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Research Article

Claims-Based Frailty Index as a Measure of Dementia Severity in Medicare Claims Data

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Abstract

Background: Dementia severity is unavailable in administrative claims data. We examined whether a claims-based frailty index (CFI) can measure dementia severity in Medicare claims.

Methods: This cross-sectional study included the National Health and Aging Trends Study Round 5 participants with possible or probable dementia whose Medicare claims were available. We estimated the Functional Assessment Staging Test (FAST) scale (range: 3 [mild cognitive impairment] to 7 [severe dementia]) using information from the survey. We calculated CFI (range: 0–1, higher scores indicating greater frailty) using Medicare claims 12 months prior to the participants' interview date. We examined C-statistics to evaluate the ability of the CFI in identifying moderate-to-severe dementia (FAST stage 5–7) and determined the optimal CFI cut-point that maximized both sensitivity and specificity.

Results: Of the 814 participants with possible or probable dementia and measurable CFI, 686 (72.2%) patients were ≥75 years old, 448 (50.8%) were female, and 244 (25.9%) had FAST stage 5–7. The C-statistic of CFI to identify FAST stage 5–7 was 0.78 (95% confidence interval: 0.72–0.83), with a CFI cut-point of 0.280, achieving the maximum sensitivity of 76.9% and specificity of 62.8%. Participants with CFI ≥0.280 had a higher prevalence of disability (19.4% vs 58.3%) and dementia medication use (6.0% vs 22.8%) and higher risk of mortality (10.7% vs 26.3%) and nursing home admission (4.5% vs 10.6%) over 2 years than those with CFI <0.280.

Conclusions: Our study suggests that CFI can be useful in identifying moderate-to-severe dementia from administrative claims among older adults with dementia.

Keywords: Administrative claims data, Dementia, Frailty

Background

In the United States, about 1 in 7 older adults above the age of 70 have dementia. Older adults with dementia are more prone to disability, poor health, and increased health care costs and utilization (1). Due to their complexity, these individuals are often excluded in randomized clinical trials thus limiting the evidence on how to improve their care. To address this, administrative claims data are increasingly used to study health outcomes and the effectiveness of health interventions among older adults with dementia. These studies define dementia using diagnosis codes (2,3). However, there is no claims-based algorithm to measure the severity of dementia. In clinical practice, dementia severity is measured using Functional Assessment Staging Test (FAST) (4), Global Deterioration Scale (5), or Clinical Dementia Rating scale (6). Although these measures consider a constellation of symptoms, functional status, and cognitive ability, a patient's ability to perform activities of daily living (ADLs) is a key factor in determining dementia severity, especially in identifying those with moderate-to-severe dementia.

Previously, we developed a claims-based frailty index (CFI) (7); although the Kim CFI was developed to estimate a deficit-accumulation frailty index, it also had a C-statistic of 0.84 for 2 or more ADL dependency in Medicare beneficiaries after age and sex adjustment (8–10). In the absence of a claims-based measure of dementia severity, we postulated that the CFI would help identify patients with moderate-to-severe dementia. A tool to identify moderate-to-severe dementia in Medicare claims data may be helpful for evaluating outcomes of drug therapy, surgical procedures, and health care services

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in beneficiaries living with dementia as well as population health management and resource allocation.

In this context, we analyzed the National Health and Aging Trends Study (NHATS)-Medicare linked data to (i) measure dementia severity via FAST stage, calculated from the NHATS survey, and (ii) measure the Kim CFI, calculated from Medicare claims data. We then assessed the usefulness of CFI in identifying people with moderate-to-severe dementia and determined the optimal CFI cut-point.

Method

Data Sources and Study Population

NHATS is an annual survey of a nationally representative sample of Medicare beneficiaries over the age of 65 years. Beneficiaries who were Black or of older ages were oversampled to improve precision of estimates for these subgroups (11). Information about demographic characteristics, health status, functioning, and cognitive status was collected via in-person assessments. NHATS survey information was linked to Medicare data for fee-for-service (FFS) beneficiaries (12,13). Our study population included the 2015 NHATS (Round 5) participants who were living in the community; had possible or probably dementia according to the NHATS dementia classification algorithm (see details later); and were continuously enrolled in Medicare FFS Part A and B for 12 months prior to their interview date to allow calculation of CFI. Of the 8 334 participants of the 2015 NHATS survey, we excluded those who were living in residential care (n = 565) or nursing home (n = 403), deceased by Round 5 (n = 296), and those who did not have dementia (n = 5 595). Of the remaining 1 475 community-dwelling participants with dementia, 661 were excluded because they lacked continuous enrollment in Medicare FFS data in the previous 12 months. Our final sample included 814 participants with dementia.

NHATS Dementia Classification

In NHATS, a participant was classified as having either "possible dementia" or "probable dementia" based on (i) the presence of self-reported history of dementia diagnosis, (ii) met criteria for 8-item Informant Interview to Differentiate Aging and Dementia (≥2 points), and (iii) performance ≤1.5 standard deviations (*SD*) below the population mean in at least one of the cognitive domains (orientation, memory, and executive function). In cognitive testing, orientation was measured by asking participants to recite the date, President, and Vice President of the United States; memory was assessed using a delayed word-recall test; and executive function was evaluated using a clock-drawing test (14). When dementia was cited as the reason for proxy interview or nonparticipation in cognitive testing, participants were classified as having "probable dementia."

Functional Assessment Staging Test

FAST staging is a 7-stage scale based on the course of functional deterioration in people with dementia (1: normal aging; 2: possible mild cognitive impairment; 3: mild cognitive impairment; 4: mild dementia; 5: moderate dementia; 6: moderately severe dementia; 7: severe dementia) (4). Among the various possible dementia severity scales used in clinical settings, we chose to use FAST scale due to two reasons. First, the FAST scale could be operationalized using data available from NHATS survey questions. Second, the FAST scale is a clinical tool that has similar properties of measuring functional status to CFI and therefore can serve as a reference to validate the ability of CFI to capture dementia severity. Because we only included participants with dementia, we operationalized FAST scale from 3 to 7 using information on ADLs, instrumental activities of daily living (IADLs), and other relevant symptoms (Table 1). Participants' FAST stage was defined starting with the most severe level (FAST 7) and continuing in descending order. For example, participants were categorized in FAST 7 if they satisfied all of the following criteria: (i) 3–6 IADL disability with at least one being finances, medications, or cooking; (ii) ADL disability with dressing, bathing, and toileting; (iii) incontinence; and (iv) either impaired speech or a need for help getting out of bed and not moving inside the house in the last month. Participants were categorized in FAST 6D-E if they did not fulfill the criteria for FAST 7 and had (i) 3–6 IADL disability and (ii) incontinence (Table 1). A similar hierarchical definition was applied to the remainder of the FAST stages.

Other Measurements

We used information on age, sex, race/ethnicity, education, participation of a proxy, self-reported comorbid conditions, and disability. ADL disability was defined as requiring help from someone to perform feeding, dressing, walking, transferring, bathing, or toileting. IADL disability was defined as either requiring help from others, not doing the activity in the last month, or not doing the activity sometimes due to difficulty in performing driving or using public transportation, shopping, cooking, doing the laundry, managing medications, or managing finances (15). Dementia medication use was ascertained from Medicare Part D claims within 1 year of the survey date, which included any of donepezil, galantamine, rivastigmine, or memantine. Death was defined if the date of death was given or death was the reason for not completing a follow-up interview. Using the Minimum DataSet (MDS 3.0), we defined time to nursing home admission from the survey interview for participants with nursing home stays longer than 100 days in the following 2 years (16).

Claims-Based Frailty Index

The Kim CFI (range: 0–1, higher scores indicating greater frailty) was calculated using 93 variables defined by diagnosis codes, Current Procedural Terminology codes, and Healthcare Common Procedure Coding System codes on Medicare claims in 12 months prior to the NHATS interview (https://dataverse.harvard.edu/dataverse/cfi). CFI estimates a deficit-accumulation frailty index and has been validated against physical performance, ADL and IADL disability, and future risk of death, institutionalization, health care utilization, and cost (7–10,17).

Statistical Analysis

We characterized the study population. We estimated C-statistic and 95% confidence interval (CI) of CFI for identifying moderate-to-severe dementia (FAST stage 5–7) and estimated sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) at CFI cut-points of 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, and 0.45. We determined the optimal CFI cut-point that maximized the sum of sensitivity and specificity. In addition, we examined

Table 1. Operationalizing Functional Assessment Staging Tool Scale in NHATS

Stage	FAST Criteria	NHATS Definition		
		IADLs[†]	ADLs[‡]	Additional Criteria
3	Objective functional deficit which interferes with a person's most complex tasks	Any number of disabilities	Any number of disabilities	Did not fulfill criteria for FAST 4–7
4	IADLs become affected	3–6 IADL disabilities (one must either be needing help with finances, medications, or cooking)	Any number of disabilities	Did not fulfill criteria for FAST 5–7
5	Needs help selecting proper attire		Needs help with dressing	Did not fulfill criteria for FAST 6B-7
6A	Needs help putting on clothes			
6B	Needs help bathing		Needs help with dressing and bathing	Did not fulfill criteria for FAST 6C-7
6C	Needs help toileting		Needs help with dressing, bathing, and toileting	Did not fulfill criteria for FAST 6D-7
6D	Urinary incontinence		Needs help with dressing, bathing, and toileting	Has incontinence -AND- Did not fulfill criteria for FAST 7
6E	Fecal incontinence			
7A	Speaks 5–6 words[*]		Needs help with dressing, bathing, and toileting	Has incontinence -AND- EITHER Has a proxy and cannot answer cognitive items because the individual is unable to speak or has impaired speech -OR- Needs help to get out of bed and has not moved inside the house in the last month
7B	Speaks only 1 word clearly[*]			
7C	Can no longer walk			
7D	Can no longer sit up			
7E	Can no longer smile			
7F	Can no longer hold up head			

Notes: ADL = activities of daily living; FAST = Functional Assessment Staging Test; IADL = instrumental activities of daily living; NHATS = National Health and Aging Trends Study.
[*]In the course of an average day or during an intensive interview.
[†]The following IADLs were assessed: getting around (driving or using public transportation), shopping, cooking, doing the laundry, managing medications, and managing finances.
[‡]The following ADLs were assessed: feeding, dressing, walking, transferring, bathing, and toileting.

cut-points that yielded an 80% sensitivity or 80% specificity. To assess the criterion validity, we compared the proportion of concurrent ADL and IADL disability, dementia medication use, and age- and sex-adjusted cumulative incidence of death and nursing home admission over 2 years based on the optimal CFI cut-point. Cumulative incidence was estimated using the Cox model for death and using the Fine and Gray model (accounting for death as a competing risk) for nursing home admission after adjusting for age and sex. A 2-sided p value of <.05 was considered statistically significant. To assess generalizability of our study sample, we compared the characteristics of participants with dementia who met the criteria for inclusion because they had 12-month FFS claims and those who did not, using t test and chi-square test. All analyses were conducted in Stata version 16.1 (StataCorp LLC, College Station, TX) and SAS 9.4 (SAS Institute, Cary, NC) using survey procedures to account for the complex survey design of NHATS and weighted to reflect national estimates.

Results

Characteristics of Study Population

Our study sample included 814 community-dwelling beneficiaries with possible or probable dementia, representing 3.11 million adults in the United States (18). Overall, 72.2% of participants in this study were aged 75 years or older, 50.8% female, and 70.1% were non-Hispanic White beneficiaries (Table 2). Hypertension (72.6%), ADL disability (37.7%), and IADL disability (81.5%) were common. Among the 814 beneficiaries with possible or probable dementia, 311 (42.4%) were categorized as mild cognitive impairment (FAST 3), 259 (31.8%) were mild dementia (FAST 4) and 244 (25.9%) had moderate-to-severe dementia (FAST stage 5–7). The mean (*SD*) CFI was 0.290 (0.094). The demographic and clinical characteristics of participants with dementia who were included were similar to those with dementia who were excluded because CFI could not be computed, except for a lower prevalence of diabetes (29.8% vs 36.1%, p = .038; Supplementary Table 1).

CFI as a Dementia Severity Measure

The C-statistic of CFI to identify FAST stage 5–7 was 0.78 (95% CI: 0.72–0.83; Figure 1). The CFI cut-point of 0.280 yielded a maximized sensitivity of 77% and specificity of 63%. The CFI cut-point 0.269 achieved an 80% sensitivity and the cut-point 0.327 achieved an 80% specificity. Table 3 presents the performance of CFI at various cut-points in identifying moderate-to-severe dementia among NHATS participants with possible or probable dementia.

Overall, the performance of CFI at different cut-points demonstrated a trade-off between sensitivity and specificity. Increasing the cut-point improved specificity, reducing false positives but also resulting in a decrease in sensitivity, potentially leading to false negatives. For example, at a cut-point of ≥0.350, CFI demonstrated a specificity of 0.85 (0.82–0.88), with the sensitivity decreased to 0.49 (0.41–0.57), indicating that CFI may fail to detect nearly half of the participants with moderate-to-severe dementia. At this cut-point, the PPV was 0.53 (0.44–0.63), indicating that slightly more than half of the participants with CFI ≥0.350 had moderate-to-severe dementia. The NPV remained relatively high across different cut-points.

Table 2. Characteristics of NHATS Participants With Possible or Probable Dementia and Fee-For-Service Medicare Enrollment for 12 Months Before Round 5 (n = 814)

Characteristic	*n* (%)
Age ≥75 years old	686 (72.2)
Female	448 (50.8)
Race	
Non-Hispanic White	466 (70.1)
Black	233 (12.9)
Other	88 (13.3)
Unknown	27 (3.7)
Proxy interview	179 (20.6)
Education	
Less than a high school diploma	314 (32.8)
High school diploma	227 (31.7)
Some college years, associate degrees	136 (17.4)
College graduate or postgraduate	111 (14.4)
Self-reported comorbid conditions	
Cancer (excluding skin cancer)	81 (12.8)
Dementia	254 (29.0)
Diabetes	236 (29.8)
Heart disease	200 (22.7)
Hypertension	618 (72.6)
Lung disease	150 (18.6)
Stroke	86 (10.2)
ADL disability	354 (37.7)
IADL disability	684 (81.5)
Dementia severity (FAST stage)	
Mild cognitive impairment (3)	311 (42.4)
Mild dementia (4)	259 (31.8)
Moderate-to-severe dementia (5–7)	244 (25.9)
CFI, mean (*SD*)	0.290 (0.094)

Notes: ADL = activities of daily living; CFI = Claims-based Frailty Index; FAST = Functional Assessment Staging Test; IADL = instrumental activities of daily living; *SD* = standard deviation. Sample sizes (n) and percentages weighted to reflect national estimates are presented.

Criterion Validity of CFI-Based Dementia Severity

Participants with CFI ≥0.280 had a higher prevalence of ADL disability (CFI <0.280 vs CFI ≥0.280: 19.4% vs 58.3%), IADL disability (72.0% vs 92.3%), and dementia medication use (6.0% vs 22.8%) at baseline and higher age- and sex-adjusted cumulative incidence of mortality (10.1% vs 23.1%) and nursing home admission (4.3% vs 9.8%) over 2 years than those with CFI <0.280 (Table 4).

Discussion

Our study suggests that CFI may be a valuable tool for identifying moderate-to-severe dementia from administrative claims data. The NHATS participants who were identified to have moderate-to-severe dementia based on CFI ≥0.280 had a higher prevalence of ADL and IADL disability and dementia medication use and a higher risk of mortality and nursing home admission in the future. The use of CFI may provide insights into the burden and outcomes of dementia in older Medicare population.

Previous research mainly focused on the identification of diagnosed dementia from administrative claims data

(3,19–21). The prevalence of dementia based on claims-based algorithms ranges from 12.7% (3) to 14.4% (22,23). Although clinically significant dementia cases are more likely to be coded in claims data (20), there has been little effort to determine dementia severity from claims data. Knox et al. (24) reconstructed the FAST scale using ADL and IADL disability items obtained during the home health Outcomes Assessment Information Set. However, this scale could be calculated only for those receiving home health care, of whom 75.9% had moderate-to-severe dementia (FAST stage 5–7) (24). The population had relatively more severe dementia compared with the overall population with dementia because 25% had been hospitalized before receiving home health services (24). In contrast, our study using the NHATS survey included a nationally representative sample of Medicare beneficiaries with dementia (25), and 25.9% had FAST stage 5–7. In addition, we estimated the dementia severity using CFI, which facilitates ascertainment for a broader population of FFS beneficiaries, regardless of home health use.

A growing body of literature showed that frailty and dementia often coexist, with a potentially bidirectional relationship (26–28). Petermann-Rocha et al. found that physical frailty was a risk factor for incident dementia (28). Other studies suggested that measures of physical frailty, such as impairments in grip strength, balance, or gait speed, had been attributed to cognitive impairment among people with frailty (29–32). A prior validation study demonstrated a correlation between the Kim CFI and poor physical function and functional limitations (8), which might account for the CFI's ability to detect older adults with moderate-to-severe dementia. Another study demonstrated that individuals with CFI score in the range of 0.25–0.34 had a 28% risk of death and an 11% risk of institutionalization for long-term care (8), aligning with the risk observed in our findings.

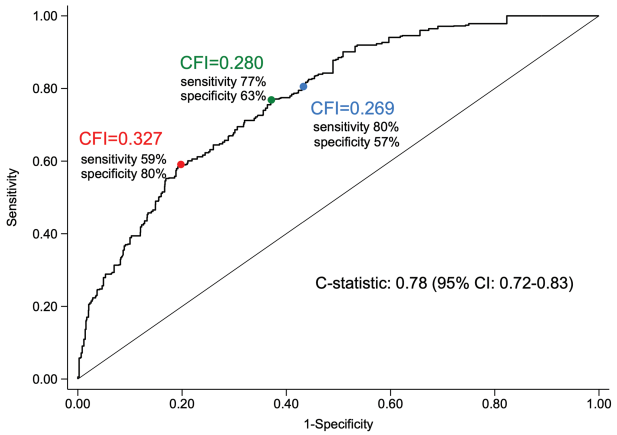

Figure 1. Receiver-operating characteristics curve of CFI in identifying moderate-to-severe dementia. CFI = Claims-based Frailty Index; FAST = Functional Assessment Staging Test. The CFI cut-point of 0.280 achieved the maximum sensitivity 77% and specificity 63% for detecting moderate-to-severe dementia (FAST stage 5–7). A CFI score of 0.269 achieved sensitivity 80% and specificity 57%, and a CFI score of 0.327 achieved specificity 80% and sensitivity 59%.

Our study has important limitations. First, misclassification by dementia status is possible. The NHATS dementia classification in part relied on self-reported physician diagnosis of dementia (n = 125), proxy report (n = 179), and AD8 ≥2 (n = 41). This classification system does not consider the interference of cognitive impairment with daily function, which is a required criterion for dementia diagnosis. However, the majority of participants with possible or probable dementia in our study had functional impairment (81.5% IADL disability and 37.7% ADL disability) and approximately 20.6% was classified by proxy (14). Second, our analysis was limited to community-dwelling participants with dementia who completed the NHATS Round 5 survey and required 12 months of continuous Part A and B enrollment so that CFI could be calculated. The similarities in characteristics between those with dementia who were included in the study and those excluded because CFI could not be determined are reassuring that our findings may be generalizable to other Medicare beneficiaries with dementia. However, additional validation studies are warranted. Third, approximately 70% of participants were classified as FAST stage 3–4, corresponding to mild dementia. The prevalence of moderate-to-severe dementia in our study population was 25.9%, which explains the moderate PPV observed for the CFI-based dementia severity assessment. If the prevalence of moderate-to-severe dementia were 50% (eg, as in the nursing home setting) (33), our optimal CFI cut-point of 0.280 would result in PPV of 67.4% and NPV of 73.1%. Fourth, estimates of dementia medications are underestimated because utilization could only be assessed among beneficiaries with Part D insurance. Lastly, because our measure of moderate-to-severe dementia is tightly linked to moderate-to-severe CFI, it remains unclear whether we can distinguish older adults with dementia living with moderate-to-severe frailty from those with moderate-to-severe dementia.

Table 3. Performance of CFI in Identifying Moderate-to-Severe Dementia Among NHATS Participants With Possible or Probable Dementia (n = 814)

CFI Cut-Point	Moderate-to-Severe Dementia (FAST Stage 5–7)			
	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
≥0.15	1.00 (1.00–1.00)	0.14 (0.10–0.18)	0.29 (0.26–0.32)	1.00 (1.00–1.00)
≥0.20	0.97 (0.94–1.00)	0.31 (0.25–0.36)	0.33 (0.29–0.37)	0.97 (0.93–1.00)
≥0.25	0.89 (0.82–0.95)	0.49 (0.44–0.54)	0.38 (0.33–0.43)	0.93 (0.88–0.97)
≥0.30	0.68 (0.59–0.76)	0.70 (0.66–0.75)	0.44 (0.38–0.50)	0.86 (0.82–0.90)
≥0.35	0.49 (0.41–0.57)	0.85 (0.82–0.88)	0.53 (0.44–0.63)	0.83 (0.80–0.86)
≥0.40	0.25 (0.18–0.32)	0.96 (0.94–0.97)	0.66 (0.53–0.79)	0.78 (0.75–0.81)
≥0.45	0.10 (0.05–0.14)	0.99 (0.98–0.10)	0.75 (0.54–0.95)	0.76 (0.73–0.79)

Notes: CFI = Claims-based Frailty Index; CI = confidence interval; FAST = Functional Assessment Staging Test; NPV = negative predictive value; PPV = positive predictive value.

Table 4. Dementia-Related Characteristics by CFI-Defined Dementia Severity Among NHATS Participants With Possible or Probable Dementia (n = 814)

Characteristics	CFI <0.280 (n = 388) n (%)	CFI ≥0.280 (n = 426) n (%)
FAST stage 5–7	49 (11.4)	195 (42.0)
ADL disability	84 (19.4)	270 (58.3)
IADL disability	287 (72.0)	397 (92.3)
Dementia medications	24 (6.0)	98 (22.8)
Death in 2 years*	46 (10.1)	145 (23.1)
Nursing home admission in 2 years*	—†	50 (9.8)

Notes: ADL = activities of daily living; CFI = Claims-based Frailty Index; FAST = Functional Assessment Staging Test; IADL = instrumental activities of daily living. Data were presented in *N* (%), where the percentage represents the national estimates from the survey weighting procedure.
*For death and nursing home admission, age- and sex-adjusted cumulative incidence was presented in parentheses.
†This estimate does not meet minimum cell size requirements (<11) for presentation and is, therefore, suppressed in accordance with the Centers for Medicare & Medicaid Services (CMS) suppression policy.

In conclusion, our study results support the use of Kim CFI in combination with dementia diagnosis as a novel method for identifying moderate-to-severe dementia from administrative claims data among Medicare beneficiaries. Our findings demonstrate high criterion validity by differentiating mild from moderate-to-severe dementia groups through associations with disability, dementia medication use, risk of 2-year mortality, and nursing home admission. Future research is needed to validate our findings on different data sources to ensure a more accurate performance.

Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences* online.

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Conflict of Interest

D.H.K. received personal fee from Alosa Health and VillageMD for unrelated work. The other authors have no conflict of interest to declare.

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Author Contributions

Study design and concept: C.M.P., D.H.K. Acquisition, analysis, and interpretation of data: All authors. Drafting of the manuscript: C.M.P., S.D.M.S. Critical revision of the manuscript for important intellectual content: All authors. Study supervision: E.P.M., D.H.K.

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