DISEASE MANAGEMENT
Volume 9, Number 1, 2006

Clinical Features of High-Risk Older Persons Identified by Predictive Modeling

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ABSTRACT

The objective of this study was to describe the clinical features of older persons identified as high risk by a predictive modeling algorithm and to determine their suitability for clinical interventions like case management or disease management. A cross-sectional survey was undertaken at a community-based general internal medicine practice with 826 older patients enrolled in a Medicare-like health plan for military retirees and their dependents. Administrative claims data provided information about all 826 enrollees' chronic conditions, their use of health services, and the cost of those services during the past year. A survey mailed to 150 identified high-risk enrollees provided information about sociodemographic characteristics, general health, bed disability days, restricted activity days, activities of daily living (ADL) limitations, and instrumental activities of daily living (IADL) limitations. Compared to the 676 low-risk enrollees, the 150 high-risk enrollees had higher prevalence of eight individual chronic conditions, higher total chronic conditions (2.93 vs. 1.48, $p < 0.001$), higher annual rates of hospital admission (1.1 vs. 0.1, $p < 0.001$), more annual hospital days (7.3 vs. 0.5, $p < 0.001$), and higher total health insurance expenditures ($22,815 vs. $3,726, $p < 0.001$). The high-risk respondents to the survey (response rate = 80.0%) had suboptimal health (42.8% "fair or poor"), impaired functional ability (36.3% with 1+ ADL limitations, 58.1% with 1+ IADL limitations), and frequent health-related disruptions in their activities during the previous six months (38.7% with 1+ bed disability day, 52.3% with 1+ restricted activity day). A claims-based predictive modeling algorithm identifies older persons whose health, functional ability, and use of health services suggest they are good candidates for clinical interventions such as case management and disease management. (Disease Management 2006;9:56–62)

INTRODUCTION

MEETING THE NEEDS of the rapidly growing older population is currently one of the major challenges facing the US healthcare system. One of the important issues is the amount of dollars spent on health care for older persons. According to the US Department of Labor, during 2002 annual expenditures on healthcare for those aged 65 and older were $78 billion, accounting for 30% of overall healthcare expenditures in the United States.[1] Americans aged 65 and older also spent 13% of their after-tax income on healthcare, causing a burden for themselves and their families.[1] In 1999, 65% of Medicare beneficiaries aged 65 and

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older had multiple chronic conditions. The number of chronic conditions has been positively associated with Medicare expenditures.[2]

In response to these rising costs and the multiple healthcare needs of older persons with chronic conditions, programs such as disease management and case management have been developed to help this population maintain their health and reduce their healthcare expenses. In order for these interventions to succeed, it is crucial that they are accurately targeted to older persons with two characteristics: they are at risk for high healthcare expenditures, and their clinical needs could be mitigated by clinical intervention. According to the National Chronic Care Consortium, successful targeting of such persons can lead to lower expenditures for health care, prevention of future high costs for the aging population, prevention of functional decline and poor health outcomes of older persons, and financial sustainability for health plans that provide services to older persons.[3]

Three approaches have been widely used to identify high-risk subgroups to receive clinical interventions. Surveys and referrals from healthcare providers can be effective, but they are expensive and are based on subjective reports that can be inaccurate. The third method, predictive modeling, is based on analysis of existing administrative data.[4]

To determine whether these risk-based targeting methods identify persons who not only have high risk of future expenditures, but also have clinical features amenable to case management or disease management, we searched the scientific literature. Initially, we entered these search terms into Pub Med, singly and in combination: "predictive modeling," "risk screening," "risk identification," "high-risk groups," "risk adjustment," "predictive risk modeling," "aged," "ACG," and "PIP-DCG." We found reports of the results of using four risk surveys and one predictive modeling method. Other predictive modeling approaches are proprietary and are not described in the peer-reviewed literature.

One survey method is designed to identify older people at increased risk of functional decline or death. This "Vulnerable Elders Survey" (VES), derived from nationally representative data, identifies high-risk persons according to their self-reported age, self-rated health, physical limitations, and disabilities in performing activities of daily living (ADLs).[5] Two other surveys use similar short questionnaires to identify older persons at risk for hospital admission [6] or high Medicare expenditures.[7] The reports of these surveys did not describe the clinical features of the high-risk older persons they identify.

In contrast, older people identified as high risk by the fourth survey method have been shown not only to generate high healthcare expenditures in the future,[8–10] but also to have high levels of chronic disease and functional disability,[11] making them good candidates for case management or disease management. This survey, the "Probability of Repeated Admission" (PRA), collects and analyzes information on eight risk factors to identify older people at high risk for repeated admission to acute care hospitals.[12]

A predictive modeling algorithm, "ACG Predictive Model (ACG-PM)", part of the Johns Hopkins ACG® Case Mix System, analyzes health insurance enrollment records and diagnostic information from claims to predict the intensity of a person's use of medical resources in the future. The ACG-PM predictions for older persons are based on age, gender, ICD-9 diagnostic codes (with extra weight on certain conditions), and pharmacy data (if available).[4] Previous use of health services is not considered, so physicians' practice patterns have little effect on ACG-PM risk scores. The ability of ACG-PM risk scores to predict older persons' use of and the costs of health care have been validated,[13–15] but the clinical features of persons with high ACG-PM scores have not been described. Thus it remains unclear whether models that predict health insurance expenditures from administrative data could be used effectively to target older persons for case management or disease management.

The objective of this study, therefore, was to determine whether older persons identified by ACG-PM scores as being at risk for generating high medical expenditures during the next year have medical conditions and functional limitations that would make them likely to benefit from special clinical interventions.

METHODS

For this study, we selected patients age 65 or older at a community general internal medicine practice who were enrolled for 12 continuous months in a Medicare-like health plan for military retirees and their dependents (n = 826). Based on health insurance claims from April 2002 to March 2003, the ACG-PM software computed each person's probability of generating insurance expenditures that would rank within the highest 5% of the population during the next year. We classified as high risk the 18% (n = 150) of the patients with the highest ACG-PM scores. We classified the remaining 82% (n = 676) as low risk. To evaluate the clinical features of this study population, we analyzed administrative data and conducted a supplemental survey of the high-risk enrollees.

We obtained information about the enrollees' demographic characteristics, use of health-related services and the cost of those services during 2002—2003, and clinical diagnoses from enrollment data and insurance claims. We used the ACG-PM software to collapse many narrow diagnostic codes submitted with the insurance claims into nine broad disease categories (expanded diagnostic clusters [EDCs]).

Before mailing the supplemental survey to the 150 high-risk enrollees, the health insurer sent a letter to them explaining the purpose and the voluntary nature of this study. A contracted research firm then mailed the questionnaire with a cover letter, a stamped return envelope, and a one-dollar bill as a token of appreciation. The questionnaire asked about sociodemographic characteristics, general health, bed disability days and restricted activity days because of illness or injury during the previous six months, and the ability to perform ADLs[16] and instrumental activities of daily living (IADLs).[17] ADLs included bathing, dressing, eating, transferring, and toileting. IADLs included the ability to walk across a room, use the telephone, perform housework, take medications, get to places beyond walking distance, prepare meals, shop, and manage money. Non-respondents were called by telephone. The Johns Hopkins University Institutional Review Board approved the study.

Table 1. Demographic and Social Characteristics of High- and Low-Risk Enrollees

Demographics	*Low-risk, n = 676*	*High-risk, n = 150*	p *value*[a]
Age, years	74.4 (6.0)	76.0 (6.3)	0.015
Age group			0.051
65–74 years	56.8%	48.6%	
75–84 years	36.2%	40.7%	
85 + years	7.0%	10.7%	
Female sex	57.4%	54.7%	0.541
White race	43.0%	54.7%	0.038

Social characteristics[b]	*High-risk survey respondents,* n = *120*
Years of education	
8th grade or less	10.0%
High school or GED	40.8%
Some college	47.5%
Household annual income	
Less than $20,000	21.0%
$20,000–$50,000	60.5%
More than $50,000	18.5%
Living alone	20.8%
Married	61.7%

[a] t-test (age), χ^2 (categorical variables).
[b] Available only for survey respondents.
Data are prevalence or mean (SD).

Statistical analysis

From the Statistical Package for the Social Sciences (SPSS), we used the Student's *t*-test or (in the case of unequal variances) the Mann-Whitney *U* test to compare the means of continuous variables and the chi-square statistic to compare the distributions of categorical variables.

RESULTS

As shown in Table 1, the high-risk enrollees were older and more likely to be white than low-risk enrollees. The survey data (response rate = 80%) show that more than half of the high-risk enrollees were married, had a high-school education, earned more than $20,000, and lived with another person.

As shown in Table 2, compared to low-risk enrollees, high-risk enrollees had twice as many chronic conditions (2.93 vs.1.48, $p < 0.001$) and higher prevalence of eight out of the nine conditions. These nine chronic conditions are prevalent, clinically important, costly, and amenable to intensive clinical intervention. The survey data show that one third to one half of the high-risk respondents had fair-to-poor health, difficulty performing ADLs and IADLs,

TABLE 2. CLINICAL CHARACTERISTICS OF HIGH- AND LOW-RISK ENROLLEES

		Survey respondents, n = *120*	
Health status[a]:general health			
Excellent		2.5%	
Very good		20.2%	
Good		34.5%	
Fair		36.1%	
Poor		6.7%	
Functional Abililty[a]			
Difficulty in performing at least one of five ADLs [b]		36.3%	
Difficulty in performing at least one of seven IADLs[c]		58.1%	
Any bed disability days in the past 6 months		38.7%	
Any restricted activity days in the past 6 months		52.3%	
Disease prevalence	*Low-risk,* n = *645[d]*	*High-risk,* n = *150*	p *value*[e]
Ischemic heart disease	15.3%	51.3%	<0.001
Congestive heart failure	2.2%	29.3%	<0.001
Hypertension	74.6%	88.0%	<0.001
Diabetes	7.1%	26.0%	<0.001
Osteoarthritis	30.4%	44.7%	<0.001
Chronic obstructive pulmonary disease	7.0%	22.0%	<0.001
Depression	4.8%	15.3%	<0.001
Dementia	4.7%	12.0%	<0.001
Parkinson's disease	1.9%	4.0%	0.113
Chronic conditions			
No. of chronic conditions (of the nine listed above)	1.48 (0.97)	2.93 (1.46)	<0.001
Use of services	*Low-risk,* n = *676*		
Mean (SD) hospital admissions per year	0.13 (0.49)	1.13 (2.38)	<0.001
Mean (SD) hospital days per year	0.51 (2.92)	7.34 (22.02)	<0.001
Mean (SD) total insurance costs per year	$3,726 ($5,038)	$22,185 ($41,506)	<0.001

[a]Data available only for survey respondents.
[b]Activities of daily living (ADLs): bathing, dressing, eating, getting in or out of chairs, toileting.
[c]Instrumental activities of daily living (IADLs): using the telephone, doing housework, taking medications, getting to places beyond a walking distance, preparing meals, shopping, managing money.
[d]Data available for 645 out of 676 low-risk enrollees.
[e]χ^2(categorical variables), Mann-Whitney *U* (continuous variables with unequal variances).
Data are prevalence or mean (SD).

and days during the past 6 months in which they were confined to bed or unable to perform their usual activities. The two groups' health insurance claims show that the high-risk enrollees had many more hospital admissions and hospital days and generated much higher total insurance payments than the low-risk enrollees.

Table 3 compares the characteristics of the 30 non-respondents and the 120 respondents to the mailed survey of high-risk enrollees. Non-respondents had higher disease prevalence, more hospital admissions and hospital days, and higher total insurance costs. These differences were not attributable to outliers.

DISCUSSION

The results of this study show that older persons with high ACG-PM risk scores have a high prevalence of chronic disease, considerable functional disability, and suboptimal general health. The extent of morbidity, disability, and suboptimal health among high-risk enrollees is almost certainly underestimated because administrative data showed that the non-respondents to our survey (20%) had more chronic conditions and generated much higher healthcare costs than the respondents. Not only are older persons with high ACG-PM scores at risk for generating high health insurance expenditures in the future, but their clinical features appear amenable to clinical interventions designed to optimize health and functional status and to contain healthcare costs, such as case management and disease management. The ACG-PM method of predictive modeling may therefore be an effective and efficient approach to screening older populations whose insurance claims data are available.

Several pragmatic challenges follow the identification of high-risk enrollees. These suggestions may be useful for aligning high-risk

Table 3. Characteristics of Survey Respondents and Non-Respondents

	Respondents, n = *120*	*Non-respondents,* n = *30*	p *value*[a]
Demographics			
Age, years	75 (6.1)	77 (6.9)	0.269
Age group			0.089
65–74 years	51.7%	36.7%	
75–84 years	40.0%	43.3%	
85 + years	8.3%	20.0%	
Female sex	58.3%	40.0%	0.071
White race	56.7%	46.7%	0.517
Disease prevalence			
Ischemic heart disease	50.0%	56.7%	0.513
Congestive heart failure	23.3%	53.3%	0.001
Hypertension	90.0%	80.0%	0.132
Diabetes	25.8%	26.7%	0.926
Osteoarthritis	49.2%	26.7%	0.027
Chronic obstructive pulmonary disease	19.2%	33.3%	0.094
Depression	15.0%	16.7%	0.821
Dementia	10.0%	20.0%	0.132
Parkinson's disease	3.3%	6.7%	0.405
Chronic conditions			
No. of chronic conditions (of the nine listed above)	2.86 (1.38)	3.20 (1.73)	0.250
Use of Services			
Mean (SD) no. of hospital admissions per year	0.66 (1.04)	3.03 (4.46)	0.002
Mean (SD) no. of hospital days per year	2.98 (6.24)	24.80 (44.01)	<0.001
Mean (SD) total insurance costs per year	$15,204 ($16,980)	$50,111 ($81,608)	<0.001

[a] χ^2(categorical variables), *t*-test (age), or Mann-Whitney *U* (for all other continuous variables due to unequal variances).

Data are prevalence or mean (SD).

enrollees' needs and programs' available resources.

- Programs should consider collecting supplemental information, such as functional and social data, from high-risk enrollees to further define their clinical needs and their likelihood of benefiting from case management or disease management. This could be performed by a clinician, such as a registered nurse, who has experience in clinical assessment, knows which clinical interventions are available, and can integrate scores from claims-based predictive modeling with self-reported information from high-risk enrollees. Information technology systems that house all of this information in one place can facilitate this integrative process.
- Programs also could use diagnoses gleaned from insurance claims to select those high-risk enrollees who are most likely to benefit from the available interventions. They could, for example, select persons with diabetes from the high-risk group and offer them a health education intervention. Similarly, they could select high-risk enrollees who have four or more chronic conditions to receive ongoing management to monitor and coordinate their complex care.
- Health plans with high turnover rates among their enrollees should consider alternatives to claims-based predictive modeling to identify their high-risk enrollees. High turnover rates produce many new enrollees who, at the time the predictive model is run, have not yet generated enough claims to be identified as high risk. Such programs should consider using other methods to identify new high-risk enrollees, such as surveys of new enrollees and referrals from clinicians.

Limitations

The results of this study probably apply to most older American populations, but this awaits confirmation because all of the participants in the present study lived in one geographic area, were insured by one health plan, and received their primary care from one practice. Larger studies of more heterogeneous older populations will be needed to confirm the generalizability of the findings presented here.

ACKNOWLEDGMENTS

Part of this paper was presented in poster form at the American Geriatrics Society 2004 Annual Scientific Meeting, May 17–20, 2004, Las Vegas.

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