Integrated Behavioral-Physical Care Management in the Primary Care Setting

Prepared for: Duke University Health System

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Abstract

Background
Care management programs for high-cost patients with complex medical and social needs are seen as an opportunity to improve quality of care, promote health, and reduce costs. However, mixed evidence of intervention effectiveness and a lack of supportive analytics tools limit the ability of programs to properly target patients with services that significantly impact health service use. The primary aim of this study is to evaluate a unified primary care and behavioral health intervention targeting high utilizer Medicaid enrollees by examining the program’s effect on subsequent health service utilization patterns. The secondary aim is to develop tools that improve the identification of patients for enrollment in high utilizer care management programs.

Methods
This study employs a case-control study design that compares program participants to a carefully matched control group. Patients engaged in primary care were identified via high numbers of emergency department visits and referrals from physicians and the state Medicaid agency. Thirty-five Medicaid beneficiaries were enrolled between August 2013 and February 2014 and included in the final analysis. Priority was given to patients with comorbid mental health or substance abuse disorders, but a number of patients with significant chronic medical illness were also enrolled. Baseline rates of emergency department visits, hospital admissions, and primary care visits were calculated
for the one-year pre-enrollment. Post-intervention rates were calculated as twice the number of encounters during a 6-month follow up period.

Results

Enrollment of high utilizer Medicaid beneficiaries in integrated behavioral-physical care management did not result in a greater reduction of emergency department visits or hospital admissions compared to patients receiving standard primary care. Patients enrolled in the program showed an average decrease of 3.46 ED visits per year and an average increase of 0.17 hospital admissions per year. Similar high utilizer patients receiving standard primary care showed an average decrease of 4.43 ED visits per year and average decrease of 0.20 hospital admissions per year. However, program participants were significantly more engaged in primary care over the follow up period compared to the control group. Patients enrolled in the program had almost no change in primary care visit rate (increase of 0.14 visits per year), whereas control patients had an average decrease of 9.71 visits per year.

Conclusion

This case-control study reveals the tough road ahead for programs attempting to show a return on investment—changes in outpatient healthcare use were not accompanied by a drop in more costly hospital healthcare use. A data application was developed to improve patient selection, which we hope reduces patient heterogeneity moving forward. More must be done to rigorously evaluate high utilizer care management programs on a larger study population.
Introduction

Care management programs targeting patients with complex needs are proliferating despite mixed evidence and a lack of effective tools to assist program operations. The aims of this study are to evaluate the impact of integrated care management on the health service utilization of a group of patients deemed to be “high utilizers” and to develop data applications that improve selection of patients for program enrollment.

Care management and coordination has been defined as “the deliberate integration of patient care activities between two or more participants involved in a patient’s care to facilitate the appropriate delivery of health care services.”¹ These programs attempt to avoid wasteful duplication of diagnostic testing, perilous polypharmacy, and conflicting care plans for patients receiving care from multiple providers. Most care management research has occurred in the Medicare setting.²⁻⁸ Results varied dramatically among six major CMS demonstrations; only one program significantly decreased patient costs, two programs significantly increased patient costs, and the remaining programs showed no changes.⁸ Care managers in successful programs were more likely to have substantial in-person contact with both patients and physicians, and to be integrated into physician practices or health systems. Successful programs share several characteristics; they serve as a communications hub between providers and patients, making sure all providers have key information about the patient; they use behavior-change techniques and motivational interviewing to help
patients follow recommendations; lastly, they have reliable information about patients’ medications and implement a comprehensive approach to transitions from hospital to home.³

Attention is shifting from reducing costs for elderly Medicare patients to reducing costs for high utilizing Medicaid patients.⁹ The Geriatric Resources for Assessment and Care of Elders (GRACE) model was developed to improve the quality of care for low-income seniors, who account for a disproportionate share of health care expenditures among the elderly population.¹⁰ The program provides patients with two years of home-based care management by a nurse and social worker who collaborate with the primary care physician and an interdisciplinary geriatrics. In two trials, the program has led to significantly reduced ED visit rates.⁵,¹¹

As attention shifts to Medicaid beneficiaries, programs must also emphasize the treatment of mental illness and substance abuse. Sixty percent of high-cost Medicaid patients have co-morbid physical and behavioral health conditions and Medicaid patients with mental illness in addition to common chronic illness incur costs that are 60-75% higher than those without a mental illness.¹²,¹³ Medicaid enrollees with comorbid mental illness receive worse care for medical comorbidities, such as diabetes,¹⁴ and have mortality rates nearly four times higher than the general population.¹⁵ Despite this need, programs that integrate behavioral and physical health services have been shown to have
varying impacts on health service use and none have specifically targeted high-cost Medicaid patients.\textsuperscript{16,17}

To address the complex needs of high utilizing Medicaid patients, “super-utilizer” programs have emerged to provide intensive outpatient care management to patients whose medical, behavioral, and social needs are unmet.\textsuperscript{18} Several of these programs incorporate behavioral health services into primary care, but the extent of service integration and resultant outcomes vary greatly.\textsuperscript{9} Programs range from mostly telephonic care management provided by health plans to teams embedded in primary care practices to teams that engage patients at home. In one primary care clinic with an interdisciplinary behavioral science group consisting of psychiatry, psychology, and social work, detection and treatment of mental illness improved, but only half of patients identified as having mental illness received adequate treatment.\textsuperscript{19} Even without co-locating behavioral health professionals, mental illness care management supporting primary care can significantly reduce depressive symptoms compared to usual primary care.\textsuperscript{20} To the extent of our knowledge, no “super utilizer” program staffed with full-time behavioral health professionals and care managers has been evaluated with a control group.

This study evaluates a unified primary care and behavioral health intervention targeting high utilizer male and female Medicaid enrollees by comparing program participants to a carefully matched control group. The program was implemented at a safety net, resident-run primary care clinic and
the goal of the program was to shift care for these patients from the high-cost hospital environment to the low-cost outpatient primary care setting. Prior analysis of administrative data revealed that clinic patients with co-morbid mental and medical illness had higher hospital utilization. The program was created in direct response to that finding, by improving access to mental health services at the clinic and providing intensive care management to patients with numerous hospital admissions and emergency department visits.

The primary aim of this study is to examine the program’s effect on “high utilizers” subsequent health service utilization patterns. Our hypotheses were that participation in the program would decrease emergency department (ED) visit rates, decrease hospital admission rates, and increase primary care visit rates among the group of high utilizers served by the program compared to a matched group of high-utilizers who did not participate in the program. Additional outcomes include inappropriate use of the ED and number of 30-day readmissions. The secondary aim of this study is to develop tools that improve the identification of patients for enrollment in the high utilizer program. Our goal is for this study to guide improvements in the program and to inform further expansion of integrated mental health and primary care services within and across health systems. This research study qualified as quality improvement and was exempted from Institutional Review Board approval.
Methods

Program Description

The behavioral-physical care management team consists of a nurse care manager, a social worker, a mental health-trained advanced practice provider (MH-APP), and a dually trained medicine-psychiatry attending (MPA). The program has four goals: enhance access to care, improve treatment of mental illness, address unmet social needs, and coordinate care. To enhance access to care, the mental health-trained APP provides walk-in access to all patients and the nurse care manager regularly contacts patients with the highest numbers of ED visits. To improve treatment of mental illness, the care manager coordinates with community mental health teams and the MPA ensures that patients are receiving appropriate mental health services by providing psychiatric consultation as needed.

To address unmet social needs, the interdisciplinary team meets twice per week to discuss patient progress and connect patients to appropriate resources. The care manager works with patients to ensure that they can obtain all medications prescribed to them and that they can secure transportation to all outpatient visits. The care manager also works closely with the clinic social worker to help connect patients with resources to assist with non-medical services such as housing and food assistance.

The nurse care manager’s main role is to coordinate care. For patients receiving care in the ED or hospital, the nurse care manager communicates with
providers to expedite discharge and transition care back to the outpatient clinic. In the outpatient setting, the nurse care manager schedules appointments and facilitates referral to subspecialists. A flag placed in each patient’s health record facilitates care coordination across settings. The flag outlines care plans for patients in the ED or hospital, encourages providers to communicate with the nurse care manager, and informs providers that patients have walk-in access at the primary care clinic during business hours.

**Participants**

The care management team began enrolling in August 2013, solely based on Medicaid enrollment status and ED utilization. Only patients engaged in primary care at the clinic were eligible for the program, and this was defined as ≥ 1 clinic visit in the preceding 12 months and ≥ 2 clinic visits in the preceding 36 months. Chart reviews were performed for all eligible patients with ≥2 ED visits in the 6-month period from January 2013 – June 2013 to assure continued use of emergency and hospital services. Later waves of enrollment included patients referred by primary care providers and the state Medicaid agency, with less focus on utilization counts. Priority was given to patients with comorbid mental health or substance abuse disorders, but a number of patients with significant chronic medical illness were also enrolled. Between August 2013 and February 2014, 37 patients were enrolled in the Home Base program.

**Study Design**
This study employs a longitudinal, case-control design to assess the impact of a behavioral-physical complex care management program on health service use patterns of high-utilizer Medicaid beneficiaries. Patients enrolled in the program during the period from August 2013 to February 2014 were compared to similar patients who received standard adult primary care. The evaluation period began on the date of enrollment for patients in the program and on September 1, 2013 for matched, control patients. Baseline rates of emergency department visits, hospital admissions, and primary care visits were calculated for the one-year pre-enrollment. All patients were given a one-month traction period for the intervention to take hold. Post-intervention rates were calculated as twice the number of encounters between 1 month post-intervention and 7 months post-intervention. Figure 1 depicts the evaluation timeline for the control group.

**Measures**

All the data elements used to match patients and evaluate outcomes were constructed using raw data extracts from the hospital’s administrative enterprise data warehouse. None of the data elements used in this study exist as fields in the administrative database, but were constructed using rules defined with the assistance of data warehouse staff, clinical providers, and in some cases externally validated criteria. In addition, extensive data manipulation was required to reconcile changes in data structure and storage that occurred due to a major shift in electronic health record systems during the evaluation period.
The three disease variables were assessed using AHRQ’s Clinical Classification Software to group ICD9 diagnosis codes from the 2 years pre-enrollment. Mental illness included the following classes of ICD9 codes: ‘adjustment disorders’, ‘anxiety disorders’, ‘attention-deficit, conduct, and disruptive behavioral disorders’, ‘mood disorders’, ‘personality disorders’, ‘schizophrenia and other psychotic disorders’, and ‘suicide and intentional self-inflicted injury.’ Substance abuse included the following classes of ICD9 codes: ‘alcohol-related disorders’, ‘substance-related disorders’, and ‘screening and history of mental health and substance abuse codes.’ Lastly, diabetes included classes of ICD9 codes for ‘diabetes mellitus without complications’ and ‘diabetes mellitus with complications.’

The two health service use variables used to identify the control group counted emergency department (ED) visits and hospital admissions within the health system in the 1-year pre-enrollment. Both of these variables required patients to pass through the ED, excluding direct admissions to the hospital. In addition, ED visits were differentiated from hospital admissions by the amount of time spent in the hospital. If the patient spent more than twenty-four hours in the hospital, the encounter was counted as a hospital admission regardless of whether or not the patient ever left the ED. This was to account for cases where patients spent several days under observation status without meeting technical criteria for admission.
The three primary outcomes of interest were differences in pre- and post-intervention emergency department visit rates, hospital admission rates, and primary care visit rates. Two secondary outcomes were differences in all-cause 30-day readmission rates and appropriate ED use rates, defined as the percent of ED visits that result in hospital admission. The care management team was interested in the final outcome measure because they specifically wanted to transition acute care visits to the hospital that didn’t require hospital admission back to the outpatient setting. Thus, while they were hoping to see an overall decrease in ED use, they were also hoping to see an increase in the percent of ED visits that result in admission. This would convey that inappropriate ED use decreased.

Statistical Analysis

Because patients enrolled in the program were high utilizer Medicaid enrollees selected via chart review, they differ systematically from other clinic patients. Propensity score matching was used to compare individuals enrolled in the program to a group of similar individuals who did not participate in the program. This case-control method reduces the effects of confounding and should allow for a less biased estimation of the impact of the program on health service utilization.21

In our analysis, the propensity score was defined as the probability of an individual participating in care management conditional on the individual’s background characteristics.22 The propensity score was computed using a
logistic regression model in which the dependent variable, treatment status, was regressed on age, three binary disease variables (mental illness, substance abuse, and diabetes), and two continuous variables for health service use variables (ED visits and hospital admissions). Conditional on the propensity score, the distribution of baseline covariates was similar between treated and untreated subjects. Sensitivity analysis testing four parameters of the propensity score model was performed to ensure robustness of the results. Tests included different sets of variables to balance populations, different cohorts, different matching method, and different evaluation time periods.

Three continuous primary outcome variables were used to estimate the effect of the integrated behavioral-physical care management program: change in annual ED visit rate, change in annual hospital admission rate, and change in annual primary care visit rate. Two additional continuous variables were calculated to capture the change in annual hospital readmission rate and change in percent of ED visits that result in hospital admission during the 6 months post-intervention. Once these values were calculated, a paired t-test was used to assess the statistical significance of the effect of treatment on each outcome. All data processing, statistical analysis, and data visualization was completed using R, version 3.0.2. Propensity score matching was executed using the ‘arm’ R package. Web application development was completed using R Studio, version 0.98.1103.
Results

An initial cohort of 4,253 patients met the criteria for being engaged in adult primary care at the clinic. The pool of eligible control patients was further restricted to those with at least two emergency department visits during the one-year pre-intervention, who had not died or ceased receiving care within the health system. Eligible patients were required to have at least one encounter at any site within the health system in the 7 months post-enrollment. Two patients enrolled in the program were dropped from the analysis; one for being an outlier across covariates and the other for ceasing to receive care at the health system. This reduced the number of eligible control patients from 4,209 to 793 and the number of patients in the treatment group from 37 to 35.

One-to-one nearest neighbor matching successfully controlled for the significant differences in observable variables at baseline between the group of patients in the intervention and the pool of patients receiving standard primary care. Table 1 shows covariates pre-matching, covariates post-matching, and bias reduction due to matching. Overall, the bias between groups was reduced from 0.50% to 0.13%. Before matching, the group enrolled in care management had significantly higher rates of mental illness and substance abuse and significantly more emergency department visits and hospital admissions. After matching, covariates were more balanced, but patients enrolled in care management still differed on rate of diabetes and hospital admissions.
Several models tested in the sensitivity analysis achieved greater bias reduction, but at the cost of using fewer variables. For example, a model using only age and number of ED visits achieved a bias of 0.06%, but groups were significantly different across important variables such as annual hospital admission rate (0.54 for the control group versus 1.89 for the treatment group). The final model was chosen because it achieved significant bias reduction while simultaneously including most variables identified by the care management team. An inability to balance diabetes and hospital admission rate was regarded as less important than balancing mental illness, substance abuse, and ED visit rate.

Post-matching, the average treatment effect on the treated can be estimated to answer the question: “did high-utilizer Medicaid patients enrolled in integrated behavioral-physical complex care management achieve more favorable outcomes when compared to similarly at-risk patients who did not receive the intervention?” Enrollment of high utilizer Medicaid enrollees in integrated behavioral-physical care management did not result in a greater reduction of emergency department visits or hospital admissions compared to standard primary care. Patients enrolled in the program showed an average decrease of 3.46 ED visits per year and an average increase of 0.17 hospital admissions per year, whereas patients receiving standard primary care showed similar changes (average decrease of 4.43 ED visits per year and average decrease of 0.20 hospital admissions per year).
However, enrollment of high utilizer Medicaid enrollees in integrated behavioral-physical care management did result in significantly greater use of primary care over the six month follow up compared to the control group. Patients enrolled in the program had almost no change in primary care visit rate (increase of 0.14 visits per year), whereas control patients had an average decrease of 9.71 visits per year. This difference in primary care use was statistically significant ($p < 0.001$) and follows naturally from the structure of the program—patients in treatment received intensive outpatient care management and had significantly more primary care visits. Results are summarized in Table 2 and Figure 2.

Lastly, the program did not significantly impact either of the secondary outcomes, percent of ED visits resulting in admission and hospital readmission rates. For both groups, 13-20% of ED visits resulted in hospital admission across time periods, suggesting that ED use remained suboptimal. The vast majority (>80%) of ED visits for both groups resulted in discharge to home, indicating that the visits didn’t require hospital admission. Rates of hospital readmission were also < 1 per year for both groups across time periods.

**Model Selection & Sensitivity Analysis**

To arrive at a final model, four important parameters were tested: the variables included in the model, the cohort included, the matching technique, and the time period used for evaluation. The behavioral-physical care management team identified ten variables that were important for selecting patients to enroll in
the program. The variables included age, presence of mental illness, substance abuse, and diabetes, an overall comorbidity index, and counts of hospital admissions, emergency department visits, and primary care visits. Over fifty permutations of these ten variables were tested to arrive at the final model, which both balanced covariates across the treatment and control group and included a sufficient number of variables from each of the three domains (demographic, diagnosis, and health service use).

Once the list of variables was identified, different treatment and control cohorts were tested. Cohorts including and excluding outliers were tested as well as various eligibility criteria for control patients. Different minimum levels of health service use were tested as well as a requirement that control patients be Medicaid recipients. Finally, different matching techniques, including 1:1 nearest neighbor, 1:5 nearest neighbor, 1:7 nearest neighbor, and caliper matching, as well as different evaluation time periods, including 3 months post-intervention and 6 months post-intervention, were tested. Not a single model tested arrived at a different conclusion compared to the final model included in the analysis.
Discussion

Programs that provide intensive outpatient care management can only show a return on investment by reducing the use of high-cost hospital services. To effectively transition care from the inpatient setting to the outpatient setting, programs must identify patients who are both in need of care management services and likely to positively respond to those services. The findings of this study reveal how difficult it can be for complex care management programs to achieve cost savings.

Patients enrolled in the program engaged in significantly more primary care usage compared to the control group, but this was not accompanied by a significant change in inpatient hospital service usage. Notably, annual rates of ED visits did drop by 3-4 visits per year for both treatment and control groups, but the drop for patients enrolled in the program was similar in size to that for patients receiving standard primary care. Thus, the similar decline in ED visit rates for both groups may be due to regression-to-mean rather than the care management program. Lastly, the program had no impact on hospital admission rates. The hospital admission rates in the year pre-intervention were about the same as those post-intervention for both treatment and control groups.

Study Limitations

Several features of the program made it difficult to evaluate. Most importantly, the small sample size limited the ability to assess the effect of the program. The small sample size provided sufficient power to only detect a large
effect size. Second, due to the inconsistent enrollment process, the quality of the matched control group is questionable. The care management team had limited access to population-level data to identify the highest health service utilizers, which led them to rely on referrals from clinic providers. Most of the clinic’s highest utilizers were enrolled, but several patients enrolled in the program didn’t meet commonly accepted definitions of being a high utilizer, such as greater than 2 ED visits in the previous six months. In addition, because patients had their charts reviewed by the team prior to enrollment, there is potential for bias if patients intentionally denied access to the services systematically differ from patients enrolled in the program. Matching reduced bias across the observable characteristics that made patients eligible for the program, but we could not control for the implicit selection criteria used during chart review.

Third, the program was only evaluated on measures of health service use. A major goal of the program was to improve management of mental illness and socioeconomic stressors in the primary care setting, but no process or outcome measures were collected. In addition, the program likely had positive externalities across the clinic, because behavioral health consultation by the on-site psychiatrist was made available to all clinic patients, not only those enrolled in the program. Thus, identification and management of mental illness in the primary care setting may have improved more broadly.

Fourth, patients enrolled in the program were very heterogeneous. Although all patients had a minimum of 2 ED visits or hospital admissions in the
year prior to program enrollment, many patients didn't meet a standard definition of “high utilizer”; greater than 2 ED visits in the previous six months. The standard deviation of number of ED visits among the treatment group remained > 8 visits/year even after the patient with > 50 ED visits was dropped from the analysis. Figure 3 plots all patients according to ED visits and hospital admissions, revealing the density of points in the bottom left, below average for both variables. This variability may be due to the lack of a consistent enrollment process—many patients were enrolled via referral from providers at the clinic or the state Medicaid agency.

Lastly, not only were patients heterogeneous at baseline, but response to care management varied dramatically. The standard deviation for change in ED visit rate among patients in the treatment group was nearly twice that for patients in the control group (12.26 visits/year and 6.42 visits/year, respectively). Figure 4 illustrates the change in ED visit rate across individuals in the control and treatment groups. The left panel, for individuals in treatment, shows far greater variability than the right panel, for individuals in the control group.

Future Directions

To improve the selection of patients for program participation, a web application was developed to display relevant data extracted from the electronic health record. Three categories of variables are of particular interest to the care management team; patterns of health service use across the care continuum, historical patterns of emergency department use, and medical diagnoses. Figure 5 displays the web interface.
On the left hand side is a panel of three interactive widgets. At the top is a drop down menu to select a group of twenty-five high-cost clinic patients to closely examine. Second, a list of three patient labels, enabling a de-identified option, clinic cost rank, and two identified options, medical record number and patient name. Third, a list of twenty-seven medical diagnoses built using AHRQ’s Clinical Classification Software groupers for International Classification of Disease (ICD) 9 codes. On the right hand side are two data visualizations depicting care utilization patterns across the continuum, Figure 6, and historical ED use trends, Figure 7.

At the bottom of the application is a table showing diagnoses for each patient. As diagnoses are selected from the list in the left side panel, results are displayed in the table. Figure 8 shows the prevalence of ten common conditions among the twenty-five costliest clinic patients.

The web application aggregates and displays population-level data in a way that allows easy comparison of high utilizer patients. This functionality goes above and beyond the electronic health record, which presents patient-level data. For example, if three patients have successfully responded to the program and are no longer in need of ongoing services, the team can use the web application to enroll three new patients. Use of the web application hopefully leads to more systematic patient targeting, which will enable better understanding of the program’s impact.
Conclusion

Complex care management for high utilizer Medicaid patients has great promise to improve quality of care while simultaneously cutting costs. However, this case-control study evaluating an integrated behavioral-physical care management program reveals the tough road ahead. We are halfway there – increasing patient engagement in primary care is feasible, but transitioning care away from the high cost hospital setting remains a challenge. Addition of care management services and removal of barriers to access outpatient services are necessary but insufficient to change health service use patterns. More must be done to understand the additional factors that drive patients to seek hospital and emergency department services.

If programs are expected to systematically identify patients for care management programs, better tools must be developed to analyze and present data at the population level. Electronic health records were developed to aid the workflow of direct patient care, and thus focus on organizing and presenting patient-level data. This makes it difficult for providers to easily compare patients across covariates, except via time-consuming chart review. A web application was developed to improve patient selection by providing population-level analysis, which we hope reduces patient heterogeneity moving forward.

Lastly, understanding the impact of care management programs that target high utilizer patients will continue to be limited by small study populations. By the nature of their mission, these programs target outliers whose numbers are
limited in any given care setting. This study included only one site, which ensured that program implementation was consistent across participants, but resulted in a small study population. Future studies must pool data from an intervention implemented at several different sites to achieve greater power, even though this may introduce heterogeneity in program implementation across sites. More must be done to rigorously study complex care management on a larger population of high utilizer patients.
References


7. Peikes D, Peterson G, Brown RS, Graff S, Lynch JP. How changes in


All data used in the analysis was collected as a by-product of care delivery, via DEDUCE. I performed all data analysis myself.

### Table 1: Covariates pre- and post-matching and bias reduction

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-Matching</th>
<th>Post-Matching</th>
<th>Bias</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Treatment</td>
<td>Control</td>
<td>Treatment</td>
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<tr>
<td></td>
<td>(n=35) Mean (SD)</td>
<td>(n=793) Mean (SD)</td>
<td>(n=35) Mean (SD)</td>
</tr>
<tr>
<td>Age</td>
<td>44.00 (13.01)</td>
<td>50.35 (16.47)</td>
<td>44.00 (13.01)</td>
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<td>Mental Illness</td>
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<td>Substance Abuse</td>
<td>0.69 (0.47)</td>
<td>0.50 (0.50)</td>
<td>0.69 (0.47)</td>
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<tr>
<td>Diabetes</td>
<td>0.46 (0.51)</td>
<td>0.43 (0.50)</td>
<td>0.46 (0.51)</td>
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<tr>
<td>Hospital Admission Rate</td>
<td>1.89 (3.17)</td>
<td>0.64 (1.06)</td>
<td>1.89 (3.17)</td>
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<tr>
<td>ED Visit Rate</td>
<td>11.63 (8.26)</td>
<td>3.32 (2.87)</td>
<td>11.63 (8.26)</td>
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</tbody>
</table>

**Mean Bias** 0.50 0.13

### Table 2: Impact of intervention on emergency department visits, hospital admissions, and primary care visits

<table>
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<tr>
<th></th>
<th>Pre-Intervention</th>
<th>Post-Intervention</th>
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<th>T Statistic</th>
<th>P Value</th>
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<tr>
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<td>Treatment (n=35)</td>
<td>Control (n=35)</td>
<td>Treatment (n=35)</td>
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<td>ED Visits per Year</td>
<td>11.63 Mean</td>
<td>10.43 Mean</td>
<td>8.17 Mean</td>
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<td></td>
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<td>0.42</td>
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<tr>
<td>Hospital Admissions/Year</td>
<td>1.89 Mean</td>
<td>1.40 Mean</td>
<td>2.06 Mean</td>
<td>1.20 Mean</td>
<td>0.17</td>
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<td></td>
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<td></td>
<td>0.65</td>
</tr>
<tr>
<td>Primary Care Visits per year</td>
<td>9.29 Mean</td>
<td>14.06 Mean</td>
<td>9.43 Mean</td>
<td>4.34 Mean</td>
<td>0.14</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td>4.00</td>
</tr>
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<td>% of ED Visits that Result in Admission</td>
<td>0.14 Mean</td>
<td>0.14 Mean</td>
<td>0.20 Mean</td>
<td>0.14 Mean</td>
<td>0.06</td>
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<td>1.22</td>
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<tr>
<td>Hospital Readmissions per Year</td>
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<td>0.29 Mean</td>
<td>0.46 Mean</td>
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<td>-1.11</td>
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**Figures**

All data used in the analysis was collected as a by-product of care delivery, via DEDUCE. I performed all data analysis myself.

**Figure 1: Evaluation Timeline**

Enrollment dates for patients in the program spanned an 8 month period, whereas enrollment date for patients not in the program was assigned to September 1, 2013.

**Figure 2: Change in health service use across outcome variables**
**Figure 3:** Scatterplot of ED Visits vs. Hospital Admissions with solid lines at the averages.

**Figure 4:** Change in ED visit rate across treatment and control groups
Figure 5: Web application interface

Figure 6: Health system encounters in the previous year
Healthcare Utilization Timeline, for Patients with Cost Rank 1-25
(with costliest at top)
**Figure 7**: Emergency department in the previous two years
ED Visits during past 2 years

**Figure 8**: Ten diagnoses displayed for the twenty-five costliest clinic patients
<table>
<thead>
<tr>
<th>Cost.Rank</th>
<th>A_Fib</th>
<th>CHF</th>
<th>Dementia</th>
<th>Cancer</th>
<th>CKD</th>
<th>ESRD</th>
<th>COPD</th>
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