Medicaid Patients at High Risk for Frequent Hospital Admission: Real-Time Identification and Remediable Risks

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ABSTRACT *Patients with frequent hospitalizations generate a disproportionate share of hospital visits and costs. Accurate determination of patients who might benefit from interventions is challenging; most patients with frequent admissions in 1 year would not continue to have them in the next. Our objective was to employ a validated regression algorithm to case-find Medicaid patients at high-risk for hospitalization in the next 12 months and identify intervention-amenable characteristics to reduce hospitalization risk. We obtained encounter data for 36,457 Medicaid patients with any visit to an urban public hospital from 2001 to 2006 and generated an algorithm-based score for hospitalization risk in the subsequent 12 months for each patient (0=lowest, 100=highest). To determine medical and social contributors to the current admission, we conducted in-depth interviews with high-risk hospitalized patients (scores >50) and analyzed associated Medicaid claims data. An algorithm-based risk score >50 was attained in 2,618 (7.2%) patients. The algorithm's positive predictive value was equal to 0.67. During the study period, 139 high-risk patients were admitted: 60 met inclusion criteria and 50 were interviewed. Fifty-six percent cited the Emergency Department as their usual source of care or had none. Sixty-eight percent had >1 chronic medical conditions, and 42% were admitted for conditions related to substance use. Sixty percent were homeless or precariously housed. Mean Medicaid expenditures for the interviewed patients were \$39,188 and \$84,040 per patient for the years immediately prior to and following study participation, respectively. Findings including high rates of substance use, homelessness, social isolation, and lack of a medical home will inform the design of interventions to improve community-based care and reduce hospitalizations and associated costs.*

KEYWORDS *Frequent hospitalization, High risk, Identifying patients, Case-finding algorithm, Homelessness*

INTRODUCTION

Patients with frequent hospital admissions comprise a small percentage of all individuals, yet account for a disproportionate share of visits and costs.¹ Four percent of all Medicaid enrollees account for almost 50% of all Medicaid expenditures.^{2,3} Medicaid patients in the fee-for-service sector comprise a minority

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of enrollees, yet account for the majority of Medicaid spending due to their disproportionately high use of health care services.⁴ These high-cost cases have caught the attention of policy makers and have contributed to a movement by states to shift Medicaid patients from fee-for-service into managed care models or “high risk” case management programs. Such state initiatives create an impetus for hospitals and health care providers to better understand and control expenditures for the highest users of health services.⁴ However, it remains unclear exactly what such initiatives should entail in order to be successful in improving care and reducing costs for this population.

While high levels of medical service use and costs may not be preventable in the face of severe illness, other factors associated with high service utilization rates may be amenable to intervention, including housing insecurity, lack of social support, substance use, mental illness, and lack of a medical home.^{5,6} One recent study of frequently hospitalized urban residents found diagnoses of substance use and mental illness to be strong predictors of fragmented care and admissions to multiple, unrelated facilities.⁷

The majority of studies examining risk factors associated with frequent hospital admissions focus only on patients with specific diagnoses such as HIV, congestive heart failure or psychiatric disease, or in specific age ranges such as infants or the elderly.^{8–10} This limits the ability of policy makers and providers to determine whether unifying factors that could be targeted for intervention exist amongst a more general population of patients with frequent hospital admissions.

States are beginning to focus on hospital admissions as a point of intervention for persons with Medicaid because reimbursements by insurers for other services such as ED visits are orders of magnitude lower and thus offer little opportunity for cost savings.¹¹ New interventions targeting high-cost beneficiaries will need to pay for themselves by generating cost savings and improved health outcomes, and the most substantial source of Medicaid expenditures, aside from long-term care, is hospital admissions.³ Among persons with Medicaid, prospective data on the attributes and predictors of frequent hospitalization are necessary before resources can confidently be deployed to diminish individuals’ hospitalization risk. Such data can then be used to develop interventions with the potential to improve health and social services for this high-risk patient population while simultaneously reducing hospital admissions and costs.

Accurate identification of frequently hospitalized, high-cost patients who might benefit from intervention can be challenging, in part because frequent use is often temporary, resulting from acute illness or injury. In fact, most patients with frequent admissions and concomitant high health care expenditures in 1 year will not have frequent admissions in the next (regression to the mean).^{12,13} This phenomenon has been demonstrated both for patients with frequent ED visits and patients with frequent hospital admissions.

A predictive case-finding methodology to identify persons at highest risk for continued frequent admissions in the future, who may therefore stand to gain the most from intervention, would help address this issue by channeling intervention resources effectively, particularly if it could be employed for use across diverse health care settings. However, the majority of published trials of interventions to reduce recurrent hospitalizations and ED visits by high frequency users do not employ predictive methodology.^{14–16} This can result in misclassification bias, with interventions being directed to patients who may not benefit because their heavy use of costly health care services would have regressed on its own, with no

intervention. Because health care resources are limited, it is essential that interventions target patients whose heavy use of the hospital will continue. This requires the ability to case-find patients likely to continue to have frequent admissions in the future, with attendant high costs.

Previously, we developed and validated a regression algorithm that uses hospital administrative data to identify patients in real time, as they are admitted to the hospital, who are at high risk of subsequent rehospitalization in the following 12 months, based on their diagnoses and service utilization history services (e.g., emergency department visits, inpatient admissions, outpatient primary, and specialty clinic visits). This algorithm uses New York State Medicaid data and thus captures patients' visit histories and diagnoses across all health care facilities state-wide.^{3,17} While previous work validated its accuracy at the state-wide level, it has not yet been implemented in a health care delivery setting as a potential tool to identify patients who might benefit from more intensive services.

The purpose of our study was twofold. We aimed to determine the accuracy of the algorithm in identifying high-risk patients when applied to the database of a large, urban, public hospital. In addition, we sought to define, through in-depth interviews with algorithmically identified high-risk patients, remediable risk factors contributing to hospitalizations that could be the basis of a future intervention to improve health and reduce costs. We considered remediable risk factors to be conditions or situations that if specifically addressed by an intervention, might result in improved health and use of outpatient and community services and less frequent ED and inpatient services use.

We hypothesized that the case-finding algorithm, when applied to our patient population, would have a positive predictive value (PPV) for readmission in the subsequent 12 months similar to that demonstrated (0.67) in the initial state-wide validation population.⁴ We also hypothesized that patients interviewed would have high rates of chronic disease as well as social risk factors for frequent hospital admission that would be amenable to intervention.

METHODS

Algorithmic Case-Finding

A case-finding algorithm developed by methods previously reported was adapted for use at the hospital level.^{4,17} Briefly, the most recent 5.5 years of Medicaid fee-for-service data were abstracted from the study hospital's financial database (January 1st, 2001 through June 30th, 2006). Using a "triggering admission" in the fourth year of data (2004–2005), we applied logistic regression techniques to hospital service utilization data (hospital admissions, emergency department, and outpatient clinic visits) and diagnoses for each patient over the previous 3 years (2001–2002 through 2003–2004) to refine an algorithm predicting the probability of admission during the fifth year (2005–2006) of data (i.e., during the 12 months following the triggering admission). Coefficients from the algorithm were then applied to the last 3 years of the dataset to generate a score for each patient predictive of patients' risk of readmission in the subsequent 12 months, which included the study period. (See Appendix 1 for a list of all variables included in the algorithm.)

Algorithm-generated patient risk scores could range from 0 to 100, with higher scores indicating greater likelihood of hospital admission in the following 12 months.

We focused on patients whose risk scores (>50) indicated a substantially increased risk for rehospitalization in the ensuing 12 months.⁴

Patient Sampling

Medicaid fee-for-service patients aged 18–64 with a risk score for readmission of greater than or equal to 50 and who spoke either English or Spanish (due to study staff fluency in English and Spanish only) were eligible for inclusion. We conducted a daily computer query to ascertain whether any patient admitted to the hospital in the preceding 24 h was on the list of patients identified by the algorithm as being at high risk for future rehospitalization and met eligibility criteria. Since many states are focused on reducing costs of persons with fee-for-service Medicaid, those with other forms of insurance were excluded. In addition, patients institutionalized in nursing homes or prisons were excluded because they may have important factors affecting hospitalizations that differ from the non-institutionalized population.¹⁸ Because there is no current plan to transfer persons with HIV from fee-for-service Medicaid into Medicaid managed care, these individuals were also excluded, as were patients who were unable to communicate. An enrollment target of 50 patients was defined because in addition to quantitative data, qualitative data were collected from each patient, and 50 qualitative interviews were determined to be more than adequate to obtain theoretical saturation yet still provide a representative sample of patients. The qualitative data are not described in this analysis. Eligible patients were approached promptly following admission and offered study enrollment. The Institutional Review Board of New York University School of Medicine approved the study.

Data Collection

After obtaining informed consent, we collected data to define the major medical and social factors that patients identified as contributing to their frequent hospital admissions. Patient interviews were conducted by either the principal investigator (MR) or a research assistant. To ensure internal consistency, interview techniques were standardized prior to subject recruitment, through PI-led interviewer training sessions conducted with patients who were not actual subjects.

Quantitative Interview Tools. It has been demonstrated that in addition to chronic disease, other factors such as mental illness, substance use, housing status, use of a medical home, medication adherence, and social networks influence use of health services.^{7,19–21} Thus, in addition to demographic information, we used previously validated tools to collect data on general health status,^{22,23} substance use,²⁴ social support,²⁵ mental health,²⁶ patient participation in his/her own health care,²⁷ usual source of care,²⁸ living situation, hunger,²⁹ and medication adherence.³⁰ Tools were selected by investigator consensus and input from experts in the areas of interest. These tools were compiled into a comprehensive quantitative instrument. (See Appendix 2 for a detailed description of quantitative interview tools.)

Claims Data. At the conclusion of the study period, we extracted diagnostic and outpatient services utilization information for our subjects from the 5.5 years of the study hospital's financial data used to develop our case-finding algorithm.

Data analysis

We used descriptive statistics to analyze demographic data. We compared scores on quantitative interview tools (SF-12, ASSIST, etc.) to the published mean scores for each instrument to determine how our study population compared to the general population on each measure. Claims data were analyzed using descriptive statistics including means and frequencies. Differences between groups were tested using Chi-square analysis. All analyses were conducted using SPSS Version 14.0.

RESULTS

Of 36,457 adult fee-for-service Medicaid patients seen at Bellevue Hospital Center (BHC) over the prior 5.5 years, 2,618 (7.2%) had an algorithm-based risk score for rehospitalization during the subsequent 12 months of 50 or greater. From August 7, 2005 to October 5, 2005, we identified and approached all high-risk patients admitted to BHC until we attained our enrollment target of 50 participants (Figure 1).

Of all 139 algorithm-identified high-risk patients with an admission during the 2-month study period, 55 (39.1%) did not meet study criteria (21 due to a diagnosis of HIV, 20 due to institutionalization in a nursing home or prison, seven due to primary language other than English or Spanish, seven due to inability to communicate). Twenty of the identified high-risk patients were discharged prior to approach by study staff due to extremely short (<24 h) lengths of stay, and four left the hospital against medical advice prior to approach. Ten patients refused to participate.

The sample was 72% male. The majority was between 35–49 (42%) and 50–64 (38%) years of age. Fifty-four percent of subjects self-identified as Hispanic, 24% as African American, 14% as White, and 8% as other. Most (60%) had less than a high school education. Public Assistance and Social Security/Disability were the primary income sources for 72% of subjects; only 4% worked.

When applied to our hospital’s Medicaid data, the algorithm, using a risk score cut-off of >50, correctly identified 67% (1,754 of 2,618) of patients in the dataset who would have a hospital admission in the subsequent 12 months (PPV 0.67), the same PPV identified when the tool was originally developed and validated using a larger dataset.⁴ The average risk score for our interviewed sample was 74.6.

FIGURE 1. Recruitment scheme.

Health Status and Services Utilization. Based on diagnoses listed in the fee-for-service Medicaid claims data and patients’ medical records, 62% of subjects had a previous diagnosis of at least one of the following chronic medical conditions: diabetes, chronic renal disease, chronic liver disease, congestive heart failure, asthma, chronic obstructive pulmonary disease, coronary artery disease, hypertension, stroke, cancer, or lupus, and 80% had a concomitant diagnosis of substance use and/or mental illness.

Among the 38% of subjects with no history of chronic disease, the vast majority (17 of 19, or 89% of patients) had diagnoses related to mental illness, substance use, or both, which accounted for their identification by the algorithm as being at high risk for future admission. SF-12 results indicated low self-rated health status: 70% of subjects rated their health as fair or poor, and subjects’ mean score for self-rated health was nearly two standard deviations below that reported by the general population. Fragmentation of care was evident; the majority of patients reported no usual source of care other than the emergency department. Subjects had an average of 3.4 hospital admissions in the year prior to study entry. Although 41 subjects (82%) had accessed some type of outpatient clinic visit at Bellevue Hospital in the past 3 years, regular use of outpatient services in the previous year, including mental health and substance use services, was low: only 30% of subjects had accessed the primary care clinic in the past year.

To minimize misclassification bias, data regarding the primary reason for admission (Table 1) were ascertained from a combination of patient interviews, patients’ medical charts, and interviews with patients’ in-house physicians and social workers.

TABLE 1 Primary diagnosis upon admission (N=50)

Admission diagnosis	Samples
Substance abuse detoxification	8
Infection	8
Pneumonia	2
Cellulitis/foot ulcer	4
Dialysis catheter	1
Septic joint	1
Cancer	5
Psychiatric illness	5
COPD/asthma	4
Lupus erythematosus	3
Alcohol withdrawal or intoxication	3
Trauma related to alcohol/substance use	3
Diabetes mellitus	2
Acute coronary syndrome	1
Adrenal insufficiency	1
Alcoholic hepatitis	1
Anemia	1
CHF	1
End-stage liver disease	1
Epilepsy	1
Fracture non-union	1
Alcoholic gastritis	1

Substance Use. Thirty-five (70%) subjects had ASSIST risk scores indicating moderate or high-risk substance abuse or dependence (vs. low-risk or no use), including eight patients who used tobacco only. After tobacco, alcohol was the most commonly used substance (36%), followed by cocaine and opioids. Seven subjects were current or former injection drug users. The primary diagnosis on admission for 21 (42%) participants was either substance use or a medical condition attributable to chronic substance use, making substance use or a related condition the single most common reason for the admission during which the interview was conducted. Primary substance use-related diagnoses included detoxification services, intoxication, or withdrawal ($n=11$), alcohol-related trauma ($n=3$), infections attributable to injection drug or chronic alcohol use ($n=3$), CHF exacerbation due to a period of heavy drug use during which no prescribed medications were taken ($n=1$), alcoholic hepatitis ($n=1$), alcoholic gastritis ($n=1$), and advanced liver disease due to chronic alcohol use ($n=1$). Diagnostic (ICD-9) codes in Medicaid claims data indicated that the majority of study patients (54%) had a formal diagnosis related to substance use. Further examination of hospital records and patient interviews identified five additional patients with substance use disorders for a total of 64% of the sample.

Mental Health. We employed two quantitative measures of mental health status. Participants' responses to the *SF-12 Mental Composite Score* indicated that 76% had greater levels of anxiety and depression than the general population. The *Brief Symptom Inventory-18* defines high risk for psychopathology based on a composite score of anxiety, depression, and somatization; 68% of our sample met case-definition criteria. These two summary measures had 70% concordance.

Taken together, substance use and mental health diagnoses identified from the Medicaid claims data were more prevalent in our study population than other medical diagnoses. Participants had high rates of hospital admission for substance use and mental health issues in the year prior to study entry, while use of outpatient services for these conditions was low. The proportion of patients with at least one inpatient admission per year due to a substance use-related condition (28%) or mental health condition (17%) was higher than the proportion using any outpatient addiction treatment (6%) or mental health services (12%).

Housing Status. Sixty percent of patients interviewed were either homeless (on the streets or in a shelter) or precariously housed with family or friends. Fifty percent identified themselves as homeless within the past 2 years. Housing status was significantly associated with usual source of care: patients who were homeless or precariously housed were over six times more likely to name the ED as their usual source of care or to say they had no usual source of care than patients who had stable housing (OR=6.4, 95% CI, 1.8–22.5). In addition, homeless patients were far more likely to have a hospital admission associated with substance use or related illness (OR=28.5, 95% CI, 3.4–242.1). Finally, 22 of the 30 (73.3%) patients who were homeless or precariously housed were admitted with mental health or substance use-related diagnoses, compared to only one of 20 housed patients.

Social Isolation. The majority of participants lived alone (52%) and had never been married (56%). Sixty-four percent had a limited social network or none at all, as reflected by their naming only two or fewer friends or relatives they felt they could talk to about important issues.

Health Care Expenditures and Utilization. Mean Medicaid cost per study participant was \$39,188 in the year prior to the study (Table 2). Notably, in the year following study participation, the same 50 patients interviewed generated a per-person average of \$84,040 in Medicaid expenditures at our hospital alone, for a total of \$4,201,981 across all participants. As in the year prior to study participation, the vast majority (86.5%) of expenditures were generated by hospital admissions, while 10.7% were generated by outpatient clinic visits and 2.81% by ED visits.

DISCUSSION

We report the results of an investigation undertaken to evaluate the feasibility in a real-world hospital setting of using a case-finding algorithm to identify patients at high risk of future hospital admission and to define remediable medical and social risk factors that might be addressed by an intervention to improve health and reduce admissions and costs among the frequent hospital users identified. The algorithm’s robust PPV in our setting and our ability to identify hospitalization risk factors among frequently admitted persons suggest that we have identified an approach that hold promise for informing interventions to improve care for this patient population.

The majority of the high-risk patients we studied had no usual source of primary care. Unstable housing, substance abuse, and mental illness also emerged as strong drivers of hospitalization. The 50 interviewed patients consumed a per-person average of nearly \$40,000 in Medicaid funds during the prior year, most of which was spent on hospital admissions. As a point of reference, mean New York State Medicaid payments for all Medicaid enrollees were \$7,583 during the same year.³¹ Billings and Mijanovich have demonstrated that patients identified by this algorithm will not only generate high costs in the 12 months prior to an index admission but will also generate even higher costs in the 12 months following discharge if no intervention is undertaken to reduce health services use. This was indeed the case for our study population, whose costs more than doubled in the year following study enrollment.⁴

These figures are a reflection of the Medicaid reimbursement structure and are helpful in guiding the use of intervention resources for this population: Inpatient admissions are reimbursed at much higher rates than ED visits; thus, while study

TABLE 2 Mean Medicaid expenditures per participant in year prior to study admission, Bellevue Hospital Center

Hospital pay center	Mean expenditures
Inpatient ^a	\$37,418
Outpatient substance abuse treatment	\$343
Outpatient mental health treatment	\$299
Emergency department	\$174
Primary care	\$168
Specialty care	\$150
Other	\$636
Total	\$39,188

^aMedicaid does not bill emergency department or outpatient clinic services provided on day of admission, only inpatient services

patients had twice as many ED visits as inpatient admissions in the year after study participation (7.44 ED visits vs. 3.54 admissions), attempts to reduce admissions will provide the most savings to Medicaid. This may not be true for other insurers. These findings are another indicator that the case-finding algorithm accurately identified patients who would continue to generate high costs and might benefit from intervention.

By conducting in-depth, real-time interviews with patients identified by a validated statistical case-finding algorithm as having high risk for future hospital admission, we were able to obtain far more nuanced information on patients' circumstances than is available from administrative data alone. While study participants were diverse, with a wide variety of diagnoses and social circumstances, they shared many risk factors for hospital admission that have traditionally been challenging for health care delivery systems to address, including homelessness, social isolation, substance use, depression and anxiety, and fragmented primary care. Patients and caregivers cited these factors as contributing substantially to their hospital admissions, consistent with other reports.⁸

Much of the literature examining characteristics of patients with frequent hospital admissions has substantial limitations, which our study sought to overcome. Some studies are focused on patients with specific conditions, limiting the generalizability of potential interventions.^{9,32,33} In others, characteristics of patients with frequent hospital admissions are defined by retrospective or administrative data,³⁴ which lacks the depth and nuance of information obtained during interviews. In addition, definitions of being a "frequent" or "high" user of hospital services vary from study to study, and in many cases, frequent use is defined within a single year, rather than over a longer period of time.^{7,12,16}

To our knowledge, this is the first study to employ a validated predictive case-finding algorithm to identify, in real time, patients at risk of future hospital admission. Our algorithm was developed to promote accurate patient identification, an important feature if it is to provide a basis for interventions targeting patients with frequent hospital admissions. Identifying patients using non-validated techniques can lead to patient misclassification and misallocation of limited intervention resources. While our hospital was the first to test the use of this algorithm, it can be applied to any hospital's multiyear dataset.

This study has several limitations. We did not interview a comparison group of low-risk patients to define more clearly the risk associated with specific drivers of hospitalization. We used visit data for a single hospital only; visits that participants made to other hospitals could not be accounted for and most likely resulted in our having undercounted prior hospitalizations, ED visits, and outpatient clinic visits. By using ICD-9 codes from claims data to define the prevalence of chronic disease, including mental health and substance use, we have likely underestimated their prevalence.³⁵ Because study patients were interviewed in the hospital, it is possible that scores on such items as mental health measures were biased, either toward depression and anxiety given the hospital setting or perhaps in the other direction, if some patients found being in the hospital comfortable compared to their usual circumstances. Finally, the study was focused on English- and Spanish-speaking fee-for-service Medicaid patients at Bellevue Hospital Center, an urban hospital that cares for an underserved patient population, which may limit the generalizability of our findings beyond the safety net hospital system.

What can be done to address the complex factors we have identified as contributing to frequent admissions among study participants? Effective interven-

tions will require partnerships between hospital- and community-based providers of care. Innovative, rational service models to address diverse yet often related conditions, including homelessness, substance use, mental health, and fragmented health care, could result in improved health and cost offsets or even savings achieved through decreased hospital utilization. Non-medical drivers of frequent hospital admission such as social isolation and homelessness must be addressed if interventions to reduce high hospitalization rates are to succeed. Yet, the defined focus and funding objectives of most health and human services agencies often limits integration of interventions across disciplines. For example, many providers of homeless services are hesitant to take on medically frail patients due to inadequate linkages with health care providers, and patients with comorbid substance use and psychiatric problems may have case workers who are restricted to managing only one of these issues. If state agencies such as Medicaid begin to test partnerships with organizations that can help improve care for high-cost patients and expand the scope of what the health care system alone can provide, opportunities for shared benefits in both improved health and reduced costs will likely emerge.

We have shown that a predictive case-finding algorithm, applied in a large, urban, public hospital, is reasonably predictive of risk of admission in the subsequent 12 months. This innovative application is being used to target a multidimensional intervention for high-risk patients in our municipal hospital system, with the goal of improving the quality of out-of-hospital care and reducing rates of hospital readmission. Wider application of this algorithm should be encouraged to identify high-risk patients who could benefit from tailored interventions in other hospitals and health care systems.

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