A Retrospective Study of Administrative Data to Identify High-Need Medicare Beneficiaries at Risk of Dying and Being Hospitalized

Emmanuelle Bélanger, PhD[1,2], Benjamin Silver, PhD[1,3], David J. Meyers, MPH[2], Momotazur Rahman, PhD[1,2], Amit Kumar, PhD[4], Cyrus Kosar, MA[2], and Vincent Mor, PhD[1,2,5]

[1]Center for Gerontology and Healthcare Research, School of Public Health, Brown University, Providence, RI, USA; [2]Department of Health Services, Policy & Practice, School of Public Health, Brown University, Providence, RI, USA; [3] RTI International, Waltham, MA, USA; [4]College of Health and Human Services, Northern Arizona University, Flagstaff, USA; [5] U.S. Department of Veterans Affairs Medical Center, Providence, RI, USA.

BACKGROUND: Developing a definition of what constitutes high need among Medicare beneficiaries using administrative data is an important prerequisite to evaluating value-based payment reforms. While various definitions of high need exist, their predictive validity for different patient outcomes in the following year has not been systematically assessed for both fee-for-service (FFS) and Medicare Advantage (MA) beneficiaries.

OBJECTIVE: To develop a definition of high need using administrative data in 2014 and to examine its predictive validity for patient outcomes in 2015 as compared to alternative definitions for both FFS and MA beneficiaries.

DESIGN: Retrospective cohort study of national Medicare claims and post-acute assessment data.

PARTICIPANTS: All Medicare beneficiaries in 2014 who survived until the end of the year ($n = 54,717,039$).

MAIN MEASURES: Two or more complex conditions, 6 or more chronic conditions, acute or post-acute health services utilization, indicators of frailty, complete dependency in mobility or in any activities of daily living in post-acute care assessments, hospitalization, mortality, days in community, Medicare expenditures.

KEY RESULTS: Based on our definition of high-need patients, 13.17% of FFS and 8.85% of MA beneficiaries were identified as high need in 2014. High-need FFS patients had mortality rates 7.1 times higher (16.23% vs. 2.27%) and hospitalization rates 3.4 times higher (40.69 vs. 12.03) in 2015 compared to other beneficiaries. Competing high-need definitions all had good specificity ($\geq$ 0.88). Having 3 or more Hierarchical Chronic Conditions yielded a good positive predictive value for hospitalization, at 0.50, but only identified 19.71% of FFS beneficiaries hospitalized and 28.46% of FFS decedents that year as high need, as opposed to 33.92% and 51.98% for the new definition. Results were similar for MA beneficiaries.

CONCLUSIONS: The proposed high-need definition has better sensitivity and yields a sample of almost 5 million FFS and 1.5 million MA beneficiaries, facilitating outcome performance comparisons across health systems.

KEY WORDS: Medicare; hospitalization; mortality; health services Need.

INTRODUCTION

It is estimated that 5% of the US population accounted for 50% of the national healthcare spending in 2012.[1] A recent New York Times editorial underscored the prevailing consensus about the importance of meeting the needs of high utilizers, but pointed out that identifying exactly who high-need, high-cost (HNHC) patients are remains a significant challenge.[2] Some argue that unsuccessful programs targeting HNHC patients include either too many patients, such as those with a single chronic condition, or patients who have limited potential for improvement.[3] Blumenthal and colleagues recently disseminated a call to action, noting that much remains to be done to harness the potential of large datasets to improve the targeting of programs and the prediction of health outcomes for this population.[4] In the context of recent changes to payment and care delivery models that emphasize the accountability of health systems (e.g., Medicare Advantage (MA), Accountable Care Organizations (ACO)), it is imperative to accurately identify HNHC patients and to examine how these value-based models improve their outcomes.

Different definitions for what constitutes "high need" exist, but past work relied on primary data or on cost rather than medical complexity. Using a representative sample from the Medicare Expenditure Panel Survey (MEPS), the Commonwealth Fund proposed an influential definition of high need (HN) as having three or more chronic diseases and a functional limitation in caring for oneself or performing basic daily tasks.[5] While they estimate that this represents approximately 12 million Americans, functional impairment is not

systematically measured by healthcare providers, and therefore health systems cannot apply this definition to their own data. Another study used claims data to develop actionable segments of top (10%) spending patients and found that certain frailty indicators and complex chronic conditions predicted top spenders.[6] Cost alone, however, can fail to detect health systems that are providing high-value care. One study of clinically vulnerable Medicare beneficiaries relied on a risk adjustment calculation developed by the Centers for Medicare and Medicaid Services (CMS),[7] defining this population as being 66 years and older and having at least 3 Hierarchical Condition Categories (HCCs).[8] When examining 2010 fee-for-service Medicare data, we find the percentage of patients with post-acute care utilization increases sharply with the number of chronic conditions, making multi-morbidity an important consideration.[9]

It remains unclear how well different definitions of HN perform when adapted to administrative data, and which components best predict hospitalization and mortality. The objective of this study was to develop a definition of HN Medicare beneficiaries using administrative data and post-acute care assessments in 2014, and to assess its ability to predict mortality, hospitalization, and other patient outcomes in 2015 as compared to alternative definitions of HNHC, among both fee-for-service (FFS) and MA beneficiaries. We ultimately aim to create aggregated measures of health systems' performance indicative of how they manage HN patients. We examine previously studied components found to predict HN and healthcare utilization,[5, 6, 8, 9] using a stepwise algorithm to capture complexity of chronic conditions, multi-morbidity, health services utilization, frailty indicators, and post-acute functional impairment.

METHODS

Datasets and Study Population

We examined 2014 and 2015 data from the 100% Master Beneficiary Summary File (MBSF), Chronic Condition Warehouse (CCW), Cost and Use File, Medicare Provider and Analysis Review (MedPAR), Minimum Data Set (MDS), Inpatient Rehab Facility Patient Assessment Instrument (IRF-PAI), and Outcome and Assessment Information Set (OASIS) files. We included all Medicare beneficiaries who survived until the end of 2014. Beneficiaries' 2014 utilization was used to define HN status and 2015 data was used to examine outcomes. Despite limitations in the available data, including MA beneficiaries is necessary because managed care has grown dramatically and dominates some markets; any health system performance measure based solely on FFS beneficiaries would be biased.[10]

High-Need Definition

We compared the performance of definitions for HN beneficiaries, namely, (1) three or more chronic conditions and functional impairment,[5] and (2) three or more HCCs,[8] with

(3) our own definition based on medical complexity (2+ complex conditions), multi-morbidity (6+ chronic conditions), any acute or post-acute healthcare utilization, indicators of frailty (2+ diagnoses), and any functional impairment in activities of daily living or mobility.

Among FFS Medicare beneficiaries, we identified those with six or more chronic conditions in the CCW. The CCW summarizes diagnostic codes present across all types of claims and is updated annually for the FFS population. We then identified beneficiaries with two or more chronic conditions considered to be complex (see eTable 1 for list) as defined by CMS.[6, 11] To be considered HN, beneficiaries also needed to have used healthcare services as indicated in the Cost and Use File, including stays at acute care hospitals or post-acute care facilities.

Chronic conditions and health services utilization are not reported in the CCW and Cost and Use Files for MA beneficiaries. We therefore ran the CCW diagnostic algorithm through inpatient claims (MedPAR), which are available for all patients at any hospital receiving Disproportionate Share payments or Medical Education payments. This allowed us to identify MA beneficiaries with two or more complex chronic conditions, or six or more chronic conditions documented as part of inpatient stays. Multi-morbidity is underrepresented in the MA population because any diagnoses made outside a MedPAR-reporting hospital are overlooked. To partly correct for this, we used the CMS-HCC V12 algorithm for beneficiaries with MedPAR claims in 2014, using a 1-year look-back period. We then calculated the mean HCC score for FFS beneficiaries who have six or more chronic conditions. MA beneficiaries who reached or exceeded this mean score were identified as having probable multi-morbidity. Finally, for MA beneficiaries, health services utilization was captured with the presence of inpatient claims (MedPAR) and post-acute care assessments.

Having selected MA and FFS beneficiaries with chronic conditions and healthcare utilization, 11 of the 12 claims-based diagnoses identified as potentially indicating frailty were searched in MedPAR data and the presence of two or more qualified beneficiaries as HN (see Appendix).[6] When available, physical function was obtained from the latest 2014 post-acute care assessment for any beneficiary. We focused on disability in activities of daily living (ADL) or in mobility (see Appendix). Beneficiaries completely dependent on any ADL or mobility item in the MDS, IRF-PAI (selected items), or OASIS assessments were considered HN. For regression modeling purposes, health services and functional impairment were coded as a single categorical variable with six groups, those without any acute or post-acute care assessments (reference group) and all other five combinations of acute stay (yes/no) and functional impairment (unavailable/yes/no).

Outcome Measures

We examined the 2015 outcomes of all Medicare beneficiaries alive at the end of 2014, namely, mortality, hospitalization, days in community per day alive, and total expenditures per day alive.

We used the Medicare Enrollment file to create an indicator of death in 2015. Using the MedPAR file, we created an indicator of any 2015 hospitalization. For all beneficiaries who were hospitalized, we created indicators of 30-day and 90-day unplanned readmissions post discharge following an unadjusted version of the CMS algorithm,[12] and 30-day and 90-day mortality post admission. Days in community per day alive was calculated by following beneficiaries over time and examining how many days were spent outside MedPAR reporting hospitals, inpatient rehabilitation facilities, or skilled nursing facilities. For FFS beneficiaries only, the total expenditures per day alive is presented, using total expenditures from the Cost and Use File.

Statistical Analyses

As part of our aim to develop a more encompassing definition of HN in administrative claims data, we present descriptive statistics of the number of beneficiaries captured from each individual component of our definition across administrative datasets. We also report a hierarchical HN indicator as a stepwise algorithm, where we present how many FFS and MA beneficiaries are retrieved using chronic conditions and health services utilization, and then how many more are retrieved by adding frailty indicators and functional impairment. We then report sociodemographic characteristics by HN status. We expect to retrieve fewer HN beneficiaries enrolled in MA because we lack the data necessary to capture chronic conditions reported in non-inpatient settings; all analyses are carried out separately for FFS and MA beneficiaries.

To assess the performance of our new definition to predict mortality and hospitalization, we compared the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the ROC curve for each definition and for our own with and without the frailty and functional impairment indicators. High sensitivity indicates that those not flagged as HN are not likely to die or be hospitalized (i.e., few false negatives). High specificity indicates that those labeled as HN are indeed very likely to die or be hospitalized in 2015 (i.e., few false positives). PPV refers to the percentage of HN beneficiaries who are actually hospitalized/deceased, while the NPV refers to the percentage of non-HN beneficiaries who are not hospitalized/not deceased. The AUROC is an indicator of overall accuracy in discriminating between positive and negative cases. We estimated logistic regression models to obtain the odds ratios of being hospitalized or dying as a function of individual components of our HN definition, adjusting for age, sex, race, and dual eligibility. Since frailty and functional impairment are contingent upon healthcare utilization, only functional impairment was estimated in logistic regression models for ease of interpretation.

RESULTS

The study population consisted of 54,717,039 beneficiaries enrolled in Medicare and surviving until the end of 2014, 31.40% of whom were enrolled in MA for at least 1 month in 2014. eTable 2 shows the number of FFS and MA beneficiaries identified as having each individual component of the HN definition. MA patients are rarely identified as meeting the chronic condition threshold on the basis of the CCW, but are likely to meet that threshold when using MedPAR. It is also notable that less than 1% of beneficiaries are identified as having two or more frailty diagnostic codes in inpatient claims.

Figure 1 contains the stepwise hierarchical selection algorithm for our definition of HN. Among FFS beneficiaries, frailty indicators derived from claims did not contribute substantially to identifying HN beneficiaries (0.06%). Adding functional impairment to a definition based solely on chronic conditions and healthcare utilization did contribute to identifying HN beneficiaries, with 1.06% and 1.93% increases in FFS and MA, respectively. Although many of those identified as HN have functional impairment (38.10% FFS, 44.86% MA), most of them had already been captured because they also have chronic conditions. In summary, our algorithm identifies 13.17% of FFS and 8.85% of MA beneficiaries who survived until the end of 2014 as HN. Table 1 provides population characteristics by HN status and type of Medicare enrollment. HN beneficiaries are older, more likely to be female, more likely to be part of a minority group, and more likely to be dual eligible than those who are not identified as HN. These trends are more pronounced among those enrolled in MA.

Table 2 presents the performance of our HN definition in predicting hospitalization and mortality in 2015, stratified by type of Medicare enrollment. Among FFS beneficiaries, the mortality rate for HN beneficiaries was 7.1 times higher (16.23% vs. 2.27%), and 3.4 times higher (40.69% vs. 12.03%) for hospitalization compared with non-HN beneficiaries. The results were similar for MA beneficiaries with 6.9 times the mortality (17.01% vs. 2.45%) and 3.3 times the hospitalization rate (39.82% vs. 12.00%). The mean percent days spent in the community was lower among HN beneficiaries and varied more (FFS: 86.95 SD 29.10; MA: 88.02 SD 27.62). The mean cost per day alive was five times higher among HN beneficiaries and varied in the sample (123.76, SD 560.83).

Table 3 displays the predictive validity of different HN definitions and the sample sizes retrieved. All definitions have very good specificity, above or equal 0.88, and excellent NPV above or equal 0.97. However, our HN definition has better sensitivity than other definitions (reaching 0.52 and 0.34 for mortality and hospitalization) and yields a much larger sample of nearly 5 million FFS and 1.5 million MA beneficiaries. While having three or more HCCs yields a good PPV for hospitalization, at 0.50, it flags 19.71% of the FFS Medicare beneficiaries hospitalized that year and 28.46% of decedents as HN, as opposed to 33.92% and 51.98% with the new definition. The AUROC reaches acceptable levels (0.70) for mortality among FFS beneficiaries using our definition. Compared with the Commonwealth definition of three chronic conditions and functional impairment, this represents an 8
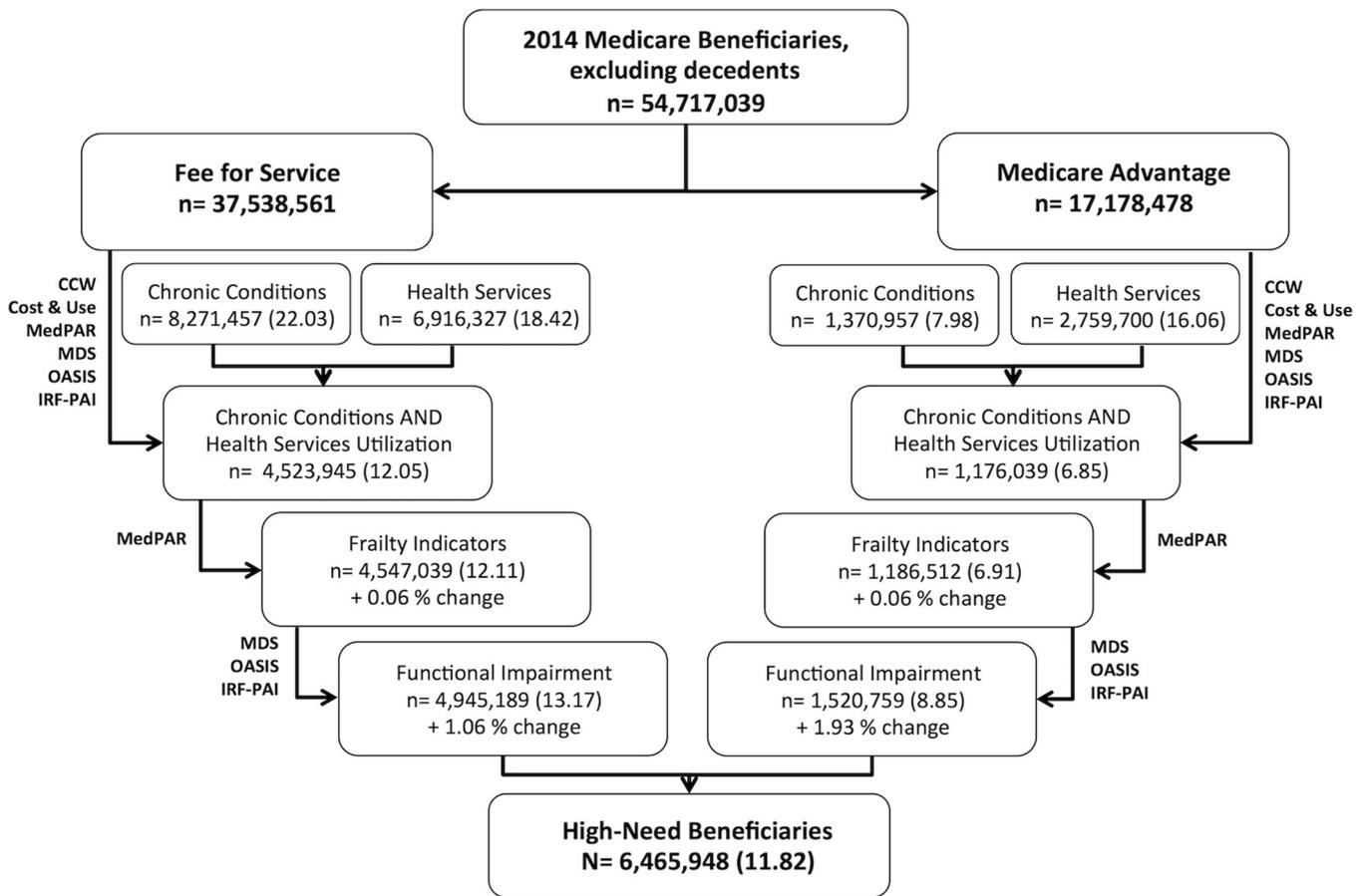
Figure 1 Stepwise identification of high-need Medicare beneficiaries.

and 10 percentage-point increases for FFS and MA, respectively, while hospitalization yields improvements of 7 and 6 percentage-points. All comparisons are statistically significant ($p < 0.001$).

Finally, Table 4 displays the adjusted odds ratios of dying and being hospitalized as a function of the different components of the HN definition. FFS beneficiaries with two or more complex chronic conditions had 1.90 times the odds of being

Table 1 Descriptive Characteristics by High Need Status and Type of Medicare Enrollment in 2014, *n* = 54,717,039

	Fee-for-service		Medicare Advantage	
	Not high need *n* = 32,593,372	High need *n* = 4,945,189	Not high need *n* = 15,657,719	High need *n* = 1,520,759
Age				
Below 65	8,259,693 (25.34)	875,723 (17.71)	2,960,323 (18.91)	242,241 (15.93)
65–74	15,191,143 (46.61)	1,364,310 (27.59)	7,743,211 (49.47)	458,464 (30.15)
75–84	6,726,183 (20.64)	1,512,156 (30.58)	3,807,666 (24.32)	491,044 (32.29)
85 and above	2,416,861 (7.42)	1,193,000 (24.12)	1,146,519 (7.32)	329,010 (21.63)
Gender				
Men	15,417,276 (47.30)	2,008,360 (40.61)	6,816,497 (43.53)	615,196 (40.45)
Women	17,176,053 (52.70)	2,936,829 (59.39)	8,841,221 (56.47)	905,563 (59.55)
Race				
White	26,671,785 (81.83)	4,047,795 (81.85)	12,262,151 (78.31)	1,173,873 (77.19)
Black	3,144,207 (9.65)	599,275 (12.12)	1,815,403 (11.59)	231,061 (15.19)
Hispanic	763,642 (2.34)	120,212 (2.43)	604,769 (3.86)	56,556 (3.72)
Asian	724,853 (2.22)	72,495 (1.47)	418,004 (2.67)	27,539 (1.81)
Other	621,186 (1.91)	52,970 (1.07)	375,267 (2.40)	22,051 (1.45)
Native American	185,774 (0.57)	29,666 (0.60)	32,311 (0.21)	4081 (0.26)
Unknown	481,925 (1.48)	22,776 (0.46)	149,814 (0.96)	5869 (0.37)
Dual eligibility				
Eligible, 12 months	4,292,050 (13.17)	1,521,256 (30.76)	2,360,945 (15.08)	480,263 (31.58)
Eligible, 1–11 months	966,442 (2.97)	287,356 (5.81)	459,948 (2.94)	106,226 (6.99)
Not eligible	27,334,880 (83.87)	3,136,577 (63.43)	12,836,826 (81.98)	934,270 (61.43)

Table 2 Patient Outcomes in 2015, by High Need Status and Type of Medicare Enrollment (Indented Rows Are Conditional on Hospitalization), *n* = 54,717,039

	Fee-for-service		Medicare Advantage	
	Not high need *n* = 32,593,372	High need* *n* = 4,945,189	Not high need *n* = 15,629,629	High need* *n* = 1,520,759
Mortality, *n* (%)				
Any death in 2015	741,211 (2.27)	802,480 (16.23)	384,228 (2.45)	268,701 (17.01)
Hospitalization, *n* (%)				
Any hospitalization in 2015	3,919,482 (12.03)	2,012,382 (40.69)	1,879,611 (12.00)	605,592 (39.82)
Hospital mortality, *n* (%)				
30-day mortality	293,419 (7.77)	330,916 (17.07)	150,458 (8.13)	104,581 (17.54)
90-day mortality	302,589 (8.02)	364,558 (18.81)	156,730 (8.47)	116,768 (19.59)
Readmission, *n* (%)				
30-day readmission	99,265 (2.63)	156,103 (8.05)	49,041 (2.65)	49,261 (8.26)
90-day readmission	146,897 (3.89)	199,639 (10.30)	72,920 (3.94)	63,314 (10.62)
Percent days in community per days alive, mean (SD)	99.21 (5.60)	86.95 (29.10)	99.16 (5.97)	88.02 (27.62)
Cost per days alive, mean (SD)	24.79 (162.91)	123.76 (560.83)	N/A	N/A

Defined as (2+ complex chronic/6+ chronic AND service utilization) OR 2+ frailty OR functional impairment

hospitalized in 2015, and those with an acute care stay in 2014 were two or more times as likely to be hospitalized in 2015 regardless of whether they received post-acute care. Those with complex chronic conditions were 2.30 times more likely to die in 2015, and those with functional impairment had odds ratios of dying at 4.77 if they had not been hospitalized in 2014, and 5.49 if they had been.

DISCUSSION

We sought to create a new, comprehensive measure of HN that is based on mandatory, claims-based assessments for both FFS and MA beneficiaries, and that has strong predictive validity to assess health systems' performance in this population. We identified 4,945,189 HN FFS beneficiaries and 1,520,759 HN MA members in 2014, and found that their mortality

and hospitalization rates were 7 and 3 times higher than non-HN beneficiaries. Relative to other HN definitions, our approach yielded comparable specificity and superior sensitivity. This approach worked well for MA members, largely because of our use of mandatory assessments that are available, even though detailed claims are not. Our analyses confirm that it is essential to look at inpatient claims and post-acute care assessments to retrieve chronic conditions and health services utilization for MA beneficiaries who now represent more than 30% of beneficiaries.[10]

Unlike previous work about high-cost patients,[6, 13] diagnostic codes indicative of frailty contributed very little to identifying high-need beneficiaries; these specific codes appear to be seldom used in the overall Medicare population. This difference likely emerges because our sample was not limited to those in the top 10% cost, and had to survive until the end of 2014 therefore excluding those with frailty codes

Table 3 Sensitivity and Specificity by High Need Definition and Type of Medicare Enrollment, *n* = 54,717,039

Fee-for-service	Mortality					Hospitalization					Total
	Sensitivity	Specificity	PPV	NPV	AUROC	Sensitivity	Specificity	PPV	NPV	AUROC	
3+ HCCs	0.28	0.95	0.19	0.97	0.62	0.20	0.96	0.50	0.86	0.58	2,324,829
3+ chronic and functional impairment	0.29	0.96	0.25	0.97	0.62	0.13	0.97	0.43	0.86	0.55	1,744,786
2+ complex chronic/6+ chronic and service utilization	0.47	0.89	0.16	0.97	0.68	0.32	0.92	0.42	0.88	0.62	4,523,945
High need*	0.52	0.88	0.16	0.98	0.70	0.34	0.91	0.41	0.88	0.62	4,945,189
Medicare Advantage											
3+ HCCs	0.26	0.95	0.18	0.97	0.61	0.18	0.96	0.46	0.87	0.57	959,009
3+ chronic and functional impairment	0.17	0.98	0.25	0.97	0.57	0.08	0.98	0.44	0.86	0.53	440,936
;2+ complex chronic/6+ chronic and service utilization	0.31	0.94	0.17	0.97	0.62	0.21	0.95	0.43	0.88	0.58	1,176,039
High need*	0.41	0.92	0.18	0.98	0.67	0.25	0.94	0.40	0.88	0.59	1,520,759

Defined as (2+ complex chronic/6+ chronic AND service utilization) OR 2+ frailty OR functional impairment

Table 4 Odds Ratios of Dying or Being Hospitalized in 2015 by Individual High-Need Component in 2014, Adjusted for Age, Sex, Race/Ethnicity and Dual Eligibility

	Fee-for-service		Medicare Advantage	
	Mortality	Hospitalization	Mortality	Hospitalization
2+ complex conditions	2.30	1.90	1.60	1.50
6+ chronic conditions	1.10	1.57	1.64	1.66
No acute care/no post-acute care	Ref	Ref	Ref	Ref
No acute care/no ADL dependency	2.15	1.61	2.93	2.10
No acute care/ADL dependency	4.77	1.43	6.59	1.90
Acute care/no post-acute care	2.10	2.35	2.15	2.45
Acute care/no ADL dependency	2.52	2.52	2.56	2.78
Acute care/ADL dependency	5.49	2.99	5.19	3.16

Given the large sample size, all odds ratios are statistically significant with confidence intervals within one decimal point

documented as part of hospice. In terms of sociodemographic characteristics, beneficiaries identified as HN were more likely to be Black and dually eligible, which is consistent with the results obtained by Beaulieu and colleagues when they examined the distribution of high-cost patients across health systems.[14]

Previous work also concluded that adding functional status to comorbidity indices improves predictions for 30-day readmission among older adults in post-acute rehabilitation.[15] There is an extensive literature about comorbidity indices that best predict mortality with the Elixhauser and Charlson indices appearing to perform best among different clinical populations.[16–18] However, the purpose of our work was not to propose the best prediction model for mortality, but to create a definition of HN that would perform well across different outcomes, that could be reproduced easily using claims-based data for both FFS and MA beneficiaries, and that yielded a large enough sample to examine the performance of health systems in caring for them. It is worth highlighting that the relative contribution of functional impairment is related to its position in the stepwise identification scheme, whereby a large number of beneficiaries suffer from both multi-morbidity and ADL disability.

A much larger percentage of HN beneficiaries identified with our definition were hospitalized and passed away in 2015 than non-HN. These numbers were also greater than those obtained with a previous definition of HN, which lends credence to the definition proposed. The different HN definitions examined all had good specificity, meaning that those who were identified as HN were indeed likely to die and be hospitalized. In our definition, combining chronic conditions, healthcare utilization, and functional impairment yielded a better sensitivity and therefore a larger sample of HN beneficiaries. The approach identifies enough beneficiaries, both MA and FFS to make it possible to compare health systems' performance in caring for this group. Quality measures based on the full population may not be as relevant to the special needs and demands of the HN population. This approach places health system comparison on a more level playing field.

This study has some limitations. First, there are limitations inherent in relying on administrative data. The study population is limited to Medicare beneficiaries, and we did not have access to instrumental activities of daily living,[5] which would yield a

larger and less functionally impaired population than the ADL dependency reported in post-acute assessments. Moreover, chronic conditions are underreported among the MA population because the CCW algorithm was applied to inpatient stays only. MedPAR inpatient claims nonetheless represent an accepted data source to examine the performance of MA plans on inpatient care.[19] Finally, when writing this article, the enrollment and claims data were incomplete for the last month of 2015, and as such the study outcomes of mortality and hospitalization are underreported. Testing the ability of our definition to predict outcomes in another population (e.g., another year) would also contribute to demonstrate its predictive validity.

In conclusion, we proposed a definition of HN based on administrative data, encompassing the complexity of chronic conditions, multi-morbidity, healthcare utilization, and functional impairment, and demonstrated better performance than competing HN definitions in predicting hospitalization and mortality for the Medicare population. The importance of targeting HN patients has recently been called into question because this focus reduces the volume of expenditures that can be impacted and the medical complexity of this population requires more intensive interventions.[20] We argue that this is an empirical question that deserves further study. Our proposed definition allows researchers to examine the health outcomes of HN beneficiaries, and how they are affected by extensive value-based payment reform.[21] The next steps of this larger research endeavor will consist in identifying top performing health systems caring for HN beneficiaries and their characteristics, including where they are situated along a continuum of accountability, from unaffiliated hospitals to Accountable Care Organizations (ACO). Being able to identify a sufficiently large sample of the HN beneficiaries at risk for hospitalization and mortality is paramount for the instigation of health policies that can have a significant impact on health outcomes and expenditures nationally.

Corresponding Author: *Emmanuelle Bélanger, PhD; Center for Gerontology and Healthcare Research, School of Public Health Brown*

University, Providence, RI, USA (e-mail: emmanuelle_belanger@brown.edu).

Compliance with Ethical Standards:

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