recognized as a population at significant risk for adverse outcomes such as functional decline, hospitalization and death.¹ Although considerable controversy exists about how best to identify frail individuals, one promising method is a deficit accumulation count.² This concept of frailty posits that the “count of what is wrong with you” is more important in contributing to vulnerability than specific conditions or physical limitations.³ Originally based on the components of a comprehensive geriatric assessment, the deficit accumulation index has now been operationalized using a variety of data sources and been shown to be robust in its prediction of poor health outcomes including institutionalization and death.^{2,4–6} Although the relationship between frailty as defined by the accumulation of deficits and mortality has been extensively examined, relatively little is known about the relationship between frailty and adverse outcomes in populations identified in specific clinical settings.

One important location for this type of research is the Emergency Department. ED use by older adults has risen dramatically over the past decade.⁷ In addition to being time- and resource-intensive, emergency care of older adults is frequently complicated by underlying chronic medical conditions and unmet social and physical needs.⁸ However, despite the complexities of their care, between one-half and two-thirds of older patients are discharged from the ED after a diagnosis and treatment plan have been formulated.⁹ Older adults who are discharged from the ED are at substantial risk for subsequent adverse outcomes including repeat health service use and death.^{10–15} Understanding whether frailty confers additional risk of adverse outcomes in this population could have important implications for risk screening as well as for ED resource planning and policy.

Because patients discharged from the ED frequently experience repeat ED visits that do not result in admission to the hospital as well as more serious events such as hospitalization, this population presents an opportunity for examining the association between frailty and different types of health service utilization. Hospitalization and nursing home admission are often due to serious illness or injury and are often considered “non-discretionary” types of health services. In contrast, ED visits that do not result in hospitalization (hereafter referred to as “outpatient ED visits”) are often for less acute conditions and, therefore, they may be more sensitive to other factors such as an individuals’ living situation, economic status or access to health care. The frailty index is a comprehensive measure of the whole health of individuals, however, it does not account for non-health related factors that may play a prominent role in outpatient service use. Thus, it is unknown whether the relationship between frailty and repeat outpatient ED visits may differ from other types of health service use.

This study was undertaken to determine whether frail older adults, based on a deficit accumulation index, are at increased risk of adverse outcomes following discharge from the ED. Specifically, our goal was to examine the association between frailty and (1) any adverse outcome, (2) outpatient ED visits, and (3) more serious events defined as hospitalization, nursing home admission or death.

METHODS

Design and Setting

This study was a secondary analysis of data from the Medicare Current Beneficiary Survey (MCBS) Cost and Use files and linked Medicare claims. The MCBS is a continuous survey of a nationally representative sample of Medicare beneficiaries drawn from the Centers for Medicare and Medicaid Services (CMS) enrollment file.¹⁶ The sample is stratified by age (with over-sampling of persons 85 and older) and drawn within zip code clusters designated as primary sampling units.¹⁶ Beneficiaries (or their proxies) are interviewed in person three times a year. The results from the survey are then combined with Medicare administrative claims data to provide additional information such as health care utilization event dates.¹⁶ MCBS survey and associated claims data were obtained from CMS following approval of data use agreement #17470. Approval for the study was also obtained from the Institutional Review Board of Duke University Medical Center.

Study sample

The study sample was restricted to community-dwelling subjects who were age-entitled to Medicare (i.e. 65 and over), not enrolled in a Medicare HMO and had at least one outpatient ED visit between January 2000 and September 2002. Subjects enrolled in a Medicare HMO plan were excluded because they did not have fee-for-service bills generated and therefore it was not possible to determine the dates of their health service use. Residents of long-term care facilities were excluded because a different data collection instrument was used for these individuals. Outpatient ED visits were based on Medicare claims.¹⁷ MCBS operates on a 4-year rotating panel design; therefore, subjects enter and leave the survey each year. To be included in this sample, participants had to be in the survey the year preceding their ED visit, so that data for predictor variables would be available, and for at least 90 days following their ED visit, so that outcome variables would be available. The cohort was originally constructed for a different study that used 90 day outcomes.¹⁸

Measurements

Deficit Accumulation Index: Frailty was defined by a Deficit Accumulation Index (DAI) which was constructed based on established methods for creating similar indices in other databases described by Rockwood and colleagues.^{2,4,6} The DAI was calculated based on the proportion of deficits present in an individual out of a possible 44 items considered (Table 1). Each health condition or impairment constituted one deficit on the DAI. Health conditions were defined as affirmative responses to items such as “Ever told you had diabetes?”. For items related to mobility and activities of daily living, participants were considered impaired (score=1) if they reported any difficulty with the task or inability to independently perform the task. For other items measured with an ordinal scale, two clinicians agreed on the response level that constituted an impairment. A higher proportion of deficits indicated a higher degree of frailty. The sample was then divided into 4 groups using the quartiles of the DAI measure. Reference cell coding was used to estimate the hazard for each quartile of increasing DAI, using participants who were least frail as the reference group.

Adverse Outcomes: The primary dependent variable was time to first adverse outcome, defined as repeat outpatient ED visit, hospital admission, nursing home admission or death, within 30 days of the index ED visit. The time frame of 30 days was chosen to reflect the time period when adverse events were most frequent¹⁸ and most likely to be related to the index ED visit. To explore whether frailty is equally predictive of different types of events, for additional analyses adverse events were further divided into the following distinct categories: (1) outpatient ED visits (ED visits that do not result in hospitalization) and (2) hospitalization, nursing home admission or death. Hospital admission, nursing home admission and death were

considered together because all are serious outcomes and there were insufficient numbers of events to permit separate analyses of nursing home admissions and deaths.

Covariates: Models were adjusted for socio-demographic variables and factors that have been previously shown to be important independent predictors of adverse outcomes in this population.¹⁸ These included: age (number of years), sex, race (white versus non-white), annual income (above or below the poverty line defined as $\geq \$10,000$ versus $< \$10,000$), living arrangements (alone versus with others), health insurance status (Medicaid versus other), recent outpatient ED visits (last 6 months, yes or no) and recent hospital admissions (last 6 months, yes or no).

Analysis—Sample weights were applied (all proportions presented are weighted) and statistical procedures that accounted for the complex sampling design of the MCBS were utilized for all analyses.¹⁹ In constructing the DAI, there was minimal missing data ($< 1\%$ missing values for any variable).

Thus, missing data were imputed using the most conservative approach; for any items that were missing, it was assumed the individual did not have the condition or impairment. Following calculation of basic descriptive statistics for all variables, Kaplan-Meier curves were constructed to illustrate event-free survival probabilities among patients in each quartile of the DAI. Cox proportional-hazards regression models were used to examine the relationship between DAI and event hazards (using the lowest quartile of DAI as the reference category). The proportionality assumption was checked by inspecting the graph of the $\log(-\log(\text{survival}))$ versus log of survival time, which resulted in approximately parallel lines for the 4 quartiles of the DAI. The first model evaluated time to first adverse event using the composite outcome of any outpatient ED visit, hospitalization, nursing home admission or death. The second model evaluated time to first outpatient ED visit. For this analysis, the competing risks of death or hospitalization were accounted for by subtracting inpatient hospitalization days from overall time at risk and censoring participants at time of death. The third model evaluated time to first hospitalization, nursing home admission or death. All models were constructed in three steps. First, only DAI and the outcome of interest were included in the model and crude hazards were estimated. Next, models were adjusted for demographics, living situation and insurance. Finally, recent ED visits and hospitalizations were added to the model to adjust for predisposition to repeat health service use. Results were expressed as hazard ratios (HR) and 95% confidence intervals (CI). Proportional hazards analyses were conducted using STATA® version 10 (StataCorp LP, College Station, TX); all other analyses were conducted using SAS® version 9.1.3 and SAS Enterprise Guide version 4.1 (SAS Institute, Inc., Cary, NC).

RESULTS

Sample characteristics

Of 17,552 subjects identified in MCBS file years 2000–2002 who were community-dwelling, age-entitled to Medicare, and not enrolled in a Medicare HMO, 3,512 (17.7%) had at least one outpatient ED visit between Jan 2000 and Sept 2002. A total of 1661 subjects were excluded from eligibility because 1) they were not in the survey the year preceding their ED visit and, therefore, data to calculate the DAI were not available or 2) they were not in the survey for at least 90 days following their ED visit and, therefore, data for outcome variables were not available. Consequently, a total of 1851 individuals constituted the analysis sample. All 1851 subjects had a DAI calculated and none were lost to follow up. Socio-demographic and clinical characteristics of the sample are displayed in Table 1.

Frailty according to DAI

Out of a possible maximum of 44, the number of deficits ranged from 0–36 (mean 11.3 and median 10). The quartile cutpoints for the DAI scores (expressed as a proportion: deficits present/possible deficits) were: 0.14, 0.23, and 0.36. The 99% limit for number of deficits was 31, representing a sub-maximal proportion of deficits of 0.70.

Frequency and type of adverse outcomes

A total of 394 (20.8% of 1851) beneficiaries discharged from the ED experienced one or more adverse outcomes within 30 days of the index visit (Table 2). The first adverse outcome was outpatient ED visit for 178/394 subjects and hospitalization, nursing home admission or death for 216/394 subjects. Overall, 199 (10.3%) patients returned to the ED but were not admitted, 205 (10.9%) were hospitalized, 27 (1.4%) were admitted to a nursing home, and 38 (2.2%) died within 30 days of ED discharge.

Relationship between DAI and any adverse outcome

The proportion of subjects who experienced any adverse outcome within 30 days of ED discharge increased according to the number of deficits. In the least frail group, 16.2% of subjects experienced an adverse outcome within 30 days compared to 27.4% of those in the most frail group. Time to first adverse outcome was shortest among the group with the highest number of deficits and longest among those with the lowest number of deficits (Figure 1).

Results of the proportional hazards analysis predicting time to first adverse outcome are displayed in Table 3. In unadjusted analyses, patients in the upper two quartiles were at higher risk of adverse outcomes compared to the least frail group HR 1.43 (1.10, 1.87) and HR 1.76 (1.31, 2.36) respectively). Adjusting for demographics, living arrangements, insurance status and recent health service use had modest effects on parameter estimates and confidence intervals.

Relationship between DAI and outpatient ED visits

There was little difference in the cumulative proportion of patients who experienced a repeat outpatient ED visit according to the DAI (8.6% in the lowest quartile compared to 9.8% in the highest quartile). Event-free survival curves overlap for most of the immediate post-index ED visit period, although they begin to separate according to DAI at around 20 days (Figure 2a). In unadjusted models, there was a trend toward modestly increased risk of repeat outpatient ED visits among the most frail group (HR 1.31, $P=0.14$). However, when additional non-health related factors were added to the model, this effect was no longer apparent (Table 3).

Relationship between DAI and hospitalization, nursing home admission or death

In contrast, more significant separation according to level of frailty was observed when serious outcomes (hospitalization, nursing home admission or death) were considered (Figure 2b). Higher number of deficits was associated with increased risk of hospitalization, nursing home admission or death in unadjusted and adjusted models (Table 3).

DISCUSSION

These data demonstrate a robust relationship between frailty as defined by a deficit accumulation index and subsequent adverse outcomes among older Medicare beneficiaries discharged from the ED. Risk of hospitalization, nursing home admission or death increased by 10–45% for each quartile of the DAI (i.e. with increasing frailty). In contrast, the risk of repeat outpatient ED visits was not significantly associated with level of frailty after adjustment for demographics, insurance status and previous health service use. These findings suggest that

repeat outpatient ED visits are a unique type of health service utilization that may be more significantly influenced by non-health related factors.

Although controversy abounds about how best to define frailty, many agree that its main consequence is an increased risk for adverse health-related outcomes.²⁰ Our findings are consistent with a growing number of studies that have measured frailty in relation to the accumulation of deficits and shown an association with adverse outcomes. Increased level of frailty as measured by deficit accumulation has been previously associated with increased mortality risk using a variety of data sources and patient populations,^{2,4,5,21–23} but the data on increased risk of institutionalization and higher number of hospital days have been limited to Canadian and Chinese populations respectively.^{2,4,5,23} The current study's findings extend previous work in a number of ways. First, these data demonstrate that frailty is associated with near-term (30-day) risk of adverse outcomes, specifically hospitalization, nursing home admission and death, in a US Medicare population. Second, these data indicate that frailty is predictive of subsequent adverse outcomes among subjects who were selected on the basis of an index type of utilization, an outpatient ED visit. Although the data were drawn from a population-based sample, all of the subjects included in this analysis were known health system "users". Finally, this study's adjustment for recent ED visits and hospitalizations accounted for the established relationship between previous and future health service utilization and thus increases our confidence with which the relationship between frailty and adverse outcomes can be reported.

This study also provides new insight into the relationship between frailty and an important but under-studied type of outpatient health care use among older adults: outpatient ED visits. Although frail older adults had slightly higher rates of repeat outpatient ED visits, this disparity was accounted for by other characteristics of this population including demographics, insurance status and previous health service use. The fact that such a comprehensive profile of patients' medical and functional status did not predict repeat outpatient ED use suggests that this particular type of ED utilization may be largely influenced by other factors such as barriers to obtaining follow-up care in other locations. Although there was little separation in event-free survival curves for outpatient ED visits in the period immediately following the index ED visit, the curves begin to separate according to level of frailty around day 20. Patients who return to the ED early after an index visit tend to go back for same problem,¹² again suggesting that lack of follow-up care may be playing a role in this type of utilization. As time goes on, frail older adults are at higher risk of developing new conditions and may well utilize more outpatient ED care overall. Without additional clinical data, these issues cannot be addressed definitively and further research in this area is clearly needed. Given that older adults account for more than 8 million outpatient ED visits annually, additional study in this area is of great importance for policy-making and resource-planning.

This study has a number of limitations. First, the DAI was constructed from survey data reported between one and 15 months preceding the index ED visit. Obtaining health status variables from the survey year preceding the index visit was necessary to ensure that these represented the beneficiary's pre-event level of health and function, however it is possible that the health status of some beneficiaries may have changed during this time. Second, because this sample was restricted to individuals who were aged 65 or over, community-dwelling and Medicare fee-for-service enrollees, this study does not provide information about younger Medicare beneficiaries, those residing in long-term care facilities and those enrolled in Medicare HMO plans. Third, use of a DAI to define frailty is only one approach and other measures of frailty may produce different results. Finally, further study is needed to determine whether deficit accumulation can be further operationalized and refined into a clinically useful construct.

Despite these limitations, these data provide important insights into the relationship between frailty as measured by the accumulation of deficits and adverse outcomes in a cohort of older Medicare beneficiaries discharged from the ED. Frailty has been defined as an excess vulnerability to stressors, with reduced ability to maintain or regain homeostasis after a destabilizing event.¹ These data suggest that an ED visit that does not result in hospitalization, qualifies as a destabilizing event in the life of a frail older adult. Patients with higher numbers of deficits were at increased risk of hospitalization, nursing home admission or death in the 30 days following their discharge from the ED. Repeat outpatient ED visits were not predicted by level of frailty and more study is needed to investigate the determinants of this unique type of health service utilization.

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Figure 1. Survival curve for first adverse outcome (outpatient ED visit, hospitalization, nursing home admission or death) according to level of frailty, adjusted for demographics, living situation, insurance status and previous health service use ($P=0.0036$ for overall difference between groups).

Figure 2.

Figure 2a. Survival curve for repeat outpatient ED visit according to level of frailty, adjusted for demographics, living situation, insurance status and previous health service use ($P=0.51$ for overall difference between groups).

Figure 2b. Survival curve for hospitalization, nursing home admission or death according to level of frailty, adjusted for demographics, living situation, insurance status and previous health service use ($P=0.0002$ for overall difference between groups).

Table 1

Selected characteristics of Medicare beneficiaries with at least one ED visit between January 2000 and September 2002, N=1851

	Raw N (weighted %)
Age, mean (SE)	77.3 (0.14)
Female	1138 (61.8)
Non-white race	269 (13.5)
Annual income < 10K	451 (22.3)
Lives alone	652 (33.7)
Medicaid insurance	386 (19.7)
Recent outpatient ED visit	131 (6.7)
Recent hospitalization	344 (18.2)
Variables used to construct DAI*	
Difficulty stooping, kneeling	1468 (78.6)
Arthritis	1189 (63.6)
Hypertension	1170 (62.5)
Difficulty walking	1092 (57.1)
Difficulty lifting 10 lbs	900 (47.0)
Hearing difficulty	858 (44.3)
Vision difficulty	799 (42.4)
Health limited social life past month	796 (41.6)
Difficulty doing heavy housework	792 (40.9)
Other heart conditions	714 (38.4)
Difficulty reaching over head	686 (36.0)
Difficulty writing	633 (33.0)
Difficulty walking	585 (30.5)
Cataracts	606 (30.4)
Fair or poor self-rated health	566 (29.9)
Lost urine last 12 months	426 (22.3)
Diabetes	409 (22.1)
Other cancer	386 (21.1)
Skin cancer	372 (19.8)
Osteoporosis	356 (19.7)
Difficulty shopping	383 (19.1)
Myocardial infarction	348 (18.7)
Emphysema, asthma or chronic obstructive pulmonary disease	328 (18.0)
Difficulty doing light housework	345 (17.4)
Angina	319 (17.2)
Difficulty getting in/out of chairs	327 (17.0)
Difficulty bathing	309 (15.4)
Stroke/brain hemorrhage	281 (14.4)
Trouble concentrating	287 (14.4)
Memory loss interferes with activity	263 (13.2)
Difficulty making meals	267 (13.1)

	Raw N (weighted %)
Hardening of the arteries	244 (13.0)
Difficulty eating solid foods	222 (11.5)
Rheumatoid arthritis	200 (10.8)
Difficulty managing money	206 (9.9)
Mental disorder	176 (9.7)
Difficulty dressing	183 (9.3)
Difficulty using the phone	174 (8.5)
Difficulty using the toilet	163 (8.3)
Problem making decisions	170 (8.2)
Broken hip	101 (4.8)
Alzheimer's disease	68 (3.2)
Difficulty eating	56 (2.9)

*
Listed in order of decreasing prevalence

Table 2

Proportion of patients with adverse outcomes within 30 days following discharge from the ED, N=1851

	First adverse outcome [#] Raw n (weighted %)	Cumulative adverse outcomes [†] Raw n (weighted %)
Outpatient ED visit	178 (9.2)	199 (10.3)
Hospital admission	186 (9.9)	205 (10.9)
Deaths	28 (1.7)	38 (2.2)
Nursing home admission	2 (0.09)	27 (1.4)
Any adverse outcome (outpatient ED visit, hospital admission, nursing home admission or death)	394 (20.8)	469* (20.8)

[#] First adverse outcome of any type (maximum one per subject)[†] Total number of outcomes during the follow-up period (subjects could have more than one)

* 394 subjects experienced a total of 469 adverse outcomes

Table 3
Proportional hazards analysis of first adverse events by deficit accumulation index (DAI), * N=1851

Any adverse event (repeat outpatient ED visit, hospital admission, nursing home admission or death)						
	Model 1 [*]		Model 2 [‡]		Model 3 [§]	
	Unadjusted HR (95% CI)	P-value	Adjusted HR (95% CI)	P-value	Adjusted HR (95% CI)	P-value
DAI quartile 1 (lowest)	reference		reference		reference	
DAI quartile 2	1.23 (0.93, 1.64)	.15	1.22 (0.92, 1.62)	.17	1.20 (0.91,1.60)	.19
DAI quartile 3	1.43 (1.10, 1.87)	.008	1.40 (1.07, 1.83)	.014	1.33 (1.02, 1.77)	.036
DAI quartile 4	1.76 (1.31, 2.36)	<.0001	1.66 (1.21, 2.27)	.002	1.44 (1.06, 1.96)	.019
Repeat outpatient ED visit						
	Model 1 [*]		Model 2 [‡]		Model 3 [§]	
	Unadjusted HR (95% CI)	P-value	Adjusted HR (95% CI)	P-value	Adjusted HR (95% CI)	P-value
DAI quartile 1 (lowest)	reference		reference		reference	
DAI quartile 2	.97 (.65, 1.49)	.87	.95 (.63, 1.40)	.78	.93 (.62, 1.39)	.73
DAI quartile 3	1.16 (.81, 1.63)	.41	1.13 (.76, 1.68)	.52	1.10 (.74, 1.64)	.63
DAI quartile 4	1.31 (.91, 1.85)	.14	1.21 (.84, 1.74)	.31	1.06 (.73, 1.54)	.76
Hospitalization, nursing home admission or death						
	Model 1 [*]		Model 2 [‡]		Model 3 [§]	
	Unadjusted HR (95% CI)	P-value	Adjusted HR (95% CI)	P-value	Adjusted HR (95% CI)	P-value
DAI quartile 1 (lowest)	reference		reference		reference	
DAI quartile 2	1.45 (.97, 2.16)	.07	1.47 (.99, 2.18)	.057	1.45 (.98, 2.16)	.066
DAI quartile 3	1.66 (1.11, 2.48)	.013	1.66 (1.11, 2.49)	.013	1.55 (1.04, 2.33)	.033

Any adverse event (repeat outpatient ED visit, hospital admission, nursing home admission or death)					
	Model 1 [*]		Model 2 ^{&}		Model 3 [§]
	Unadjusted HR (95% CI)	P-value	Adjusted HR (95% CI)	P-value	Adjusted HR (95% CI) P-value
DAI quartile 4	2.42 (1.63, 3.59)	<.0001	2.35 (1.52, 3.61)	<.0001	1.98 (1.29, 3.05) .002

^{*} Model 1 - unadjusted

[&] Model 2 - adjusted for age, sex, race, income, living alone, insurance status

[§] Model 3 - adjusted for age, sex, race, income, living alone, insurance status, previous ED visits, previous hospitalizations

DAI=Deficit Accumulation Index

The quartile cutpoints for the DAI scores (expressed as a proportion: deficits present/possible deficits) were: 0.14, 0.23, and 0.36.