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Predictive indices for functional improvement and deterioration, institutionalization, and death among elderly Medicare beneficiaries

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Abstract

Background—Prediction models can help clinicians provide the best and most appropriate care to their patients and can help policy makers design services for groups at highest risk of poor outcomes.

Objective—The objective was to develop prediction models identifying both risk factors and protective factors for functional deterioration, institutionalization, and death.

Design—Cohort study using data from the Medicare Current Beneficiary Survey (MCBS)

Setting—Community survey.

Participants—This study included 21,264 Medicare beneficiaries 65 years of age and older who participated in the MCBS from the 2001–2008 entry panels and were followed for two years.

Methods—The index was derived in 60% and validated in the remaining 40%. β-coefficients from a multinomial logistic regression model were used to derive points, which were added together to create scores associated with the outcome.

Main outcome measure—The outcome was activity of daily living (ADL) stage transitions over two years following entry into the MCBS. Beneficiaries were categorized into one of four outcome categories: stable or improved function, functional deterioration, institutionalization, or death.

Results—Our model identified 16 factors for functional deterioration (age, gender, education, living arrangement, dual eligibility, proxy use, Alzheimer's disease/dementia, angina pectoris/coronary heart disease, diabetes, emphysema/asthma/chronic obstructive pulmonary disease, mental/psychiatric disorder, Parkinson's disease, stroke/brain hemorrhage, hearing impairment,

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vision impairment, and baseline ADL stage) after backward selection (p<.05). Compared to stable or improved function, the risk of functional deterioration ranged from ≤1 to ≥6, ≤4 to ≥22 for the risk of institutionalization, and ≤3 to ≥16 for the risk of death.

Conclusion—Predictive indices, or point and scoring systems used to predict outcomes, can identify elderly Medicare beneficiaries at risk of functional deterioration, institutionalization, and death and can aid policy makers, clinicians, and family members in improving care for older adults and supporting successful aging in the community.

INTRODUCTION

As the United States (US) population ages, the variation in functioning level increases, and the problem of severely disabled individuals becomes paramount. Advances in medical technology with associated reductions of highly fatal diseases led to dramatic increases in average life expectancy from 49 to 73 years of age in the US over the last (20th) century, leaving individuals with increased exposure to the cumulative, often disabling, effects of chronic illnesses and disabilities.[1] With the largest ever expansion in life expectancy occurring in the last decades of the 20th century, the proportion of the US population 65 years and older is expected to increase from 12.4% in 2000 to 19.6% in 2030.[2]

Most older adults prefer to remain at home and age in their communities.[3] Therefore, understanding how to support older adults to remain in the community as safely and as long as possible is important. Policy makers and clinicians are challenged with developing and providing services with limited resources and needing to focus on high impact problems. One way to aid policy makers and clinicians is by creating prediction models to help forecast patient outcomes. Creating predictive models can help plan and develop services and can help identify groups at highest risk of poor outcomes. For example, knowing the functional status of a beneficiary is important because it can help decide if the person can live independently or may require a caregiver.[4] Clinicians can propose appropriate care to the patient such that a poor outcome may be delayed or avoided, and caregivers can begin to prepare psychologically and financially for what may happen.[5] Furthermore, if beneficiaries have higher probabilities of a poor outcome, they may benefit from interventions intended to maintain current functioning levels.[4]

Our goal was to develop prediction models identifying both risk factors and protective factors for functional deterioration, institutionalization, and death. While the results of our study may only explain predictive relationships rather than causation or effectiveness of interventions, the information obtained from prediction models can help clinicians provide the best and most appropriate care to their patients, depending on the patients' circumstances, and can help policy makers design services to support older adults to remain in communities. Medicare provides health insurance for about 43 million elderly and disabled people, accounting for 14% of the federal budget.[6] Using the Medicare Current Beneficiary Survey (MCBS),[7–9] a current and ongoing national survey, this study presents prediction models for an activity of daily living (ADL) stage transition outcome of four levels (stable or improved function combined, functional deterioration, institutionalization, and death) among elderly Medicare beneficiaries within two years of entering the survey.

Although there has been a predictive model for mortality,[10] to our knowledge prediction models for functional deterioration or institutionalization using ADL activity limitation stages have not been previously created.

METHODS

This study was approved by the Institutional Review Board at the University of Pennsylvania.

Data source

The MCBS,[7–9] conducted by the Centers for Medicare and Medicaid Services and representative of the Medicare population, was used for this study. Survey weights are used to account for non-response and weighted sampling, and the MCBS oversamples people 80 years and older because of their special needs.[8] Sample persons or their proxies are interviewed about their functioning and health status during the fall of their entry year into the survey and each subsequent fall, and about their health care utilization starting January 1st following their fall interview for a total of four years.

Study cohort

The study sample included 30,356 community-dwelling adults at baseline aged 65 years and older participating in the MCBS from the entry panels of 2001–2008 and were followed for two years. Some beneficiaries were missing information on covariates included in the models, including race, education, proxy respondent, satisfaction in the care coordination and quality of their overall quality of care, satisfaction in the care coordination and quality of information given, satisfaction in the care coordination and quality in the concern for their overall health, satisfaction of the ease/convenience to medical care, satisfaction of the out-of-pocket costs to access medical care, having a usual source of care, perceived barrier to the receipt of healthcare because of financial reasons, and baseline ADL stage and were therefore excluded (n=2,210). Other beneficiaries were lost to follow-up (n=6,882) in the two years following baseline and were also excluded. Thus, 21,264 beneficiaries were included in the final analyses.

Outcome

Beneficiaries were categorized into one of four outcome categories: remained stable in ADL activity limitation stage and improved in stage were combined, deteriorated in stage, was institutionalized, or died.

Stable or improved function and functional deterioration were based on activity limitation stages.[11,12] Traditional measures of activity limitations, such as counts, express severity of disability but do not indicate which specific activities are limited making it difficult to project specific service needs. Without expressing which activities a person has difficulty performing, the implications of ADL limitation and care burden are unknown. Therefore, we chose to measure activity limitations by the new emerging system of stages.[11,12] Activity limitation stages were developed to specify clinically meaningful patterns of increasing difficulty with self-care items and to represent the severity and types of limitations

experienced. Stages improve on simple counts of limitation which only captures severity. We had previously found that older Medicare beneficiaries with more disabled ADL activity limitation stages were associated with higher hazard ratios for mortality,[13] higher risk of being hospitalized,[14] and higher hazard ratios for being admitted to a long-term care (LTC) facility.[15]

ADL stage during the entry year of the survey was compared to the stage obtained two years following entry into the MCBS. The items within the ADL domain are eating, toileting, dressing, bathing/showering, getting in or out of bed/chairs, and walking. The derivation of ADL activity limitation stages have been described previously,[11,12] but a brief description follows below. In the MCBS, the sample person or proxy was asked regarding each ADL item, "Because of a health condition, do you (or does the person you are answering for) have difficulty with…?"[7–9] There are a total of 5 stages: stage 0 (no limitation), stage I (mild limitation), stage II (moderate limitation), stage III (severe limitation), and stage IV (complete limitation). Greater disabilities are associated with higher numbered stages. Stage III was designed to account for patterns of limitation that are atypical of the hierarchy and is a non-fitting stage.

Institutionalization was determined from the MCBS Key Record file that indicated which participants were interviewed in a facility rather than in the community two years after entry into the MCBS. Death was determined by linking MCBS data with the National Death Index.

Covariates

We selected covariates based on our previous findings,[16,17] and grouped them into different categories that include sociodemographics, health conditions, impairments, perceived facilitators to receiving healthcare, perceived barriers to receiving healthcare, and function.

Sociodemographics were age (65–74, 75–84, or ≥85), gender, and race (non-Hispanic white, non-Hispanic black, Hispanic, or other). Education was categorized as below high school graduate and high school graduate or higher. Living arrangement was classified as lives with spouse, lives with children, lives with others, lives alone, or lives in a retirement community. Dual eligibility was categorized as Medicare and Medicaid dual enrollee versus Medicare only. An indicator for proxy use versus self-respondent was included.

Health conditions were comprised of comorbidities or impairments that a doctor told the respondent had or occurred within the past year. The comorbidities were Alzheimer's disease, angina pectoris or coronary artery diseases, complete or partial paralysis, diabetes type 1, 2, or other, emphysema/asthma/chronic obstructive pulmonary disease (COPD), hypertension, mental or psychiatric disorder, myocardial infarction, other heart conditions, Parkinson's disease, and stroke or brain hemorrhage.

Impairments were severe hearing impairment or deaf and severe vision impairment or no usable vision.

Perceived facilitators to receiving healthcare were measured through several questions. We included two questions that measured the respondent's satisfaction of their access to medical

care, which included ease/convenience and out-of-pocket costs, and three questions that measured the respondent's satisfaction with care coordination and quality of their overall quality of care, information given, and concern for overall health. Responses were provided on a Likert scale with scores ranging from 1 to 4 corresponding to very satisfied to very unsatisfied.[18]

An additional perceived facilitator to receiving healthcare was indication of a usual source of care, i.e., a particular place where medical care is received such as a doctor's office, which was categorized as yes or no.

A perceived barrier to the receipt of healthcare because of financial reasons was ascertained through two questions. The first question had two parts. Respondents were first asked if they had trouble getting healthcare in the previous year. A positive response led to a second question asking the reason for trouble. Responses suggesting financial difficulties (not enough money, cost too high, service/supplies not covered, or not eligible for public coverage) were coded as yes to having a barrier because of financial reasons. The second question asked if medical care was delayed due to cost in the previous year. Beneficiaries were coded as having trouble getting or reported delaying healthcare because of financial reasons if they indicated financial difficulties in trouble getting healthcare or yes in delaying healthcare due to cost.

Another perceived barrier to the receipt of healthcare was having transportation difficulties which was ascertained from those who responded that they experienced transportation barriers when asked if they had trouble getting needed healthcare.

Function was measured by baseline ADL stages as described above under the outcome sub-section. The covariates were all obtained from the Access to Care files.

Model development

We randomly selected 60% of the Medicare beneficiary sample (n=12,758) for the derivation cohort to create the prediction score system and used the remaining 40% of the Medicare beneficiary sample (n=8,506) as a validation cohort. Our primary goal was to create a prediction score system to estimate the risk of functional deterioration, institutionalization, and death within two years among Medicare beneficiaries 65 years of age and older according to their sociodemographics, health conditions or impairments, perceived barriers and facilitators to receiving healthcare, and function compared to those who were stable or improved in function as we were interested in predicting the poor health outcomes. In 5 steps, we estimated a multinomial logistic regression model for stage transition within two years and used that model to create a risk score: (1) identification and categorization of variables based on previous findings[16,17] that were found to be associated with stage transition, (2) assessment of the association of the variables with stage transition in the derivation cohort using chi-square tests, (3) estimation of a parsimonious model in the derivation cohort; (4) development of a point-scoring system in the derivation cohort; and (5) validation of both the model and point system in the validation cohort.[19]

Specifically, in step 3, candidate predictors were entered into a multinomial logistic regression model if p<.20 stage transition in step 2. We then used stepwise backward selection to obtain the final parsimonious model in which all predictive variables were statistically significant at p<.05.

Points were assigned to each variable in the final model by dividing each significant beta coefficient by the lowest significant beta coefficient and rounding to the nearest integer. A value of "0" was assigned to non-significant (i.e., p≥.05) β-coefficients for categorical variables that overall were significant. A risk score was determined for each Medicare beneficiary for a particular level of the outcome (i.e., functional deterioration, institutionalization, or death) by adding up the points for all risk factors indicated. According to these risk scores, beneficiaries were divided into quartiles.

R-square was used to determine the goodness-of-fit of the model.[20] The R-square produced by SAS can be interpreted as the amount of information gained when including the predictors in the model in comparison with the model without any predictors. For the development and validation cohorts, we also estimated 6 pairwise c-statistics and the M-index which is the average of the 6 c-statistics, separately. The pairwise c-statistic is the probability of correctly discriminating between two cases from different categories that are randomly selected.[21]

Descriptive analyses accounted for complex sampling including weight, clustering, stratification, and sub-population and all statistical analyses used SAS 9.4 (SAS Institute, Inc.).[22] P-values are two-sided, with statistical significance defined *a priori* as p<.05.

RESULTS

Within two years, 9,496 (77.7%) Medicare beneficiaries from the derivation cohort had stable or improved function, 1,765 (12.8%) had functional deterioration in their ADL stage, 287 (1.7%) were institutionalized, and 1,210 (7.8%) died (Table 1).

About 43% of the Medicare beneficiaries 65 years of age and older from the derivation cohort were male, 82% were non-Hispanic white, 74% had at least graduated from high school, 54% lived with their spouse, 11% were dual eligible for Medicare and Medicaid, and 6% used a proxy (Table 1). The most common comorbidities were hypertension, diabetes, and emphysema/asthma/COPD. Only about 6% of beneficiaries in the derivation cohort reported severe vision or hearing impairments. A small proportion of beneficiaries were unsatisfied with their overall quality of care (3%), information given (5%), concern for overall health (5%), ease and convenience (5%), and out-of-pocket costs (17%). Most Medicare beneficiaries had no limitation in their baseline ADLs (72%). The majority of beneficiaries had a usual source of care (98%). There was a small proportion who reported having trouble getting healthcare or delaying healthcare because of financial reasons (8%). The characteristics of the validation cohort were similar to those individuals in the derivation cohort (Table 1).

There were a total of 26 variables with p<.20 in the unadjusted analysis which was included into a multinomial logistic regression model.

Our model identified 16 factors for functional deterioration (advanced age, male gender, below high school education, living with children or alone, only having Medicare insurance, using a proxy, Alzheimer's disease/dementia, angina pectoris/coronary heart disease, diabetes, emphysema/asthma/COPD, mental/psychiatric disorder, Parkinson's disease, stroke/brain hemorrhage, hearing impairment, vision impairment, and more disabled baseline ADL stage), 11 factors for institutionalization (advanced age, male gender, non-Hispanic black or Hispanic race, living with others, alone, or in a retirement community, only having Medicare insurance, Alzheimer's disease/dementia, angina pectoris/coronary heart disease, complete/partial paralysis, diabetes, mental/psychiatric disorder, and more disabled baseline ADL stage), and 15 factors for death (advanced age, male gender, non-Hispanic black or Hispanic race, below high school education, living with children, alone, or in a retirement community, only having Medicare insurance, using a proxy, Alzheimer's disease/dementia, diabetes, emphysema/asthma/COPD, myocardial infraction, Parkinson's disease, stroke/brain hemorrhage, vision impairment, and more disabled baseline ADL stage) after backward selection where each variable was $p<.05$ (Table 2).

The summed scores divided the sample into quartiles. The risk of functional deterioration compared to the reference level which combined stable or improved function ranged from a score of ≤1 in the lowest quartile to ≥6 in the highest quartile in the derivation cohort (Table 3). For institutionalization (compared to the reference), the score ranged from ≤4 in the lowest quartile to ≥22 in the highest quartile. Finally, for death (compared to the reference), the score ranged from ≤3 in the lowest quartile to ≥16 in the highest quartile.

The R-Square obtained from the multinomial logistic regression model was 0.1847 in the derivation cohort, and 0.1668 in the validation cohort. For the derivation cohort, the 6 pairwise c-statistics were 0.664, 0.868, 0.803, 0.666, 0.666, and 0.606 for discriminating between no change and functional deterioration, no change and institutionalization, no change and death, functional deterioration and institutionalization, functional deterioration and death, and institutionalization and death, respectively. The M-index was 0.712. For the validation cohort, the corresponding c-statistics were 0.648, 0.848, 0.776, 0.629, 0.644, and 0.576, respectively for the same comparisons and the M-index was 0.687.

DISCUSSION

We were able to use information obtained from the MCBS to create a multiple outcome index that provides the likelihood of functional deterioration, institutionalization, and death among Medicare beneficiaries 65 years of age and older. This index was derived and validated using data representative of the Medicare elderly population that included more than 21,000 beneficiaries. The index identifies risk factors and protective factors and can lead to insights on preventive measures to reduce the likelihood of functional deterioration, institutionalization, and death and to support successful aging in the community. Although we obtained information from the MCBS, the same information on sociodemographics, health conditions, impairments, and function could be easily retrieved from an electronic medical record or from patients' responses.

Our study confirmed that advanced age, male gender, and non-Hispanic black and Hispanic race, as noted in the literature, are risk factors for functional decline,[23–25] institutionalization,[26–30] and death.[25,29,31] Males have usually been noted as dying earlier than females. Moreover, there have been disparities among different ethnic groups. Although these factors cannot be changed, clinicians may be able to discuss options and treatment plans with patients and family members, thus enabling patients and family members to clarify and set goals and priorities.

Low education level (i.e., below high school diploma) was shown to be a risk factor for functional deterioration and death. Other studies[25,29] have found similar results and these may be the result of disparities in the community. Similarly, living arrangement and being dual eligible for Medicare and Medicaid were both associated with all three negative outcomes. People who need help in the home in addition to their spouse have greater care burden.[26] However, it is uncertain if the caregiver is able to meet the beneficiary's need or even wants to help. Dual eligibility may be a proxy for poverty. Unmet needs may lead to functional deterioration, need for institutionalization, or even death among these elderly Medicare beneficiaries.

Similar to other investigators,[25,32] we found that needing a proxy respondent was a risk factor for functional deterioration and mortality. Requiring a proxy to respond to survey questions indicates the need for greater care burden. Most beneficiaries who need a proxy respondent may have debilitating chronic conditions or cognitive impairment.

Only a handful of comorbidities were found to be risk factors for functional deterioration, institutionalization, or death in our model. Previous research has shown that Alzheimer's disease is independently associated with institutionalization.[27,28] Heart diseases such as angina and myocardial infraction,[33] respiratory diseases such as emphysema/asthma/COPD,[34] and stroke/brain hemorrhage[35] are known to be leading causes of death. Diabetes[25,36] and Parkinson's disease[37,38] have been shown to be independently associated with functional deterioration and institutionalization. The effect of additional risk factors, including complete/partial paralysis[39] and mental/psychiatric disorder[40] on functional deterioration, institutionalization, and death may be mitigated by education or clinical management.

Hearing impairment has been associated with other poor outcomes, such as risk of any hospitalization[41] and all-cause mortality. Similarly, no usable vision or vision impairment in our study was a risk factor for both functional deterioration and death. Others have also found that people with vision impairment have functional impairments[42] and increased mortality.[43,44] Vision impairment may not allow a beneficiary to live independently at home due to difficulty performing self-care activities as well as safety issues. Vision impairment could lead to falls or medical prescription mismanagement, thus potentially leading to institutionalization and/or death.

Previous studies have shown that more disabled baseline ADL stage has been associated with functional deterioration,[45] institutionalization,[45,46] and death[10,13,45,47] among the elderly. Beneficiaries categorized at more disabled activity limitation stages will have

increased care burden which may require the need for institutionalization, or the burden may be so severe that the beneficiaries are at risk for death. Discussions on the values and goals of care as part of advance care planning and the creation of advance directives are especially important in this high risk group.

Table 4 demonstrates how the prediction tool can be used to assign scores to patients depending on their sociodemographics, health conditions, impairments, and function conditional on which outcome the beneficiary may need to face in the near future or possibly want to avoid. Points for each factor are added or subtracted together to obtain a risk score, and the score for a particular outcome will aid clinicians in guiding patients to avoid the outcome. For example, Mrs. A is a 76-year-old Non-Hispanic white woman with arthritis, diabetes type 2, and severe vision impairment. She lives alone and receives Medicare plus Medicaid. She has no difficulty eating, using the toilet, dressing, bathing, or getting in and out of her bed or chairs. She states she does have difficulty walking. Mrs. A has mild self-care limitations staged at ADL-I. As expected from her stage, severe vision impairment, and the physical configuration of her primary care provider's (PCP's) clinic, she finds seeing her PCP difficult. Even if dropped off at the clinic, she needs assistance for the long, painful, difficult walk to the patient waiting area and another to the laboratory for blood draws. Will she be risking further functional deterioration, institutionalization, or death by not obtaining recommended levels of care? Mrs. A has a sum score of 11 for functional deterioration, a sum score of 21 for institutionalization, and a sum score of 15 for death. Therefore, her predicted probability for function deterioration is 28.5%, 2.3% for institutionalization, and 9.8% for death in the following two years. Understanding the characteristics that predict functional deterioration, institutionalization, and death within 2 years can help policy makers, clinicians, and family members learn how to diminish those factors that can be reduced while educating and planning for those factors that cannot. Patients and family members may also have psychological and financial planning needs if the patient has a high probability of functional deterioration and/or institutionalization. Beneficiaries will be at different risk levels for the various outcomes after two years. The different risk levels may lead to different priorities and goals, depending on the outcome beneficiaries seek to avoid.

As for model calibration, the pairwise c-statistics showed that our final model can discriminate institutionalization and death from no change in function well (c-statistics are about 0.80). For the other pairs of outcome categories, our model did not discriminate as well (c-statistics between 0.58 and 0.66).

STRENGTHS AND LIMITATIONS

Some strengths of this study include the large sample size, the current and ongoing nature of the survey, breadth of data available, and generalizability of the findings to the community-dwelling Medicare population aged 65 years and older.

This study had several limitations. ADL activity limitation stages were derived based on self-or proxy-reported responses, which may not be an accurate portrayal of which activities are truly difficult to perform. There may be response bias due to imperfect recall since survey questions ask the respondent to recall events during the past year. We included proxy

responses even though proxies may not have answered the same way as the sample person. However, bias may have been introduced if proxy responses were excluded.[48] Also, a high percentage of the sample was lost to follow-up. The interpretation of the results could change if those individuals were not lost to follow-up and their outcomes were known. Additional variables, such as self-advocacy, may have been associated with the outcomes, but were not measured in the MCBS. Our study results can only be applied to the elderly Medicare population since beneficiaries less than 65 years of age were excluded.

CONCLUSION

Predictive indices can identify elderly Medicare beneficiaries at risk of poor outcomes and can aid policy makers, clinicians, and family members in improving care for older adults and supporting successful aging in the community. Specifically, the MCBS provides clinicians with data that allows Medicare beneficiaries to be stratified according to four strata. Being able to understand these risk factors will help clinicians educate patients and families in how to reduce the risk of poor outcomes. Identifying beneficiaries who will benefit most from special attention may be key to improving outcomes and could also inform targeted interventions to reduce disparities for people with disabilities. Large health systems could adopt this scoring system to enable clinicians to estimate the risk of functional deterioration, institutionalization, and death within the electronic medical record. Before using this scoring system, however, the clinical utility of the model needs to be validated in future studies. Once validation studies are carried out, understanding the link between sub-groups of people most vulnerable to functional decline, institutionalization, and death and lapses in healthcare can help guide the development and implementation of interventions. Surveillance could enable disability management that reduces risks of adverse outcomes and improves the quality of life among elderly Medicare persons with disabilities.

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Table 1

Outcome and Baseline Characteristics of Medicare Current Beneficiary Survey Sample Persons in the Total, Derivation, and Validation Cohorts

Characteristics	Total N (weighted %) N=21264	Derivation N (weighted %) N=12758 (60%)	Validation N (weighted %) N=8506 (40%)
Outcome of Activity of Daily Living stage transition			
Functional stable/improvement Functional deterioration Institutionalization Death	15847 (77.8) 2880 (12.6) 512 (1.9) 2025 (7.8)	9496 (77.7) 1765 (12.8) 287 (1.7) 1210 (7.8)	6351 (77.8) 1115 (12.2) 225 (2.0) 815 (7.9)
Baseline characteristics			
Sociodemographics			
Age			
65–74	9531 (56.1)	5729 (56.2)	3802 (56.0)
75–84	8620 (34.2)	5142 (34.0)	3478 (34.5)
≥85	3113 (9.7)	1887 (9.8)	1226 (9.5)
Gender			
Male	9211 (43.6)	5494 (43.2)	3717 (44.1)
Female	12053 (56.4)	7264 (56.8)	4789 (55.9)
Race/Ethnicity			
Non-Hispanic white	17534 (82.1)	10520 (82.0)	7014 (82.1)
Non-Hispanic black	1700 (8.0)	1051 (8.3)	649 (7.6)
Hispanic	1436 (6.8)	837 (6.7)	599 (7.1)
Other	594 (3.1)	350 (3.0)	244 (3.2)
Education			
≥High school diploma	15252 (74.1)	9126 (74.0)	6126 (74.3)
Below high school diploma	6012 (25.9)	3632 (26.0)	2380 (25.7)
Living arrangement			
Retirement community	1514 (6.1)	885 (5.9)	629 (6.5)
With spouse	10784 (54.2)	6469 (54.2)	4315 (54.2)
With children	2079 (8.9)	1249 (9.0)	830 (8.9)
With others	980 (4.7)	596 (4.7)	384 (4.6)
Alone	5907 (26.0)	3559 (26.1)	2348 (25.8)
Dual eligibility			
Medicare only	18731 (89.0)	11226 (88.8)	7505 (89.3)
Medicare and Medicaid	2533 (11.0)	1532 (11.2)	1001 (10.7)
Beneficiary or proxy interview			
Beneficiary	19852 (94.1)	11911 (94.2)	7941 (94.0)
Proxy	1412 (5.9)	847 (5.8)	565 (6.0)
Health conditions			
Alzheimer’s disease/dementia	592 (2.2)	366 (2.3)	226 (2.1)

Characteristics	Total N (weighted %) N=21264	Derivation N (weighted %) N=12758 (60%)	Validation N (weighted %) N=8506 (40%)
Angina pectoris/coronary artery disease	2191 (9.8)	1319 (9.7)	872 (9.9)
Complete/partial paralysis	568 (2.5)	364 (2.7)	204 (2.2)
Diabetes/high blood sugar	4737 (22.5)	2830 (22.4)	1907 (22.6)
Emphysema/asthma/Chronic Obstructive Pulmonary Disease	2919 (13.6)	1726 (13.2)	1193 (14.2)
Hypertension	12971 (60.1)	7752 (59.7)	5219 (60.5)
Mental/psychiatric disorder	1251 (5.8)	762 (5.8)	489 (5.6)
Myocardial infarction/heart attack	3013 (13.0)	1805 (12.9)	1208 (13.1)
Other heart conditions	2954 (12.7)	1773 (12.8)	1181 (12.6)
Parkinson's disease	277 (1.1)	153 (1.1)	124 (1.2)
Stroke/brain hemorrhage	2415 (10.3)	1471 (10.4)	944 (10.1)
Impairments			
Severe hearing impairment/deaf	1602 (6.6)	953 (6.5)	649 (6.7)
Severe vision impairment/no usable vision	1621 (6.5)	963 (6.4)	658 (6.6)
Perceived facilitators to receiving healthcare			
Access to medical care			
Unsatisfied with ease/convenience	1045 (4.7)	622 (4.6)	423 (4.7)
Unsatisfied with out-of-pocket costs	3576 (17.3)	2170 (17.5)	1406 (17.1)
Care coordination and quality			
Unsatisfied with overall quality of care	720 (3.4)	434 (3.4)	286 (3.3)
Unsatisfied with information given	998 (4.6)	614 (4.7)	384 (4.5)
Unsatisfied with concern for overall health	998 (4.7)	586 (4.7)	412 (4.9)
Has a usual source of care	20793 (97.7)	12467 (97.6)	8326 (97.7)
Perceived barriers to receiving healthcare			
Has trouble getting healthcare or delayed healthcare because of financial reasons	1531 (7.8)	920 (7.8)	611 (7.8)
Has transportation difficulties	52 (0.2)	29 (0.2)	23 (0.2)
Function			
Activity of Daily Living Stage			
0	14658 (72.3)	8754 (72.0)	5904 (72.7)
I	3487 (15.1)	2119 (15.3)	1368 (14.8)
II	1710 (6.9)	1032 (6.9)	678 (6.9)
III	1199 (4.9)	731 (4.9)	468 (4.8)
IV	210 (0.8)	122 (0.8)	88 (0.8)

Table 2

Regression Coefficients in the Final Multinomial Logistic Regression Model for Functional Deterioration, Institutionalization, and Death in the Derivation Cohort (N= 12758)

	Functional deterioration				Institutionalization				Death			
Predictor	**β Coefficient**	**Adjusted Odds Ratio (95% Confidence Interval)**	**P Value**	**Score***	**β Coefficient**	**Adjusted Odds Ratio (95% Confidence Interval)**	**P Value**	**Score***	**β Coefficient**	**Adjusted Odds Ratio (95% Confidence Interval)**	**P Value**	**Score***
Sociodemographics												
Age (ref: 65–74)												
75–84	0.4775	1.61 (1.43–1.82)	<.0001	4	1.4357	4.20 (2.79–6.34)	<.0001	11	0.8877	2.43 (2.05–2.88)	<.0001	7
≥85	0.951	2.59 (2.20–3.05)	<.0001	7	2.4694	11.82 (7.64–18.26)	<.0001	18	1.9212	6.83 (5.61–8.31)	<.0001	14
Gender (ref: female)												
Male	−0.3017	0.74 (0.66–0.83)	<.0001	−2	−0.3724	0.69 (0.51–0.94)	0.017	−3	0.6184	1.86 (1.61–2.15)	<.0001	5
Race (ref: Non-Hispanic white)												
Non-Hispanic black	0.0919	1.10 (0.84–1.44)	0.506	0	1.2568	3.51 (1.38–8.96)	0.009	9	0.6001	1.82 (1.29–2.57)	0.001	4
Hispanic	0.1422	1.15 (0.93–1.44)	0.203	0	1.7803	5.93 (2.51–14.04)	<.0001	13	0.5154	1.67 (1.25–2.25)	0.001	4
Other	0.2597	1.30 (0.91–1.85)	0.150	0	−0.2512	0.78 (0.15–4.02)	0.764	0	0.0555	1.06 (0.64–1.75)	0.829	0
Education (ref: ≥High school diploma)												
No high school diploma	0.2155	1.24 (1.10–1.40)	0.001	2	0.1954	1.22 (0.92–1.60)	0.166	0	0.2265	1.25 (1.08–1.45)	0.002	2
Living arrangement (ref: With spouse)												
With children	0.257	1.29 (1.08–1.56)	0.006	2	0.0218	1.02 (0.61–1.70)	0.933	0	0.4076	1.50 (1.20–1.88)	0.0003	3
With others	0.0983	1.10 (0.85–1.43)	0.456	0	0.8283	2.29 (1.30–4.03)	0.004	6	0.2939	1.34 (0.99–1.82)	0.057	0
Alone	0.135	1.15 (1.01–1.30)	0.043	1	0.8683	2.38 (1.66–3.42)	<.0001	6	0.2395	1.27 (1.07–1.51)	0.006	2
Retirement community	0.0547	1.06 (0.85–1.32)	0.624	0	1.6584	5.25 (3.53–7.82)	<.0001	12	0.4165	1.52 (1.19–1.94)	0.001	3
Dual eligibility												
Medicare only	−0.2649	0.77 (0.65–0.91)	0.003	−2	−0.8622	0.42 (0.30–0.59)	<.0001	−6	−0.3036	0.74 (0.60–0.90)	0.003	−2
Proxy (ref: beneficiary responded)												
Proxy responded	0.4966	1.64 (1.32–2.04)	<.0001	4	0.3812	1.46 (0.96–2.24)	0.080	0	0.6005	1.82 (1.46–2.28)	<.0001	4
Health conditions (reference: no)												
Alzheimer’s disease/dementia	0.9307	2.54 (1.83–3.52)	<.0001	7	2.1364	8.47 (5.37–13.35)	<.0001	16	1.1835	3.27 (2.40–4.45)	<.0001	9

	Functional deterioration				Institutionalization				Death			
Predictor	**β Coefficient**	**Adjusted Odds Ratio (95% Confidence Interval)**	**P Value**	**Score***	**β Coefficient**	**Adjusted Odds Ratio (95% Confidence Interval)**	**P Value**	**Score***	**β Coefficient**	**Adjusted Odds Ratio (95% Confidence Interval)**	**P Value**	**Score***
Angina pectoris/coronary artery disease	0.1731	1.19 (1.00–1.41)	0.051	1	−0.6685	0.51 (0.32–0.83)	0.006	−5	−0.0664	0.94 (0.76–1.15)	0.528	0
Complete/partial paralysis	0.2024	1.22 (0.88–1.70)	0.224	0	0.6814	1.98 (1.15–3.41)	0.014	5	−0.1514	0.86 (0.60–1.22)	0.400	0
Diabetes/high blood sugar	0.4168	1.52 (1.34–1.72)	<.0001	3	0.5372	1.71 (1.28–2.28)	0.0003	4	0.3493	1.42 (1.22–1.65)	<.0001	3
Emphysema/asthma/Chronic Obstructive Pulmonary Disease	0.3244	1.38 (1.19–1.61)	<.0001	2	−0.0521	0.95 (0.65–1.40)	0.791	0	0.6774	1.97 (1.67–2.33)	<.0001	5
Mental/psychiatric disorder	0.3326	1.40 (1.13–1.72)	0.002	2	0.6009	1.82 (1.22–2.73)	0.004	4	0.1079	1.11 (0.86–1.45)	0.420	0
Myocardial infarction/heart attack	−0.0189	0.98 (0.84–1.15)	0.816	0	0.1724	1.19 (0.84–1.69)	0.336	0	0.2897	1.34 (1.12–1.59)	0.001	2
Parkinson’s disease	0.9049	2.47 (1.60–3.83)	<.0001	7	0.6273	1.87 (0.84–4.17)	0.125	0	0.6875	1.99 (1.27–3.12)	0.003	5
Stroke/brain hemorrhage	0.2852	1.33 (1.13–1.57)	0.001	2	0.2409	1.27 (0.90–1.80)	0.172	0	0.3039	1.36 (1.13–1.63)	0.001	2
Impairments												
Severe vision impairment/no usable vision	0.4222	1.53 (1.26–1.84)	<.0001	3	0.0834	1.09 (0.74–1.59)	0.667	0	0.3511	1.42 (1.16–1.74)	0.001	3
Severe hearing impairment/deaf	0.2972	1.35 (1.11–1.63)	0.002	2	−0.0976	0.91 (0.60–1.37)	0.645	0	−0.0704	0.93 (0.75–1.16)	0.524	0
Function												
Activity of Daily Living Stage (ref: Stage I)												
Stage 0	0.0178	1.02 (0.89–1.17)	0.802	0	−0.4905	0.61 (0.44–0.86)	0.004	−4	−0.6238	0.54 (0.45–0.64)	<.0001	−5
Stage II	−0.2811	0.76 (0.60–0.94)	0.014	−2	0.4065	1.50 (1.01–2.23)	0.043	3	0.4816	1.62 (1.30–2.01)	<.0001	4
Stage III	−1.6013	0.20 (0.14–0.29)	<.0001	−12	0.4275	1.53 (0.99–2.37)	0.054	3	0.4365	1.55 (1.22–1.96)	0.0003	3
Stage IV	−12.8875	omitted—floor effect	0	0.4635	1.59 (0.69–3.65)	0.275	0	1.0191	2.77 (1.75–4.40)	<.0001	8	

*Score was calculated by dividing each significant variable’s β coefficient by the lowest β coefficient and then rounding to the nearest integer.

Table 3

Outcome Predicting Rates by Sum Score Quartiles

Sum point scores	Derivation cohort		Validation cohort	
Functional deterioration				
	Outcome achieved, n/Total, n	**Probability, %**	**Outcome achieved, n/Total, n**	**Probability, %**
≤ −1	225/3319	6.78	171/2186	7.82
0 – 2	386/2994	12.89	251/1973	12.72
3 – 5	466/2534	18.39	272/1690	16.09
≥ 6	688/2414	28.50	421/1617	26.04
Institutionalization				
≤ 4	4/2961	0.14	6/2031	0.30
5 – 13	11/2522	0.44	10/1587	0.63
14 – 21	53/2381	2.23	55/1663	3.31
≥ 22	219/1919	11.41	154/1295	11.89
Death				
≤ 3	52/2716	1.91	45/1778	2.53
4 – 9	151/3232	4.67	119/2212	5.38
10 – 15	208/2126	9.78	147/1451	10.13
≥16	799/2632	30.36	504/1725	29.22

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Table 4

Two-year Functional Deterioration, Institutionalization and Death Predictive Indices and Associated Risk Groups*.

	Functional deterioration		Institutionalization		Death	
Predictor	**Point**	**Score**	**Point**	**Score**	**Point**	**Score**
Baseline characteristics						
Age						
65–74	0		0		0	
75–84	4		11		7	
≥85	7		18		14	
Gender						
Male	−2		−3		5	
Female	0		0		0	
Race						
Non-Hispanic white	0		0		0	
Non-Hispanic black	0		9		4	
Hispanic	0		13		4	
Other	0		0		0	
Education						
≥High school diploma	0		0		0	
Below high school diploma	2		0		2	
Living arrangement						
With spouse	0		0		0	
With children	2		0		3	
With others	0		6		0	
Alone	1		6		2	
Retirement community	0		12		3	
Dual eligibility						
Medicare only	−2		−6		−2	
Medicare plus Medicaid	0		0		0	

	Functional deterioration		Institutionalization		Death	
Predictor	**Point**	**Score**	**Point**	**Score**	**Point**	**Score**
Proxy interviewed						
Beneficiary	0		0		0	
Proxy	4		0		4	
Health conditions						
Alzheimer's disease/dementia	7		16		9	
Angina pectoris/coronary artery disease	1		−5		0	
Complete/partial paralysis	0		5		0	
Diabetes/high blood sugar	3		4		3	
Emphysema/asthma/Chronic obstructive pulmonary disease	2		0		5	
Mental/psychiatric disorder	2		4		0	
Myocardial infarction/heart attack	0		0		2	
Parkinson's disease	7		0		5	
Stroke/brain hemorrhage	2		0		2	
Impairments						
Severe hearing impairment/deaf	2		0		0	
Severe vision impairment/no usable vision	3		0		3	
Function						
Activity of daily living stage						
0	0		−4		−5	
I	0		0		0	
II	−2		3		4	
III	−12		3		3	
IV	0		0		8	

Identify predicted probability based on the sum score:

Functional deterioration		Institutionalization		Death	
Sum Scores	**Predicted probability (%)**	**Sum Scores**	**Predicted probability (%)**	**Sum Scores**	**Predicted probability (%)**
≤ −1	6.78	≤ 4	0.14	≤ 3	1.91
0 – 2	12.89	5 – 13	0.44	4 – 9	4.67

Identify predicted probability based on the sum score:					
Functional deterioration		**Institutionalization**		**Death**	
Sum Scores	**Predicted probability (%)**	**Sum Scores**	**Predicted probability (%)**	**Sum Scores**	**Predicted probability (%)**
3 – 5	18.39	14 – 21	2.23	10 – 15	9.78
≥ 6	28.50	≥ 22	11.41	≥16	30.36

*Instructions

[1]The 2-year functional deterioration, institutionalization, and death predictions involve 3 different scoring systems.

[2]Score the person according to the presence of each predictor. Enter the associated points in its score box.

[3]Add the points associated with each predictor to obtain a sum score for the relevant scoring system.

[4]In the sum score box, circle the range of the sum score to determine the person's risk group and the average likelihood of functional deterioration, institutionalization, and death.

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