Identification of high resource utilizing patients on internal medicine hospital services

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ABSTRACT

In order to provide high quality, cost-efficient care, it is critical to understand drivers of the cost of care. Therefore, we sought to identify clinical variables associated with high utilization (cost) in patients admitted to medical services and to develop a robust model to identify high utilization patients. In this case–control analysis, cases were identified as the 200 most costly patients admitted to internal medicine/internal medicine subspecialty services using our institution's computerized clinical data warehouse over a 7-month time period (November 1, 2012–May 31, 2013). 400 patients admitted in the same time period were randomly selected to serve as controls. The mean cost for the highest utilization patients was $126,343, while that for randomly matched patients was $15,575. In a multivariable regression model, the following variables were associated with high utilization of resources: African American race, age 35–44, admission through the emergency department, primary service of hematology–oncology, a history of heart failure or paralysis, a diagnosis of HIV, cancer, collagen vascular diseases and/or coagulopathy, a reduced albumin, and/or an elevated creatinine. The in hospital mortality rate for high utilization patients was 19%, compared to 8% for controls (p=0.0002). A predictive model using 14 different readily available clinical variables predicted high utilization with an area under the curve of 0.85. The data suggest that high utilization patients share similar demographic and clinical features. We speculate that a predictive model using commonly known patient characteristics should be able to predict high utilization patients.

Significance of this study

What is already known about this subject?

- Factors that drive cost for a hospitalization are complex.
- There has been robust investigation into the factors important in readmission in both the medical and surgical literature as well as strategies to reduce readmission rates.
- Few studies have evaluated the relationship between patient characteristics, resource utilization, and costs during the hospital stay.

What are the new findings?

- This study identified demographic and clinical features of patients associated with high utilization of resources during a hospitalization.
- This study developed a predictive model using commonly available patient characteristics that should be able to predict high utilization patients.
- Outcomes are worse in the high utilization patient population.

How might these results change the focus of research or clinical practice?

- The current research should focus clinicians on several areas that are likely to be important to reduce cost and improve the quality of care for this patient population.
- This research provides a tool for identification of patients at risk to utilize large amounts of hospital resources.
- Not only does this research highlight the use of analytics to provide prognostic information about patient populations such as high utilizers, but it also points to possible future research around specific interventions.

INTRODUCTION

Providing high quality, cost-efficient healthcare has become an increasingly important part of the national healthcare discussion.[1] For example, ~18% of the national GDP budget is spent on healthcare.[2] An average of $9255 per capita is spent on healthcare, and is associated with an average life expectancy of 78 years.[2] This life expectancy is similar to Chile, the Czech Republic, Korea and Slovena, all of whom on average spend much less per capita.[3] As the US strives to reduce cost and increase quality, there has been substantial focus on several areas in medicine. These include decreasing readmission rates, reducing the use of tests with limited value, improving end of life care, and enhancing transitions from inpatient hospitalization to lower levels of care.[4–7]

The factors that drive cost in hospitalized patients are complex;[8] certain diseases lend

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themselves to more extensive diagnostic investigation, and some diseases are associated with more intensive therapeutic intervention. The presence of comorbidities and complications also contribute to higher cost and resource utilization during a hospital stay, and this is undoubtedly impactful on many levels. Administrative costs are also important. In one analysis, they accounted for over $150 billion in healthcare dollars in 2007 and were projected to increase to over $300 billion by 2018.[9] Administrative costs have been described in the literature as: nursing administration, central services and supply (excluding the purchase cost of supplies), medical records, utilization review and the salary costs of the human resource department.[10] Comparatively speaking, administrative costs on average in the USA are triple (per capita) annually when compared with Canada; per capita costs in the US average some over $1000.[11]

Although there has been robust investigation of the factors important in readmission in the medical and surgical literature[12 13] as well as strategies to reduce readmission rates,[14] less attention has been given to the relationship between patient characteristics and resource utilization and costs during the hospital stay. In this study, we hypothesized that specific clinical features would likely be associated with high utilization (cost) in patients admitted to general and subspecialty internal medicine services. Further, we predicted that these clinical variables can be identified with commonly available data, and could be used to develop a model to predict patients likely to consume significant resources during their hospital stay. The predictability of patients' likelihood of significant utilization and costs within a hospital stay could offer valuable information to develop guidelines that increase the efficiency and effectiveness of administrative and clinical services.

METHODS

This case-control study included consecutive patients admitted to the internal medicine and subspecialty services from November 1, 2012–May 31, 2013 at the Medical University of South Carolina. Medical subspecialties included Pulmonary/Critical Care, Hematology, Oncology, Gastroenterology, and Hepatology. We collected over 40 unique variables for each patient at the time of presentation, including demographic, clinical and laboratory (including bilirubin, albumin, prothrombin time, aspartate aminotransferase, alanine aminotransferase, blood urea nitrogen (BUN), and serum electrolytes) data. We preferentially chose to analyze data at the time of admission. The admission time frame was defined as the 24 hours after the recorded admission time. The study was approved by the Medical University of South Carolina's Institutional Review Board.

Definitions

For this analysis, it is assumed that costs are a proxy for resource utilization. Thus, a higher cost patient consumes more, or more intense, amounts of services than a lower cost patient. Total hospital cost was the primary outcome measure of the study. Financial data included actual total MUSC hospital costs for each hospitalization, which were provided through the hospital's patient accounting system. By definition, total hospital costs were the sum of both fixed (expenses that do not fluctuate based on level of patient care) and variable costs (expenses driven by specific patient care factors). Fixed and variable costs were available for all non-physician components of the hospital stay. These include, but are not limited to, surgical suites, catheterization suites, intensive care units, postoperative or postprocedural floor care, respiratory therapy, physical therapy, pulmonary functions, anesthesia, recovery room, medical and surgical supplies, laboratory costs, pharmaceutical costs, pulmonary functions, telemetry and social services. All costs are reported in 2014 US dollars.[15]

Gender, age, race, insurance status, primary service and source of admission were retrieved and coded as binary or categorical variables. The origin of admission was defined as the way in which the patient was admitted to the hospital. This included one of the three following specific mechanisms: (1) via the emergency department, (2) via a hospital to hospital transfer or (3) through direct admission from a clinic.

We used patient residence zip code matched with the 2010 Census to determine poverty status of the patient's area of residence and the distance calculated as a continuous variable from the patients' zip code center point to the MUSC healthcare campus. The variable poverty was given a value of 1 if that zip code has ≥25% of citizens below the federal poverty level.

Admitting diagnoses were defined based on the international classification of diseases, ninth revision (ICD-9) coding and were organized based on disease groups included the following: infectious, cancer (excluding bone marrow/blood), endocrine, diseases of the blood and blood-forming organs, diseases of the circulatory system, diseases of the respiratory system, diseases of the genitourinary system, diseases of the digestive system, diseases of the musculoskeletal system, and others which included all diagnosis that did not fit into one of the aforementioned categories. Chronic comorbid conditions were defined as dichotomous indicators based on enhanced ICD-9, clinical modification (ICD-9-CM codes from a modified Elixhauser (excluding cardiac arrhythmias) and Charlson (myocardial infarction, cerebrovascular disease, and dementia) coding algorithm as described.[16]

Clinical variables that would be readily available and possible predictive were also analyzed. These included the following: admission blood pressure, respiratory rate, and heart rate, and body mass index. Laboratory variables included the following: complete blood count, sodium, potassium, creatinine, BUN, bicarbonate, hemoglobin A1C, internationalized ratio, procalcitonin, and brain natriuretic peptide.

Statistical analysis

The primary outcome measure for this study was based on cost, as defined above. The sample included all patients that were admitted to MUSC during the study period; cases were defined as the 199 highest cost patients and were matched to 400 randomly selected control patients admitted during the same time period; the 200 high utilizer patients were not included in the control group. Demographics, clinical and laboratory characteristics of the patients were summarized using descriptive statistics (means, proportions and p value). A multivariable logistic

regression model was used to identify clinical features associated with patients identified a priori as 'high utilizers'. Only subjects with complete data were included in the logistic analysis. Multicollinearity was assessed. If two variables exhibited high correlation, one was dropped from the model based on clinical relevance. Backward selection processes were used to help determine variables for use in a predictive model (based on $p<0.05$ for overall variable; components of each variable may have $p\geq0.05$ compared to reference component within the variable). Receiver operating characteristic (ROC) curves were created by plotting sensitivity against (1—specificity) and the area under the ROC curve (AUC) was used to determine the accuracy of predictions. SAS V.9.3 (SAS Institute Inc., Cary, North Carolina, USA) was used for statistical analyses. A p value <0.05 was used as the criterion for statistical significance.

RESULTS

Of all admissions occurring from November 2012 to May 2013 on the internal medicine service, we identified the top 200 most costly encounters (as defined in the Methods above). One patient with multiple encounters was excluded. We subsequently matched these patients in a 2:1 fashion (based on age and gender) with randomly selected patients admitted from the same time frame (figure 1).

The average age of patients admitted in the high utilizer group was 54, similar to the control group (table 1). High utilization patients were comparatively more likely to be African American than control patients (43% vs 34%, respectively, $p=0.028$, table 1). The most common payer source for both groups was Medicare, however, a higher proportion of patient's in the high utilization group were insured by Medicaid (24% vs 17%, respectively, $p=0.038$). A greater proportion of high utilization patients were admitted through the ER compared to controls (26% vs 9%, respectively, <0.0001, table 1).

High utilization patients were more likely to have an ICD-9 admission diagnosis of neoplasm, infectious and/or parasitic diseases and diseases of respiratory system (table 2). Notably, patients in the high utilization were less likely to have a diagnosis of an endocrine or cardiovascular disorder.

At the time of admission, patients in the high utilization group had clinical signs consistent with a higher level of acuity including lower systolic and diastolic blood pressures and a higher heart rate. High utilization patients also had laboratory evidence of greater acuity, including a comparatively increased BUN and creatinine (see online supplementary table S1).

HOSPITAL COSTS

Total hospital costs were the sum of both fixed (expenses that do not fluctuate based on level of patient care) and variable costs (expenses driven by specific patient care factors). Both fixed and variable costs were available for all non-physician components of the hospital stay. Cost across almost all allocated hospital areas measured was higher in the high utilization group, and total cost was more than eight times higher in the high utilization group than the

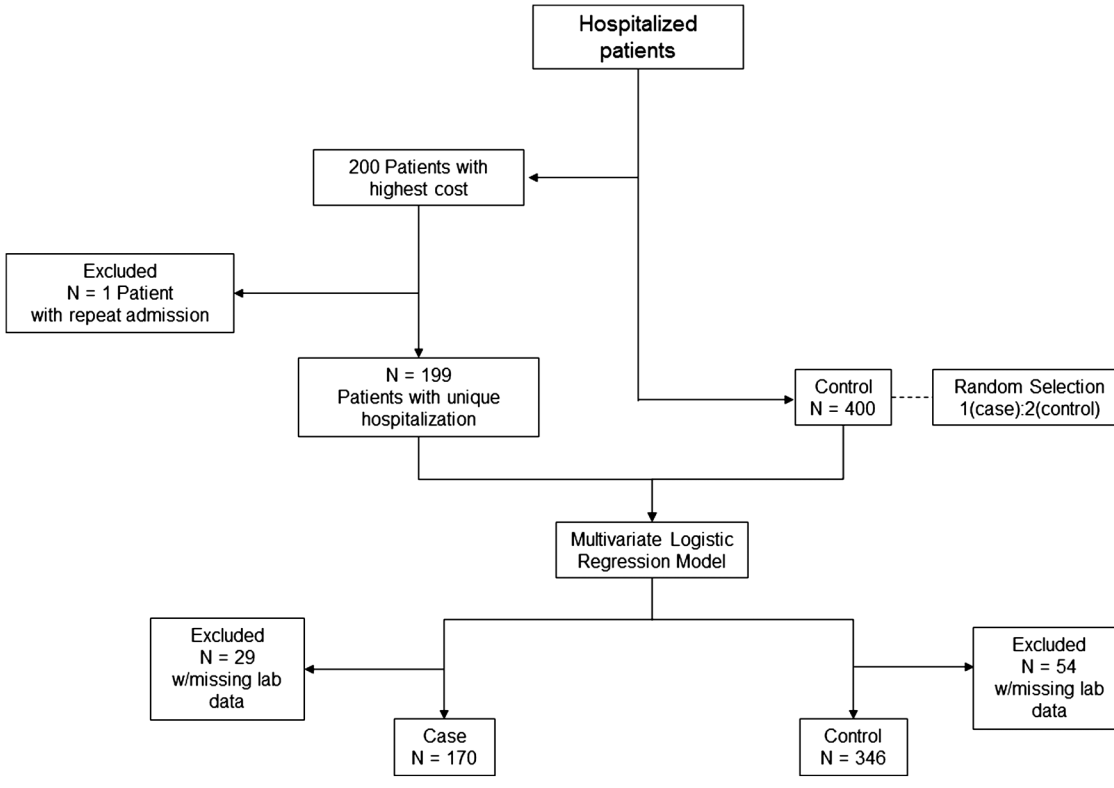

Figure 1 Flow diagram of patients. Shown are the numbers of patients included in the study. Cases were defined as the 200 highest cost patients and were matched to 400 randomly selected control patients admitted during the same time period (patients within the 200 high utilizer cohort were not included in the control group). Regression analysis compared cases to controls as depicted, and included only patients with complete data.

Table 1 Demographic features

	High utilization patients (N=199)	Control (N=400)	p Value
Age (year, mean, SD)	54±16	56±18	0.474
Age group N (%)			0.079
18–34	24 (12%)	65 (16%)	0.175
35–44	31 (16%)	39 (10%)	0.037
45–54	33 (16%)	53 (13%)	0.273
55–64	55 (28%)	104 (26%)	0.669
65+	56 (28%)	139 (35%)	0.104
Sex N (%)			0.377
Male	118 (59%)	222 (56%)	
Female	81 (41%)	178 (45%)	
Race N (%)			0.088
Black	86 (43%)	136 (34%)	0.028
White	107 (54%)	251 (63%)	0.035
Other	6 (3%)	13 (3%)	0.877
Payer			0.203
Medicaid	48 (24%)	68 (17%)	0.038
Medicare	87 (44%)	200 (50%)	0.147
Commercial	53 (27%)	109 (27%)	0.873
Uninsured	11 (6%)	23 (6%)	0.912
Patient origin			<0.0001
Clinic/physician	67 (34%)	165 (41%)	0.073
Emergency room	52 (26%)	35 (9%)	<0.0001
Hospital to hospital transfer	80 (40%)	200 (50%)	0.024
Primary service			<0.0001
CAR cardiology	34 (17%)	139 (35%)	<0.0001
GAI gastro-intestinal	4 (2%)	22 (6%)	0.0483
GIM general internal med	56 (28%)	96 (24%)	0.2727
HON hematology-oncology	59 (30%)	71 (18%)	0.0009
PUL pulmonary	46 (23%)	72 (18%)	0.1382
Distance (miles, mean, SD)	**74±77**	**81±105**	**0.3731**
Poverty (%)	**52 (26%)**	**90 (23%)**	**0.3251**

control group (table 3). ICU and routine nursing care, pharmacy services, hemodialysis services and laboratory draws were some of the largest drivers of the cost difference.

CLINICAL VARIABLES ASSOCIATED WITH INCREASED UTILIZATION

We next performed logistic regression analyses with a total of 46 variables in order to identify clinical variables that were associated with higher costs. Following our backwards selection process, 14 variables had a p value <0.05 (table 4). Of most significance, patients with AIDS/HIV were 6.5 times more likely to be high utilizers, as were patients with paralysis (OR: 5.9), coagulopathy (OR: 4.2) and congestive heart failure (OR: 3.1). Patients admitted from the emergency department were 5.2 times more likely than patients admitted from clinic (reference) to be high utilizers. Compared to admitting diagnosis of symptoms, signs and ill-defined conditions (reference), patients with admitting diagnosis of infections and parasitic diseases were 3.3 times more likely to be high utilizers. Patients admitted to hematology–oncology were 3.0 times more likely to be high utilizers than patients admitted to the general medicine service (reference). Using all 14 variables, we developed a model with an AUC of 0.85 (see online supplementary figure S1).

Patients in the high utilization group also had different outcomes than patients in the control group (table 5). First, high utilization patients were more likely to be discharged to another facility (31% vs 7%, p<0.0001) or to die during the incident hospitalization (19% vs 8%, p=0.0002), rather than to home. Further, as might be predicted, hospital length of stay was significantly greater in the high utilizer group, and patients in the high utilizer group were more likely to require home health services (34% vs 22%, p=0.0027). Conversely, control patients were more likely to be discharged home without home services.

DISCUSSION

This study assessed patients utilizing hospital resources at a high rate, and identified demographic (eg, African American race) and clinical (eg, history of cancer, infectious and/or parasitic disease, or disease of respiratory system, elevated BUN/creatinine, and a low albumin) features associated with high utilization. We have also developed a predictive model using commonly available patient characteristics that could be able to predict high utilization

Table 2 Clinical diagnoses

	High utilization (N=199)	Control (N=400)	p Value
Admitting diagnoses			<0.0001
Infectious and parasitic diseases	17 (9%)	14 (4%)	0.009
Neoplasms	45 (23%)	34 (9%)	<0.0001
Endocrine, nutritional and metabolic diseases, and immunity	4 (2%)	30 (8%)	0.006
Diseases of the blood and blood-forming organs	5 (3%)	22 (6%)	0.097
Diseases of the circulatory system	34 (17%)	112 (28%)	0.003
Diseases of the respiratory system	25 (13%)	27 (7%)	0.017
Diseases of the digestive system	7 (4%)	34 (9%)	0.023
Diseases of the genitourinary system	4 (2%)	14 (3%)	0.314
Diseases of the musculoskeletal system and connective tissue	4 (2%)	7 (2%)	0.823
Symptoms, signs, and ill-defined conditions	28 (14%)	63 (16%)	0.590
Injury and poisoning	16 (8%)	14 (4%)	0.016
Supplementary classification of factors influencing health status and contact with health services	2 (1%)	12 (3%)	0.128
Other combined	8(4%)	17 (4%)	0.895

patients. Finally, we illustrated that outcomes are worse in the high utilizer patient population.

Other studies have focused on costs in hospitalized patients. One study attempted to predict hospitalization costs by focusing on DRGs.[17] It was shown that predictive models could be obtained using certain clinical variables, however, the data were published 20 years earlier, and an easily usable clinical tool was not developed. Additionally, outcomes were not captured during that study. A study using a 6-item self-report questionnaire known as the Identification of Seniors at Risk (ISAR) tool in patients over age 65 seen in the emergency department attempted to predict the number of acute care hospital days over a 6-month follow-up period.[18] The ISAR tool predicted high subsequent hospital utilization with a sensitivity of 73% and a specificity of 51%, and an AUC of 0.68, but did not evaluate resource utilization at the index hospitalization.[18] Finally, a third study examined whether interns' impressions about their patients functional status and illness acuity using a system designed to help them sign out to their colleagues might predict outcomes and resource utilization.[19] The investigators found that interns' estimates of patients' illness severity and anticipated function at the time of discharge generally predicted outcomes and costs of hospitalization, but did not identify specific variables associated with high utilization.[19]

Table 3 Cost data

	Cost ($)	
Allocated hospital area	High utilization patients (mean ±SD)	Control (mean±SD)
ICU nurse stations	$41 231±38 234	$8290±6842
Routine nurse stations	$27 094±34 549	$5560±5011
Pharmacy	$20 436±19 745	$2595±3521
Laboratory	$13 556±14 076	$1456±2296
Pulmonary function	$8082±11 390	$1238±1707
Dialysis	$7180±9548	$1669±1961
Non-OR supplies	$7066±9555	$1209±3066
OR supplies	$4139±9415	$1490±4454
Radiology	$3340±3446	$712±802
Surgical services	$3227±4336	$1373±1910
Therapeutic services	$1791±2381	$324±360
Cardiovascular services	$1737±2968	$985±1685
Endoscopy	$1639±2358	$1607±1302
Emergency services	$1603±1228	$1243±784
Total	$126 343 ±87 352	$15 575 ±13 543

Several of the findings of our study were predictable. The fact that race (African American patients) was associated with cost is supported by previous research in the area of socioeconomic disparities in healthcare.[20 21] Second, we found that patients with greater numbers of comorbid conditions were higher utilizers, consistent with data suggesting that comorbid chronic conditions are associated with increased hospital mortality.[22] Finally, we found that specific clinical variables such as acute kidney injury and low albumin were associated with increased utilization, consistent with data suggesting that these clinical features have been reported to be indicators of poor prognosis.[23 24]

We recognize several limitations of our study. First, our study was performed at a single center, and was retrospective in design. Since our hospital serves as a tertiary referral center, which is expected to accept very high acuity and complicated patients, the findings may not be generalizable to hospitals that are not tertiary referral centers. Additionally, we focused on variables available at the time of admission, with the exception of the primary admitting diagnosis, which was taken from coding that was done at the time of discharge. Although this likely improved the specificity of specific diagnoses, it would also limited the sensitivity for detecting patients with potentially high downstream high costs prospectively. While this might limit the use of the model as an intervention tool, it would not be expected to impact the conclusions of the study. Finally, the use of ICD-9 codes has limitations based on the reliance of providers entering data and/or the possibility of coding errors; though we cannot exclude such errors, they would be expected to be similar in case and control groups.

Providing high value low cost care in an expanded number of patients is on the forefront of the national

Table 4 Clinical variables associated with increased utilization

Variable	Estimate	P Value	OR	Lower OR	Upper OR
Sex					
Female (ref.)					
Male	0.79	0.00	2.21	1.32	3.70
Admit source					
Clinic/physician (ref.)					
Emergency department	1.65	<.0001	5.23	2.47	11.08
Transfer from hospital	−0.15	0.64	0.87	0.47	1.59
Primary service					
General internal medicine (ref.)					
Cardiology	−0.90	0.06	0.41	0.16	1.05
Gastrointestinal	−1.33	0.06	0.26	0.07	1.08
Hematology-oncology	1.11	0.02	3.02	1.22	7.50
Pulmonary	0.26	0.50	1.29	0.61	2.73
Admitting diagnosis					
Symptoms, signs, and ill-defined conditions (ref.)					
Infectious and parasitic diseases	1.20	0.03	3.31	1.09	10.00
Diseases of the genitourinary system	−1.13	0.17	0.32	0.07	1.62
Diseases of the musculoskeletal system and connective tissue	−0.26	0.77	0.77	0.14	4.37
Injury and poisoning	0.29	0.63	1.34	0.41	4.37
Supplementary classification of factors influencing health status and contact with health services	−1.02	0.28	0.36	0.06	2.26
Neoplasms	0.87	0.08	2.38	0.89	6.35
Other combined	0.03	0.96	1.03	0.29	3.70
Endocrine, nutritional and metabolic diseases, and immunity disorders	−1.53	0.04	0.22	0.05	0.91
Diseases of the blood and blood-forming organs	−1.26	0.08	0.29	0.07	1.13
Diseases of the circulatory system	−0.26	0.54	0.77	0.33	1.79
Diseases of the respiratory system	0.69	0.14	1.99	0.80	4.98
Diseases of the digestive system	−0.84	0.20	0.43	0.12	1.57
Congestive heart failure	1.14	0.00	3.14	1.62	6.05
Paralysis	1.78	0.01	5.95	1.53	23.15
Hypothyroidism	0.74	0.04	2.10	1.04	4.24
AIDS/HIV	1.87	0.01	6.48	1.45	29.05
Cancer	−0.96	0.01	0.38	0.20	0.74
Rheumatoid arthritis/collagen vascular diseases	1.10	0.01	3.00	1.30	6.93
Coagulopathy	1.43	<.0001	4.18	2.36	7.41
Systolic blood pressure	−0.01	0.01	0.99	0.98	0.10
ANION GAP	0.06	0.04	1.07	1.00	1.13
Albumin serum	−0.59	0.00	0.55	0.39	0.80

Table 5 Outcomes

	High utilization patients (N=199)	Control (N=400)	<0.0001
Total cost (mean; median±SD)	$126 343; $98 018±$87 352	$15 575; $10 643±$13 543	
Length of stay (mean; median±SD)	39.4; 31.0±35.5	5.8; 4.0±5.1	<0.0001
Discharge status			<0.0001
Home with no service	22 (11%)	238 (60%)	<0.0001
Home with home health service	67 (34%)	89 (22%)	0.0027
Another facility	62 (31%)	28 (7%)	<0.0001
Hospice	11 (5%)	12 (3%)	0.1294
Death	37 (19%)	33 (8%)	0.0002

healthcare picture. Additionally, many US citizens remain uninsured.[25] It is generally accepted that current spending on US healthcare will to continue to rise[2] and that a large portion of healthcare expenditure in the US will be due hospitalization.[2] National programs are underway to attempt to lower the cost of hospitalization by reducing unnecessary testing.[26 27]

Our study has implications in the area of healthcare cost management. As it becomes increasingly important to identify patients and strategies that improve the care that is

delivered,[28] the current research should focus clinicians on several areas that are likely to be important to investigators. However, additional studies are needed to prospectively verify our predictive model. Additionally, much care needs to be taken into what are the implications of this information. Further research is needed into identifying strategies to improve care provided to this high risk and vulnerable population.

In summary, factors more common among high utilizers include being African American, aged 35–44, admission through the ER, having a history of CHF, paralysis, hypothyroidism, HIV, cancer, collagen vascular diseases or coagulopathy, having low albumin or elevated creatinine. These variables are objective, readily identified during hospitalization. As focus grows on reduction of cost in the acute hospital setting, this research provides a tool for simple identification of patients at risk to utilize large amounts of hospital resources.

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Contributors DWW was involved in the study concept and design; acquisition of data; analysis and interpretation of data; drafting of the manuscript; critical revision of the manuscript for important intellectual content. MCM was involved in the study concept and design; acquisition of data; analysis and interpretation of data. AG was involved in the study concept and design; acquisition of data; analysis and interpretation of data. JZ was involved in the analysis and interpretation of data; statistical analysis, critical revision of the manuscript for important intellectual content. PDM was involved in the analysis and interpretation of data; statistical analysis, critical revision of the manuscript for important intellectual content. DCR was involved in the study concept and design; analysis and interpretation of data; drafting of the manuscript; critical revision of the manuscript for important intellectual content.

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