5-4-2017

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Recommended Citation

O'Connor, M., Hanlon, A., Mauer, E., Meghani, S., Masterson-Creber, R., Marcantonio, S., Coburn, K., Van Cleave, J., Davitt, J., Riegel, B., Bowles, K. H., Keim, S., Greenberg, S. A., Sefcik, J., Topaz, M., Kong, D., & Naylor, M. (2017). Identifying Distinct Risk Profiles to Predict Adverse Events among Community-Dwelling Older Adults. *Geriatric Nursing, 38* (6), 510-519. http://dx.doi.org/10.1016/j.gerinurse.2017.03.013

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Abstract

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Keywords

Chronic Disease, Emergency Service, Hospital, Female, Hospitalization, Humans, Independent Living, Male, Medicare, Outcome Assessment (Health Care), Risk Assessment, United States

Disciplines

Geriatric Nursing | Geriatrics | Health and Medical Administration | Health Services Administration | Health Services Research | Medical Humanities | Medicine and Health Sciences | Nursing | Preventive Medicine | Public Health and Community Nursing

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HHS Public Access

Author manuscript

Geriatr Nurs. Author manuscript; available in PMC 2018 June 07.

Published in final edited form as:

Geriatr Nurs. 2017 ; 38(6): 510–519. doi:10.1016/j.gerinurse.2017.03.013.

Identifying distinct risk profiles to predict adverse events among community-dwelling older adults

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Abstract

Preventing adverse events among chronically ill older adults living in the community is a national health priority. The purpose of this study was to generate distinct risk profiles and compare these profiles in time to: hospitalization, emergency department (ED) visit or death in 371 community-dwelling older adults enrolled in a Medicare demonstration project. Guided by the Behavioral Model of Health Service Use, a secondary analysis was conducted using Latent Class Analysis to generate the risk profiles with Kaplan Meier methodology and log rank statistics to compare risk profiles. The Vuong-Lo-Mendell-Rubin Likelihood Ratio Test demonstrated optimal fit for three risk profiles (High, Medium, and Low Risk). The High Risk profile had significantly shorter time to hospitalization, ED visit, and death ($p < 0.001$ for each). These findings provide a road map for generating risk profiles that could enable more effective targeting of interventions and be instrumental in reducing health care costs for subgroups of chronically ill community-dwelling older adults.

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Introduction

Almost half of the current adult United States (US) population lives with at least one chronic illness, many of whom suffer from multiple chronic conditions (MCC).[1] The US Census Bureau estimates the population aged 65 or older will increase from 13% in 2010 to 20% in 2030.[2] Currently, two-thirds of all Medicare beneficiaries suffer from two or more chronic conditions with 37% suffering from five or more.[3] Furthermore, as our population ages, it is expected that older adults living with MCCs will dramatically increase as the incidence of MCCs increases with age.[3] In 2010, 63% of older adults aged 65 to 74 suffered from MCCs. Among older adults 85 or older, 83% suffered from MCCs.[3]

Prior research indicates that older adults with MCCs frequently have complex care needs and often experience transitions in care, which are frequently managed poorly[4] making them vulnerable for poor outcomes[5] including hospitalization, emergency department (ED) use, increased physician visits,[2] shorter time to death,[6] medication errors,[7,8] reduced quality of life[9] and decline in functional status.[10] Moreover, MCCs are contributing to this population's higher rates of hospitalization and ED visits.[2] Medicare beneficiaries with four or more chronic conditions have higher overall Medicare spending compared to those with three or less.[3] In addition to increasing unnecessary costs for payers and leaving older adults at risk for poor outcomes, avoidable hospitalizations also accelerate cognitive decline,[11] delirium,[12] and increase risk for medical errors[13,14] and death.[3,15]

Medicare beneficiaries with six or more chronic conditions have a 30-day all-cause hospital readmission rate of 25% compared to 19% for all fee-for-service Medicare beneficiaries.[3] Hospitalization costs incurred by Medicare recipients exceeded $120 billion in 2012, an increase of $10 billion from 2006.[16] It is well established that Medicare expenditures for unplanned and potentially preventable hospitalizations and ED visits contribute substantially to increases in costs. In 2011, 28% of all Medicare fee-for-service hospital admissions were potentially avoidable and 55% of all treat-and-release ED visits were considered preventable among this same population.[17]

To date, the majority of attention has been placed on individual risk factors associated with hospitalization among community dwelling older adults.[18–20] There has been little emphasis and evidence of how health system and individual clinical factors can be clustered into distinct risk profiles predicting the likelihood each risk profile has of experiencing adverse events such as hospitalization, ED visits, and death. Several studies have examined demographic factors associated with risk for hospital readmission such as lack of physician follow-up,[19] living alone, having four or more diagnoses, taking five or more medications[20] or having functional impairment.[21] Other studies have developed prediction models for hospital readmission but none have performed well enough for widespread use.[22]

Berkowitz and Anderson[23] found men to be 20% more likely to be readmitted than women and that Blacks and dual eligible Medicare/Medicaid beneficiaries have slightly increased risk. Patients with end-stage renal disease,[23] heart failure[19] and multiple chronic conditions[3] also have a higher risk for admission. Other important drivers for hospital admission include poor social support and poverty[24]; as both have been found to negatively impact health care

adherence.[25] Patients living in high-poverty neighborhoods are 24% more likely to be hospitalized[26] and married patients have significantly less risk of hospital admission, suggesting the importance of social support. While several approaches have been utilized to measure likelihood of risk for poor outcomes, predictive model development is lacking and strategies for risk-reduction of avoidable and costly healthcare utilization outcomes have not been tested.

These findings suggest that opportunities exist to improve primary care outpatient and community services to prevent and reduce hospital admissions and ED visits.[17] While much emphasis has been placed on readmission risk, the literature remains scant on identifying groups of co-occurring risk factors (risk profiles) associated with potentially avoidable hospitalizations, ED visits or death. This knowledge could enable more effective targeting of resource intense interventions and be instrumental in reducing health care costs while enhancing quality of life for high-need, high-cost subgroups of chronically ill community-dwelling older adults.[27] Seeking new models of care are essential to reduce Medicare spending, manage risk for adverse events and to meet the needs of the growing population of chronically ill older adults living in the community.

Existing literature has utilized administrative data to retrospectively examine hospital admission risk within the context of specific diagnosis types. This information is potentially useful on its own, but it is likely more valuable to examine common patterns of clinical risk factors associated with risk for any hospitalization, ED visit or death among older adults with multiple co-morbid conditions. Stratifying older adults is critical for aligning risk of adverse patient events to enable timely preventive interventions to diminish such risk. To address these gaps in knowledge, an exploratory, hypothesis generating analysis was conducted using extant data from a Medicare demonstration project. The goal of developing risk profiles is to manage rather than avoid risk, allowing providers to link identified needs with targeted interventions provided before an adverse event or further decline occurs. We employed a unique analytical technique, Latent Class Analysis (LCA), to identify how various health system, clinical and sociodemographic risk factors co-occur among older adults living at home (referred to as risk profiles). Once these clusters were identified, we examined the differences in three adverse events (time to hospitalization, ED visits and death) among these distinct risk profiles.

Conceptual framework

The Behavioral Model of Health Service Use proposed by Andersen[28] and refined by Andersen and Newman[29] served as the conceptual basis of this study. The model suggests individual and health system factors impact health care utilization (Fig. 1).29 A multidisciplinary team of clinical scholars[30–32] first determined the existence of individual and health system risk factors predisposing older adults to health care utilization, specifically hospitalization, ED visits and death identified from the literature. We then determined latent classes comprised of the individual risk factors (referred to as risk profiles) associated with these adverse events using Latent Class Analysis. A Latent Class Analysis is a way to classify cases in a manner that has not been previously established. We hoped to be able to identify classes where certain risk factors co-occurred to get a better understanding

of risk profile groups. Finally, the team explored the relationships between the distinct risk profiles and time to first hospitalization, time to first ED visit (health care utilization variables) or death, 3 months through 5 years following admission to a community-based care coordination program. This approach allowed the team to employ a unique analytical lens to identify how various clinical risk factors co-occur among older adults living at home, to distinguish distinct risk profiles, and to examine differences in time to hospitalization, ED visits and death between the distinct risk profiles (Table 1).

Methods

Design

This exploratory, hypothesis generating study was conducted using an extant data set from Health Quality Partners (HQP), a nonprofit research organization committed to improving preventative care for chronically ill community-dwelling older adults often with multiple co-morbid conditions who are vulnerable for poor outcomes.[33] Between 2002 and 2015, HQP conducted a randomized controlled trial as part of the Medicare Coordinated Care Demonstration (MCCD) program to evaluate the impact of a community based nurse care management model to improve health outcomes among chronically ill older adults residing in their homes in eastern Pennsylvania. The HQP program includes several evidence-based preventive and care management interventions delivered by community-based nurse care managers in collaboration with local health care and social service providers.[34] Institutional Review Board approval was provided via the expedited method from the University of Pennsylvania.

Data set/sample

Data collected by HQP's nurse care managers included the Sutter Health Questionnaire[30] and time to: first hospitalization, first ED visit, and death. The Sutter is a screening questionnaire without psychometric qualities that solicits information regarding a patient's perceived health status, comorbidities, medications, function and prior healthcare utilization (within 6 months).[35] The Sutter was completed by the nurse care managers via patient interview. Participants in the HQP program were: (a) adults age 65 or older, (b) diagnosed with coronary artery disease, heart failure, asthma, diabetes, hypertension, or hyperlipidemia, and (c) receiving care in a primary care practice that agreed to work with the HQP program. Exclusion criteria included dementia, end-stage renal disease, schizophrenia, active cancer, life expectancy less than 6 months, and residence in a long-term care facility.

As part of the HQP study, participants were randomized into the intervention or control group. Control group participants received usual care (no care coordination) and had no additional contact with HQP. Intervention patients were "…offered a comprehensive, integrated, and tightly managed system of care coordination, disease management, and preventive services delivered by HQP community-based nurse care managers working in collaboration with primary care providers" (p. 1) as previously published.[34] All data with the exception to outcome data, was collected at baseline prior to receiving the nurse care manager intervention. The duration of the nurse care manager intervention varied according to the patient's death or choice to withdrawal.

For the purposes of this study, analyses were based on the 371 HQP patients enrolled in the intervention group only from April 1, 2009 to October 2013. We chose this date range because nurse care managers started to record healthcare utilization data into HQP's clinical record on April 1, 2009. Control group (usual care) data were not available for analysis and, therefore, not included in this study. Older adults with multiple chronic conditions are a heterogeneous population. Consequently, important clinically significant relationships are often undetected. This data set provided a unique opportunity to analyze a more homogenous population.

Variables

The Sutter questionnaire, considered patient self-report data, was completed by nurse care managers via patient interview prior to study randomization and HQP intervention services. Based on the risk factors identified by the multidisciplinary team of clinical scholars[30–32] as important in the literature and according to the Behavioral Model of Health Service Use,[29] clinical items from the Sutter questionnaire were identified as risk factors to include in this study and are referred to as indicator variables. The indicator variables were any variables the investigators considered directly related to risk of poor healthcare outcomes (hospitalization, ED visits, death). After identification of the risk profiles, 10 demographic items from the Sutter questionnaire were used to describe the underlying patient characteristics associated with the distinct risk profiles and are referred to as covariates. The covariates were any variables used to describe the risk classes, but not directly related to risk (Table 1).

Covariates

The ten demographic and patient characteristic covariates included age at enrollment, gender, self-reported health status, number of medications, having lost ten or more pounds in the last 2 months without wanting to, current living arrangement, caregiving status, recent loss of a loved one, tobacco use and feeling depressed in the last 3 months (Table 1).

Indicator variables

The thirty-two clinical risk indicator variables obtained from the Sutter were dichotomized and included items such as self-reported diagnoses, having a poor functional status, number of comorbidities, and number of previous hospital admissions (Table 1).

Outcome variables

The outcome variables included time to first hospitalization, time to first ED use, and time to death. Time was measured as number of months from date of program enrollment to either: date of 'event' (first hospitalization, first ED visit, death), disenrollment date, or 10/23/2013 for participants still active without an event (date of data collection completion), whichever occurred first.

Statistical analysis

A secondary analysis using Latent Class Analysis (LCA) with MPlus (version v.7.0, Los Angeles, CA) was conducted. LCA uses a model-based approach in which the probabilities

of class membership are estimated from model parameters and individuals' observed scores.[36] This is in contrast to traditional clustering methods such as k means clustering, which typically involves minimizing within cluster variance and maximizing between cluster variance. In LCA, individuals are assumed to belong to one set of k latent classes and the size or the numbers of classes are not known a priori.[36] LCA allows simultaneous examination of several indicator variables, as well as inclusion of mixed measurement levels in the model. This means that variables can be included regardless of the scaling of the observed variables.

The 32 clinical indicator variables were used in the LCA to construct the latent classes of risk profiles. The Vuong-Lo-Mendell-Rubin Likelihood Ratio Test was used to quantify optimal model fit and determine the number of classes. After risk profiles were constructed, Fisher's Exact tests/Chi-Square tests and ANOVA were used to examine differences between categorical/continuous demographic covariates (patient characteristics) and risk class membership where appropriate. Endorsing probabilities represented the probability of a 'yes' response for each clinical indicator variable, given class membership from the latent class analysis (Table 1).

To better understand how the clinical (indicator) risk factors co-occur within the latent risk profiles, we examined the "endorsing probabilities" of having the risk factor given risk profile membership. For example, when considering the clinical indicator risk factor for "arthritis" we looked at whether or not a patient had arthritis at the time of Sutter completion. For each risk profile, the specific endorsing probability would represent the probability that a patient had arthritis at Sutter completion given the patient was placed into that risk profile. Thus, each indicator factor has a set of endorsing probabilities that are associated with the set of risk profiles. Comparing the endorsing probabilities based on risk profile membership allowed us to examine the co-occurrence of indicator factors within risk profiles and to determine whether there was a clear distinction in clinical risks between profiles constructed. Lastly, time to first hospitalization, time to first ED visit, and time to death were compared between risk profiles using Kaplan Meier methodology and comparisons were made using log rank statistics. Patients without the event of interest (hospitalization, ED visit, death) were censored at last follow-up or date of data collection completion.

Results

The older adults in this analysis were on average, 77 years old, with the majority being female (58%). Thirty-two percent of older adults described their health status as fair to poor and 82% reported taking 5 or more medications. Seventy-three percent reported having four or more chronic conditions as determined by the Sutter Health Questionnaire. Three independent and clinically meaningful risk profile classes were identified and labeled High Risk (n = 125, 34%), Medium Risk (n = 145, 39%), and Low Risk (n = 101, 27%) (Table 2).

Class membership

The High Risk class was defined as the class with the highest total endorsing probability, taken as the sum of all endorsing probabilities. The High Risk class was most

distinguishable by clinical indicator variables with endorsing probabilities greater than or equal to 60% and at least 15% greater than the endorsing probabilities of the other two risk classes (Fig. 2). The High Risk class had a higher probability of reporting at least one prior ED visit and one prior hospitalization in the last 6 months, having been to a doctor or clinic four or more times in the last 6 months, requiring assistance with activities of daily living (ADLs) and instrumental activities of daily living (IADLs), requiring special equipment (hospital bed, Hoyer lift, cane, commode, walker, etc.), having arthritis, fallen to the ground in the past year, and being limited in activities (bedbound, housebound, or requiring the assistance of another to leave the house) (Table 2). The High Risk class was predominantly female and taking five or more medications. About one-quarter reported feeling depressed and having lost 10 or more pounds in the last 2 months without wanting to, and over half reported 'poor' health status. Fisher's Exact tests/Chi-Square tests were significant for seven covariates (Table 3).

The Medium Risk class was defined as the class with the middle total endorsing probability. The Medium Risk class did not have any endorsing probabilities at least 15% less than both of the other two classes nor did it have any endorsing probabilities at least 15% greater than both of the other two classes. The Medium Risk class had endorsing probabilities of reporting at least one prior ED visit and one prior hospitalization in the last 6 months, having been to a doctor or clinic four or more times in the last 6 months, requiring assistance with ADLs and IADLs, requiring special equipment (hospital bed, Hoyer lift, cane, commode, walker, etc.), and having arthritis, fallen to the ground in the past year between the Low Risk class and High Risk class. Notably, 3 indicator variables had endorsing probabilities greater than the High Risk class (although not greater by at least 15%). These were greater probabilities of having high blood pressure or taking medication for high blood pressure, having high cholesterol or taking medication for high cholesterol, and having 4 or more comorbidities.

The Low Risk class was defined as the class with the lowest total endorsing probability. The Low Risk class was most distinguishable by clinical indicator variables with Low Risk endorsing probabilities less than or equal to 30% and at least 15% less than the endorsing probabilities of the other two classes. The Low Risk class was more likely to report: not having visited the ED in the last 6 months; having been to a doctor or clinic three or less times in the last 6 months; not requiring assistance with IADLS; not having diabetes, circulation problems, stomach/intestine problems, trouble controlling bowel/bladder, anxiety, depression, uncorrected vision or hearing loss; and having less than four comorbidities (Table 2). Of the seven significant covariates, those most representative of the Low Risk class included: a self-reported health status of 'excellent' or 'good'; taking four or less medications; no recent loss of a loved one; and denied any feelings of depression in the prior 3 months (Table 3).

Impact of class membership on time to hospitalization, emergency department use and death

Statistically significant differences in time to first hospitalization were observed by class membership (log-rank $p < 0.001$, Fig. 3). All classes had distinctive profiles of time to

hospitalization, with the High Risk class presenting consistently smaller Kaplan-Meier survival probabilities over time compared to the other two risk classes. At 6 months, 8% in the Low Risk class, 19% in the Medium Risk class, and 34% in the High Risk class experienced a hospitalization. By 36 months, all patients in the High Risk class experienced a hospitalization compared to 69% in the Medium Risk class and 27% in the Low Risk class.

Statistically significant differences in time to first ED use were also observed by class membership (log-rank $p < 0.001$, Fig. 4). All classes had distinctive profiles over time, with the High Risk class again showing consistently smaller Kaplan-Meier survival probabilities over time compared to the other two classes. At 6 months, 2% in the Low Risk class, 5% in the Medium Risk class, and 19% in the High Risk class experienced an emergency department visit. At 36 months, about 27%, 39%, and 48%, respectively, experienced an ED visit.

Lastly, significant differences in time to death were also observed by class membership (log-rank <0.001, Fig. 5). The profile over time for the High Risk class noticeably declines compared to the other two classes. At 12 months, 2%, 5%, and 7%, in the Low Risk, Medium Risk, and High Risk classes, respectively, died. However, from 12 months to 24 months, about a quarter of the High Risk class died while the other class percentiles remained relatively constant. At 36 months, about 2%, 21%, and 54%, and at 48 months 8%, 23%, and 62% respectively, died. Kaplan-Meier survival estimates from zero to 60 months for time to first hospitalization, time to first emergency department use, and time to death are found in Figs. 3–5.

Discussion

This research furthers understanding of distinct risk profiles among chronically ill community-dwelling older adults related to their probability for increased risk for hospitalization, ED visit or death, 3 months through 5 years following admission to a nurse-led community-based care coordination program. Women were most likely to be in the High Risk class possibly because 58% of the sample were women who tend to live longer than men and are more likely to have chronic conditions.[3] Furthermore, in the United States, 46% of women aged 75 and over live alone[37] with the oldest women more likely to have been recently widowed, potentially increasing their risk for an adverse event. Needing assistance with IADLs was the clinical risk factor that most discretely distinguished between all classes in addition to also having the greatest variability between High and Low Risk class. Our results also indicate that an older adult's self-perception gives insight into their risk (as the Sutter questions are patient self-report) as excellent to good self-reported health status was associated with lower risk. Finally, our results confirm previous findings[20] that older adults taking five or more medications is positively associated with risk for adverse events but having 4 or more co-morbid conditions has been found in prior work to increase risk for adverse events[23] but did not distinguish between High and Medium Risk in our study.

While risk for adverse events among chronically ill older adults has been previously studied, it is unclear how community-based health care providers have applied these findings. For example, requiring assistance with ADLs and IADLs was more likely to co-occur among

community-dwelling older adults in the High Risk profile. IADLs include activities using the telephone, shopping, meal preparation, housekeeping, laundry, transportation, finances and the medication administration.[38] Requiring assistance with IADLs may not trigger a high risk alert as needing assistance with ADLs might and thus could be overlooked as a risk factor for hospitalization, ED visits and death. The creation of distinct risk profiles will assist community-based health care clinicians to more critically evaluate and anticipate a chronically ill older adult's needs allowing them to either initiate services or intervene more effectively while they are receiving services.

Our findings have clinical and health delivery implications as the risk profile alone are not useful in preventing adverse events. However, the risk profile could prove beneficial when used by community-based nurses to guide targeted interventions and provide evidence based resources to community dwelling older adults. Being anticipatory and proactive in addressing medical, self-management, social, behavioral and safety needs of those identified as High and Medium Risk could be useful in preventing adverse events. This study begins to yield insight into unique risk profiles among vulnerable older adults living at home. If independently validated in other studies, these risk profiles could be used by primary care and other community-based clinicians to identify older adults living in the community who may be at risk for poor outcomes and trigger clinicians to initiate individualized, targeted interventions. Targeted interventions may include the initiation, continuation or increased frequency of several community-based services such as nurse-led care coordination,[34] home health care,[39,40] hospice, phone calls between visits,[41] telehealth,[42] physician follow up[43] and handyman services[44] to mitigate risk. Additionally, the risk profiles, if further refined, could be integrated into clinical decision support systems to assist clinicians identify specific community-based referrals needed by older adults according to their level of risk.[45] Classifying community dwelling older adults into three risk profiles may also be helpful to determine the intensity and type of services to render according to their level of risk. These results also provide support for nurse-led community-based interventions and a road-map of critical information to increase efficiency and improve the care and services provided to chronically-ill, community-dwelling older adults and reduce potentially avoidable and costly events such as hospitalization, ED visits and death among this already vulnerable population.

This analysis included intervention only patients; community-dwelling older adults not receiving community-based interventions may in fact experience worse outcomes. By utilizing risk profiles to identify subgroups that would benefit most from targeted interventions, resources could be appropriately aligned to prevent progression to a higher risk class. For example, older adults in the Medium to High Risk classes are likely to benefit from skilled home health, home delivered meals, caregiver support and adult day services where those in the Low Risk class may require only outpatient referrals such as physical and occupational therapy, phlebotomy and transportation services potentially leading to the efficient use of scarce healthcare resources while meeting the needs of vulnerable older adults living at home. Finally, by regularly assessing and monitoring for changes in class membership earlier and more broadly, implementation of nurse care coordination could limit the use of avoidable and costly unplanned healthcare utilization slowing the growth of Medicare spending.

Finally, multiple studies reveal patient engagement is critical to effective care management.[5] Prior research with this same population showed that in-person nursing contact and nurse continuity enhanced patient enrollment in the program potentially due to patient engagement of chronically ill older adults.[46] A nurse-led, community-based care coordination program is the ideal venue to promote patient engagement, employ risk profiles, slow transition to a higher risk class and potentially avoidable healthcare utilization.

Use of the Sutter Health Questionnaire with its existing variables, as the primary instrument to elicit information from older adults is the primary limitation of this study. However, this instrument is employed among a unique, homogenous population of chronically ill older adults providing insight into the health risks of this distinct group. Additional limitations include analyzing older adults from one geographic area in Pennsylvania, outcome data provided by participating hospitals only, and reliance on patient self-report, leaving the possibility that some hospitalizations and ED visits were omitted. Controversy exists on the accuracy of self-report health care data,[47] however prior research indicates obtaining hospitalization and ED visit utilization via self-report from older adults living in the community is a relatively accurate method to obtain information.[48] Self-report data has been employed in prior published research to predict hospitalization,[49] mortality and nursing home placement among chronically ill older adults.[50,51] Additionally, only intervention patients of the Medicare Coordinated Care Demonstration were included in this study as control group data were unavailable to the study team due to the nature of the demonstration. [34] We expect that including intervention only patients had little impact on risk class, as baseline data was collected from older adults prior to randomization into groups and the start of the intervention. Outcomes however, could have been influenced by the nurse care manager intervention, which was individualized based on risk, but only intervention group outcomes were available for comparison. Because the predictor variable of all three outcomes was the risk profile, and because risk profiles were constructed from a multitude of risk factor items collected at baseline, we suspect that any confounding of intervention strategies/doses with risk profile membership would be minimal. However, we do acknowledge that this confounding could still exist. Without the proper data on intervention administration, we can only state this as a limitation. Dichotomizing number of chronic condition and medications by four or more is also a limitation and has implication particularly for the endorsing probabilities of the Medium Risk class.

Finally, this study employed secondary data limiting the analysis to the data collected by HQP including limited ethnicity information and socio-economic status. The data analyzed in this study is observational, prone to selection bias and particular intervention characteristics are likely confounded with clinical patient characteristics. However, these findings are useful for supporting future studies, generating hypotheses, and understanding the complex relationship between clinical factors and outcomes. Despite these limitations, the results of this study provide empirical evidence for the development of future research studies testing care coordination interventions and disease management strategies for community-dwelling older adults. The growing body of avoidable healthcare utilization research has focused mainly on preventing adverse events by identifying individual characteristics of the older adult and has not sought to identify profiles indicating risk.

Applying latent class analysis provides a unique analytical lens to identify how various risks co-occur and what demographic and clinical factors underlie these risks.

Recommendations

At the time of data collection, Health Quality Partners (HQP) completed the Sutter questionnaire with patients upon participation in the demonstration and then again in 24 months. Given the marked difference in time to hospitalization, ED visits and death rates between risk groups, completing the Sutter or a similar assessment every 6 months might more proactively alert nurses to a change in patients' risk status and deploy interventions to prevent a potentially avoidable adverse event. However, it is possible that HQP may have already realized a similar benefit by having their frequent, ongoing follow-up assessments include several key components of the Sutter questionnaire (e.g., falls, IADLs) that assists the nurse care manager to more quickly identify shifts in risk classification.

Future research is recommended to validate findings and to apply this methodology to a larger, more diverse sample of community-dwelling older adults that includes sufficient numbers of older adults with distinct health issues (e.g., cognitive impairment, functional deficits) with more robust data, including those not receiving a nurse-led care coordination intervention, on health care resource use to examine if profiles hold. This line of inquiry would benefit from mixed methods research to capture risk from a patient and unpaid caregiver perspective. Additional research would also be beneficial to determine and test targeted interventions based on the latent risk classification characteristics identified in this analysis. Moreover, additional research is needed to better understand the potential long-term financial and health benefits of providing interventions to reduce risks among those at Medium (or "rising") Risk as it may be critical to developing more effective and sustainable systems of population health management. A sizable subset of those at Medium Risk may be close enough in time to increased utilization of costly health services, yet have a greater opportunity to avoid hospitalization, ED visits and death, if they can be identified and provided appropriate preventive interventions. Undertaking such research requires the ability to identify those at Medium Risk, a task for which analysis of latent class(es) may be well suited.

Conclusion

This research lends support for nurse-led, community-based care coordination programs and will inform interventions based on our enhanced understanding of distinct risk classes that predispose older adults to decreased quality of life and possibly disproportionate health care utilization. Through repeated assessment of risk class membership, care coordination resources can be aligned for those older adults in the community at greatest risk for hospitalization or ED visit(s). Prevention of adverse events can offset substantial costs, including exposure to medical errors, hospital acquired infections, and decline in functional and cognitive ability, and risk of further fragmentation of care delivery.

Acknowledgments

The authors would like to acknowledge and thank the New-Courtland Center for Transitions and Health and the patients of Health Quality Partners, LLC.

Funding: This work was supported by the NewCourtland Center for Transitions and Health. Justine S. Sefcik received support from the National Institutes of Health, National Institute of Nursing Research (T32NR009356; F31 NR015693). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

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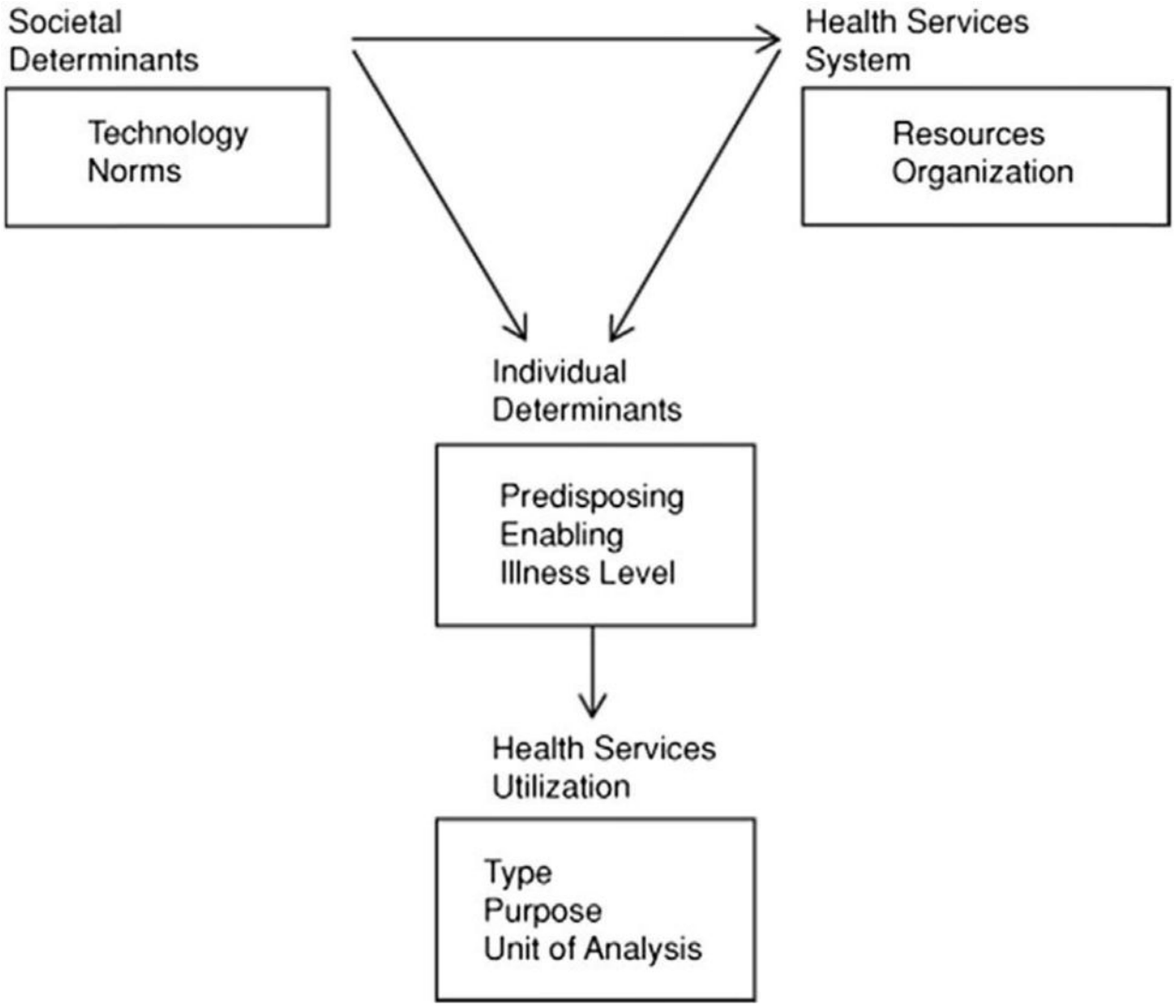

Fig. 1.
Behavioral model of health service use.[29]

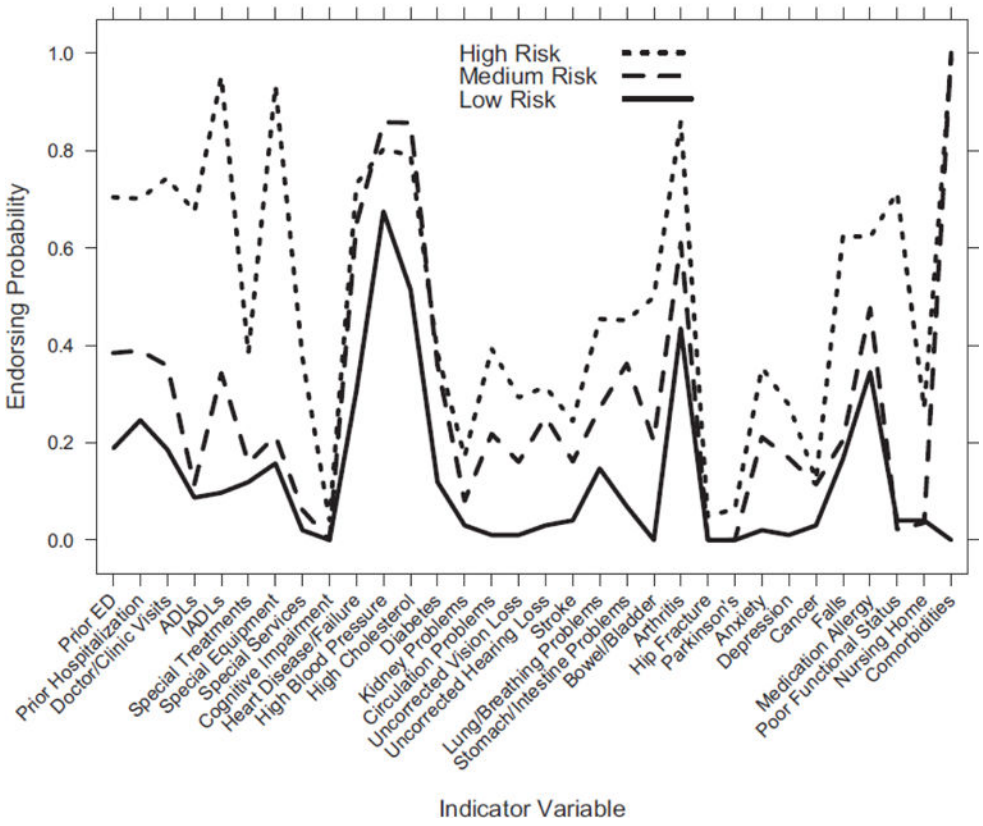

Fig. 2.
Risk endorsing probabilities of indicator variables.

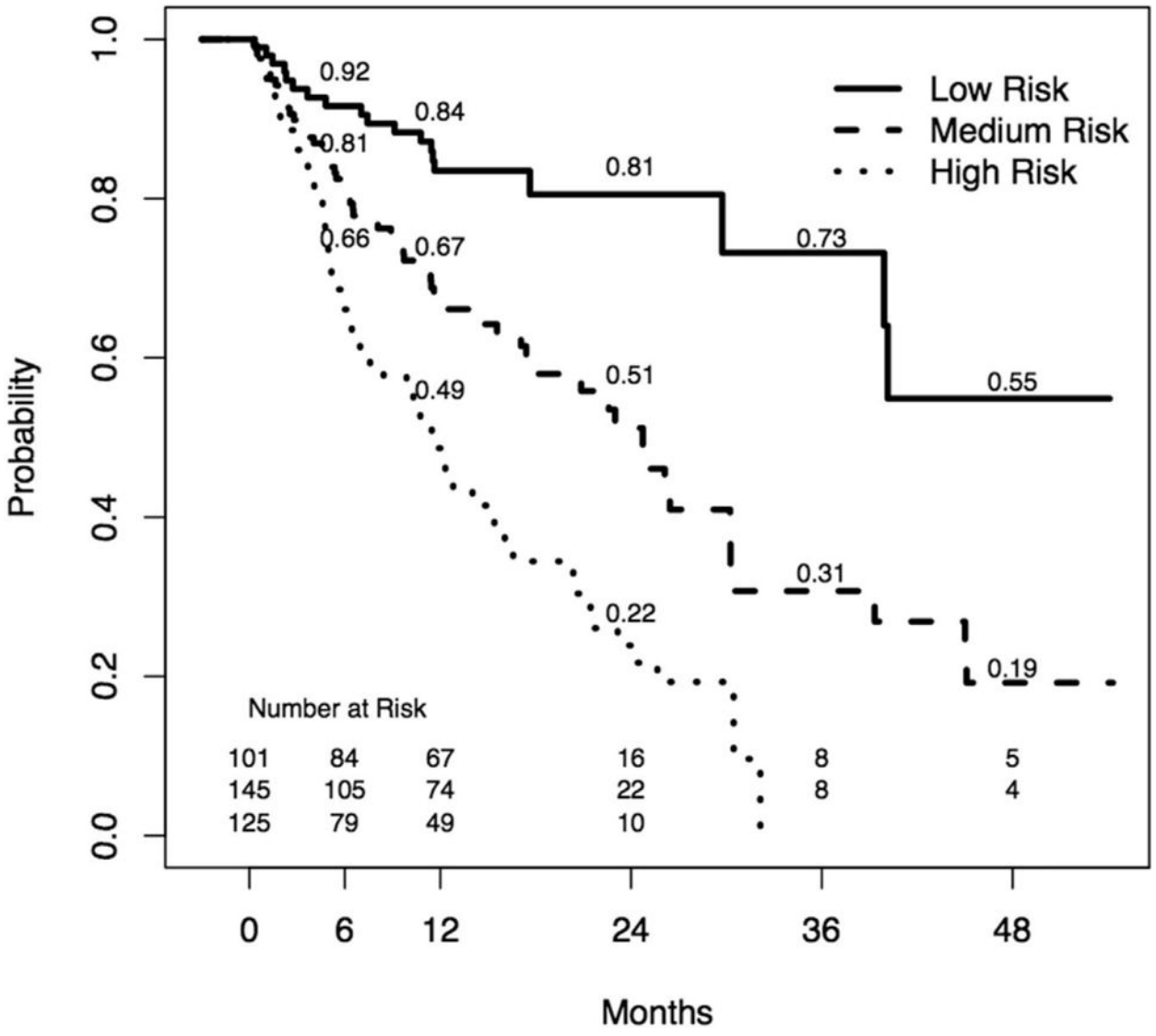

Fig. 3.

Time to first hospitalization Kaplan Meier curve by class with survival probabilities, log-rank ($p < 0.001$).

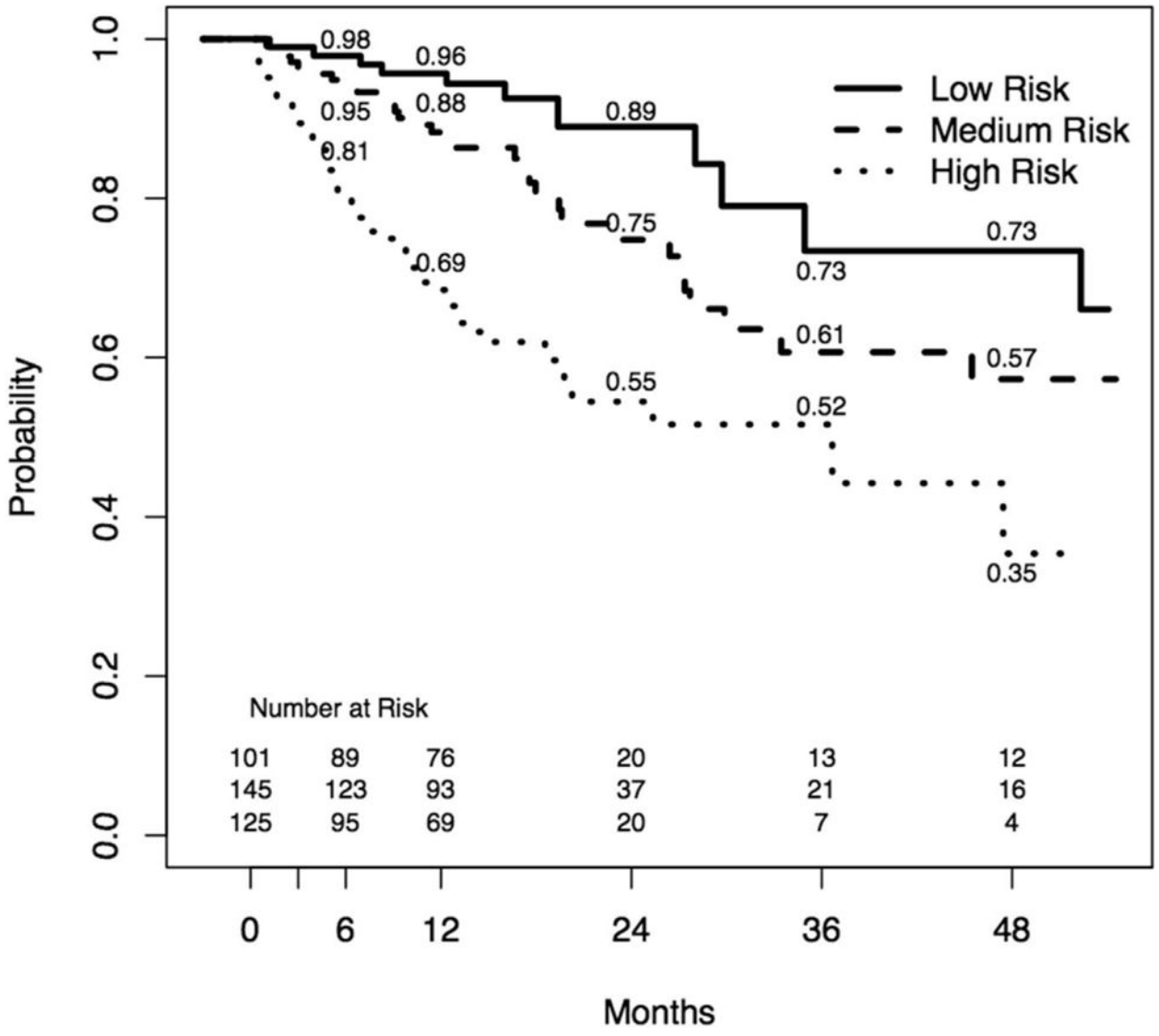

Fig. 4.

Time to first emergency department visit Kaplan Meier curve by class with survival probabilities, log-rank ($p < 0.001$).

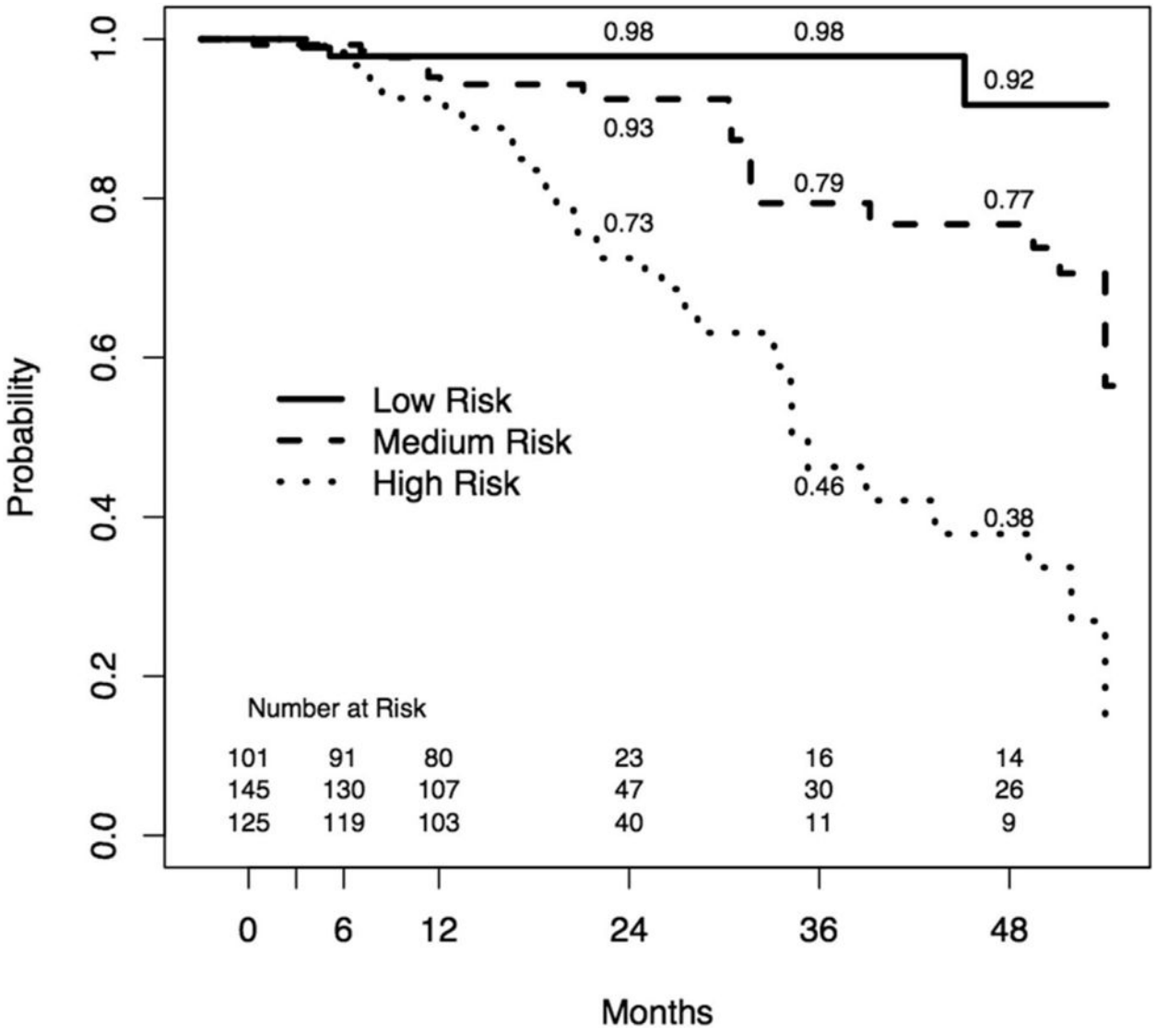

Fig. 5.

Overall survival Kaplan Meier curve by class with survival probabilities, log-rank ($p < 0.001$).

Table 1

Study variables and definitions.

Covariates (10)	
Variable	**Definition (dichotomous except where indicated)**
Individual patient characteristic variables	
Age[a]	Age upon enrollment
Gender	Male/female
Loss of a loved one	Lost a loved one in the last year (yes/no)
Current living arrangement	Currently living alone (yes/no)
Self-reported health status	Excellent/good vs fair/poor
Number of medications	4 or less vs. more than 4
Weight loss	Lost 10 pounds or more in the last two months without wanting to (yes/no)
Caregiving status	Caring for someone else (yes/no)
Self-reported depression	Felt depressed in the past three months (yes/no)
Current tobacco use	Currently smokes or uses tobacco (yes/no)
Indicator variables (32)	
Variable	Definition (dichotomous yes/no)
Clinical variables	
Health system factors	
Prior ED	Has visited the ED at least once in the last 6 months
Prior hospitalization	Has stayed overnight in the hospital at least once in the last 6 months
Prior doctor/clink visits	Has been to a doctor/clinic 4 or more times in the last 6 months
Special treatments	Requires special treatments such as tubefeeding, tracheostomy or wound care, injections, ostomy or catheter care, chemotherapy or oxygen
Special equipment	Requires special equipment such as hospital bed. Hoyer lift, grab bars, bedside commode, wheelchair, walker, or cane
Special services	Is receiving any services such as home health, outpatient therapy, adult day services. transportation, or delivered meals
Nursing home	Has been in/was considering/or is in a nursing home in the past year
Individual factors	
ADLs	Requires assistance with activities of Daily Living
IADLs	Requires assistance with Instrumental Activities of Daily Living
Cognitive impairment	Has cognitive impairment or is taking medication for serious memory loss
Heart disease/failure	Has heart disease/failure or is taking medication for heart disease (heart attack, stent, bypass, angina, heart failure)
High blood pressure	Has high blood pressure or is taking medication for high blood pressure
High cholesterol	Has high cholesterol or is taking medication for high cholesterol
Diabetes	Has diabetes or is taking medication for Diabetes (high blood sugar)
Kidney problems	Has kidney problems or is taking medication for kidney problems
Circulation problems	Has circulation problems or is taking medication for circulation problems
Uncorrected vision loss	Has uncorrected vision loss or is taking medication for uncorrected vision loss
Uncorrected hearing loss	Has uncorrected hearing loss or is taking medication for uncorrected hearing loss

Covariates (10)	
Variable	**Definition (dichotomous except where indicated)**
Stroke	Has had a stroke or is taking medication for stroke
Lung/breathing problems	Has lung/breathing problems or is taking medication for serious lung/breathing problems (Asthma or Chronic Lung Disease)
Stomach/intestine problems	Has stomach/intestine problems or is taking medication for stomach/intestine problems
Bowel/bladder	Has trouble controlling bowel/bladder or is taking medication for trouble controlling bowel/bladder
Arthritis	Has arthritis or is taking medication for arthritis
Hip fracture	Has a hip fracture or is taking medication for hip fracture (within 12 months)
Parkinson's	Has Parkinson's or is taking medication for Parkinson's disease
Anxiety	Has anxiety or is taking medication for anxiety
Depression	Has depression or is taking medication for depression
Cancer	Has cancer or is taking medication for cancer (other than skin)
Falls	Has fallen to the ground in the past year
Medication allergy	Is allergic to any medications
Limited in activities	Is limited in activities by needing to stay in bed, in the house, or needs assistance from another person or device to leave the house
Comorbidities	Has 4 or more comorbidities
Outcome variables (3)	
Variable	Definition
Health care utilization factors	
Hospitalization[a]	Time to first hospitalization (in months)[b]
ED use[a]	Time to first ED use (in months)[b]
Death[a]	Time to death (in months)[b]

[a]Continuous.

[b]If no event, time to last disenrollment date or 10/23/13 (data collection date).

Table 2

Probability of risk factors within each latent class.

Variable	Low	Medium	High
Prior ED	0.188	0.384	**0.704**
Prior hospitalization	0.246	0.389	**0.701**
Prior doctor/clinic visits	0.188	0.358	**0.744**
ADLs	0.087	0.114	**0.674**
IADLs	0.097	0.343	**0.952**
Special treatments	0.119	0.158	0.383
Special equipment	0.157	0.214	**0.933**
Special services	0.02	0.062	0.374
Cognitive impairment	0	0	0.04
Heart disease/failure	0.307	0.65	0.732
High blood pressure	0.675	0.858	0.803
High cholesterol	0.514	0.857	0.79
Diabetes	0.119	0.359	0.383
Kidney problems	0.03	0.08	0.171
Circulation problems	0.01	0.218	0.393
Uncorrected vision loss	0.01	0.16	0.293
Uncorrected hearing loss	0.03	0.253	0.314
Stroke	0.04	0.161	0.244
Lung/breathing problems	0.147	0.271	0.454
Stomach/intestine problems	0.069	0.352	0 451
Bowel/bladder	0	0.203	0 499
Arthritis	0.435	0.611	**0.859**
Hip fracture	0	0	0.048
Parkinson's	0	0	0.064
Anxiety	0.02	0.211	0.354
Depression	001	0.168	0.277
Cancer	0.03	0.114	0 124
Falls	0.167	0.205	**0.625**
Medication allergy	0.345	0.477	0.622
Limited in activities	0.04	0.022	**0.714**
Nursing home	0.04	0.035	0.27
Comorbidities	0	1	0.99

The bolded ones are most representative of the high risk class.

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Table 3

Relationship between class membership and patient characteristics.

Covariates[a]	**Risk class**				
	Low	**Medium**	**High**	**Chi-square**	***p*-value**
Female	**51%**	**51%**	**70%**	**12.5**	**0.002**
Male	**49%**	**49%**	**30%**		
Self-reported health status fair/poor	**13%**	**26%**	**53%**	**44.38**	**<0.001**
Self-reported health status excellent/good	**87%**	**74%**	**47%**		
Recent weight loss	**5%**	**5%**	**22%**	**24.64**	**<0.001**
No recent weight loss	**95%**	**95%**	**78%**		
Five or more medications	**60%**	**86%**	**94%**	**43.34**	**<0.001**
Less than 5 medications	**40%**	**14%**	**6%**		
Lives alone	24%	30%	34%	3.03	0.219
Does not live alone	76%	70%	66%		
Is a caregiver to someone else	**8%**	**18%**	**7%**	**9.37**	**0.009**
Is not a caregiver to someone else	**92%**	**82%**	**93%**		
Uses tobacco	3%	8%	3%		0.169
Does not use tobacco	97%	92%	97%		
Recent loss of a loved one	**11%**	**25%**	**26%**	**9.44**	**0.009**
No recent loss of a loved one	**89%**	**75%**	**74%**		
Self-reported depressed	**3%**	**12%**	**27%**		**<0.001**
Not self-reported depressed	**97%**	**88%**	**73%**		

Age on enrollment[b]	***N***	**Mean**	**Median**	**SD**	**Min**	**Max**	**F**	**Pr > F**
Low	**101**	75.68	75.00	6.83	65.00	92.00	17.89	<.001
Medium	**145**	75.77	75.00	6.66	65.00	94.00		
High	**125**	80.48	81.00	8.12	65.00	97.00		

Significant findings at the 0.05 level were bolded.

[a] Fisher's Exact Test.

[b] ANOVA.