OUTCOMES FOLLOWING HOSPITAL DISCHARGE: THE ROLES OF POST–ACUTE CARE PATHWAY AND PATIENT SOCIOECONOMIC STATUS

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ABSTRACT

Ye Zhu: Outcomes Following Hospital Discharge: The Roles of Post–Acute Care Pathway and Patient Socioeconomic Status
(Under the direction of Sally C. Stearns)

Short-term (30-day) hospital readmissions are a major financial burden for the Medicare system. Low socioeconomic status (SES) and a hospital's safety-net status are important factors associated with higher hospital readmission rates. Post–acute care (PAC) location may also be affected by SES and subsequently affect post-discharge outcomes. This study examined the associations between SES and PAC location (Aim 1), post-discharge outcomes with PAC location considered (Aim 2), and the associations by safety-net status (Aim 3) to better understand the roles of SES and PAC location in affecting post-discharge outcomes.

The study identified Medicare Current Beneficiary Survey Fee-for-Service participants with inpatient hospitalizations from 2006 to 2011. SES was measured at the individual level (dual-eligibility, income, and educational level) and the area level (the Area Deprivation Index). The 30-day post-discharge outcomes included hospital readmission, hospice/death, or neither. PAC locations based on Medicare claims included home health, skilled nursing facility, inpatient rehabilitation facilities (Aim 1 only), or home. Multinomial logistic regressions were used, comparing models using variables from claims data versus the full set of variables from provider files, area health resources, and survey data. Inverse probability weights were used to control for selection of PAC location (Aims 2 & 3).

The results suggested that dual-eligible patients were more likely to use SNFs, while patients living in deprived areas were less likely to use SNFs. Overall, readmission rates were

higher for dual than non-dual patients. Dual patients had slightly higher readmission rates in safety-net than in non-safety-net hospitals. Controlling for additional variables including the SES measures of income and education and PAC locations increased the explanatory power of the models but did not substantively change the associations.

The study results supported the important roles of dual-eligibility and area deprivation level in predicting PAC locations and post-discharge outcomes as well as the role of safety-net status in the post-discharge outcomes. This study aimed to help policy makers understand ways to address the disadvantage for safety-net hospitals, and to contribute to efforts to ensure access for vulnerable patients with limited resources while promoting high-quality health care and reimbursement commensurate with costs.

I dedicate this work to

my husband Huanyao
for being strong, patient, and supportive of me
and for being my backbone;

my sons Arthur (five years old) and Felix (three years old)
for being huge but healthy and pleasant distractions
and for making me laugh every day;

my parents
for giving me a positive soul
and for always encouraging me to believe in myself and be happy;

and my friends
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LIST OF ABBREVIATIONS

ADI	Area Deprivation Index
AHRQ	Agency for Healthcare Research and Quality
AMI	Acute Myocardial Infarction
ASPE	Office of The Assistant Secretary for Planning and Evaluation
ATC	Access To Care
C&U	Cost and Use
CABG	Coronary Artery Bypass Graft
CAHPS	Consumer Assessment of Healthcare Providers and Systems
CMS	Centers for Medicare and Medicaid Services
COPD	Chronic Obstructive Pulmonary Disease
ER	Emergency Room
HCUP	Healthcare Cost and Utilization Project
HF	Heart Failure
HHA	Home Health Agency
HRRP	Hospital Readmission Reduction Program
HRS	Health and Retirement Survey
IOM	Institute of Medicine
IPPS	Inpatient Prospective Payment System
IRF	Inpatient Rehabilitation Facility
LTCH	Long-Term Care Hospital
MCBS	Medicare Current Beneficiary Survey
NAS	National Academy of Science
NH	Nursing Home

NQF	National Quality Form
NRD	Nationwide Readmission Database
NS-SEC	National Statistics Socioeconomic Classification (UK)
PN	Pneumonia
RAC	Recovery Audit Contractor
RSRR	Risk-Standardized Readmission Rate
SES	Socioeconomic Status
SEP	Socioeconomic Position
SNF	Skilled Nursing Facility
THA	Total Hip Arthroplasty
TKA	Total Knee Arthroplasty

CHAPTER 1. INTRODUCTION

Introduction

Medicare short-term (30-day) hospital readmissions are a major financial burden for the Medicare system, costing over $26 billion annually.[1] From 2007 to 2011, about 20% of Medicare patients were readmitted to the hospital within 30 days of discharge; among these short-term hospital readmissions, only 10% were planned and, depending on the type of disease, 20%–27% were potentially avoidable.[1,2] On average, readmission stays are longer and more costly than the person's initial admission.[3,4] More broadly, high 30-day readmissions are thought to reflect worse quality of care.

To reduce this burden, the Centers for Medicare & Medicaid Services (CMS) enacted the Hospital Readmission Reduction Program (HRRP) starting in October 2012 to penalize hospitals with high readmission rates for acute myocardial infarction (AMI), heart failure (HF), and pneumonia (PN).[4] Total hip/knee arthroplasty (THA/TKA), chronic obstructive pulmonary disease (COPD), and coronary artery bypass graft (CABG) surgery were subsequently included in later years.[4] The goal of the HRRP is to improve hospital performance during inpatient care, improve post-discharge outcomes, reduce short-term readmissions, and reduce unnecessary medical costs. The risk-adjusted 30-day hospital readmission rate is used to determine whether hospitals are assigned a penalty. Readmission rates are adjusted by factors known to affect readmission risks but outside the hospital's control: patient demographics, comorbidities, and patient frailty.[5]

Although many important factors that can impact health outcomes are adjusted in HRRP, one important factor not included in risk adjustment is the patient's socioeconomic status (SES). Low SES is associated with significantly higher likelihood of 30-day hospital readmission.[6–12] Including SES in the HRRP formula would essentially accept provision of lower-quality care (higher readmission risk) for low SES patients, while not controlling for SES in the HRRP means that hospitals with a high volume of poor patients may be financially disadvantaged. The argument against adjusting risk for SES was that it would ultimately be more advantageous for low-SES patients to hold hospitals responsible for providing high-quality care for all patients. In other words, by not allowing a higher rate of readmission for low-SES patients who are considered more vulnerable to worse health outcomes, providers would have an incentive to improve quality of care and to address SES-related healthcare disparities. However, concerns were raised that this strategy would not benefit low-SES patients but instead could potentially harm their access to care. Studies also suggested that hospitals with high readmission rates get a disproportionate share of patients with higher social risks (e.g., low SES levels).[1,3] Therefore, hospitals with a higher share of low-SES patients may have higher readmission rates and accordingly face a higher likelihood and level of penalties.[13] The penalties can significantly increase financial burden, harm quality improvement efforts, and even incentivize hospitals to reduce inpatient care for low-SES patients. These concerns may be particularly pressing for safety-net hospitals located in underserved areas that may have very limited resources to improve quality.[13–15] Therefore, although studies suggested that safety-net hospitals may obtain better outcomes for low-SES patients, penalties can still be problematic.[16]

To fully understand the implications of SES for examining the disparities in care usage and outcomes of post–acute care (PAC), it is important to consider the pathway of post–acute care when analyzing the relationship between SES and post-discharge outcomes. A report mandated by Congress under the IMPACT Act (with the report being developed by the Office of the Assistant Secretary for Planning and Evaluation) recognized social risk factors (e.g., SES, age, gender, and race) as important players in the process of health care that influence health outcomes. This report reviewed a series of studies examining the association between social risk factors and overall post–acute care performance and introduced that SES levels were not equally distributed between skilled nursing facilities (SNF) and home health agencies (HHA).[5] Other studies suggest that low-SES patients may be associated with PAC location after discharge.[17,18] Differences in PAC use by SES status could affect the overall association of SES with post-discharge outcomes. Therefore, more evidence on the association of various measures of SES with type of PAC use following discharge is needed.

The long-term goal of this research is to examine the factors that affect post-discharge outcomes within low-SES patient groups and to provide information for developing appropriate policies. The overall objective of this study is to examine to what extent PAC location may modify the role of SES as a contributing factor to poor post-discharge outcomes (especially readmissions) for patients. The central hypothesis is that low SES is associated with a higher likelihood of post-discharge readmissions, but the association may vary by location of post-discharge care and whether the discharging hospital is a safety-net hospital. For Medicare beneficiaries discharged from an index hospitalization, this study has the following aims:

Aim #1: To examine the association between SES level and the post–acute care location (with a focus on home with self-care, HHA, SNF, or inpatient rehabilitation facility [IRF]) after hospital discharge. The hypothesis is that patients with lower individual-level SES are more likely to use institutional facilities, but patients with lower area-level SES are less likely to use institutional facilities.[5]

Aim #2: To examine to what extend PAC location affected the association between SES and the likelihood of 30-day post–acute events (i.e., hospital readmission, hospice/death, or none of these events). The hypothesis is that patients with lower SES are more likely to have 30-day readmission, with effects varying by type of PAC location. The analysis will group hospice initiation or death prior to readmission within 30 days as censoring outcome events.

Aim 3: To examine the effect of PAC location on the association between SES and post-discharge outcomes by hospital's safety-net status. Low-SES patients (at individual- and area-level) are hypothesized to have lower probabilities of readmission or hospice/death if their index hospitalization was in a safety-net hospital compared to persons whose index hospitalization was in a non–safety-net hospital.

This observational study will use data for Medicare Fee-for-Service (FFS) beneficiaries age 65.5 years or older who participated in the Medicare Current Beneficiary Survey (MCBS) from 2006 to 2011. These findings will help inform policy makers about the differences in post-discharge outcomes based on patient SES measures according to pathway of post–acute care as well as the discharging hospital's safety-net status. The study results may contribute to the development of policies to ensure appropriate reimbursement and improve quality of care.

Background

To establish the methodological and policy background for this study, this section: 1) introduces the important policy target of reducing hospital short-term readmission rates, 2) identifies important factors related to readmissions, and 3) reviews the current definitions and measures of SES.

Short-Term Readmissions

Hospital short-term readmissions are defined as all-cause readmissions into inpatient hospital units within 30 days after hospital discharge.[5] The short-term readmission rate has been used by CMS as a measure of the quality of care a hospital provides during hospitalizations. Studies suggest that high rates of readmissions occurring within 30 days post-discharge may indicate poor quality of care in the hospital or the transitional care process and that many readmissions could be prevented.[20] The high rate of short-term readmissions may not only represent poor care but also constitutes a huge financial burden for CMS. Almost 20% of Medicare patients were readmitted to hospital within 30 days of discharge, leading to an annual cost as high as $26 billion.[1,21,22] Measuring the hospital readmissions rate and penalizing those hospitals with excessive readmission rates has become a tool used by CMS to increase incentives for hospitals to reduce readmissions.

Hospital Readmission Reduction Program (HRRP)

The Hospital Readmission Reduction Program (HRRP) was initiated by CMS in October 2012 to reduce short-term hospital readmission rates. Under HRRP, a predicted 30-day readmission rate was calculated for each hospital in the Inpatient Prospective Payment System (IPPS), and those hospitals with excessive rates were penalized by reduced Medicare payments. Only index hospitalizations with certain applicable diseases were calculated; readmissions not only to the same but other hospitals were included in the calculation. This policy has apparently reduced short-term readmission rates dramatically.[11,23]

The diseases addressed by the HRRP are under expansion by CMS; besides the diseases selected when HRRP started in 2012, total hip/knee arthroplasty (THA/TKA) and chronic obstructive pulmonary disease (COPD) were added in 2015. Coronary artery bypass graft (CABG) surgery was included starting in 2017.[4]

The program adopted the risk adjustment method developed by National Quality Form (NQF).[1] The disease-specific excess readmission ratio is calculated for each hospital as the ratio of the adjusted actual readmissions to the expected readmissions at an average quality hospital treating the same patients (FY 2012 IPPS/LTCH PPS final rule, 76 FR 51673 through 51675). CMS defines a hospital's excess readmission ratio as the hospital's readmission performance relative to the national average for the hospital's profile of patients with that applicable condition.[4] The ratio is calculated for each disease based on admissions over a three-year period (e.g., July 2009 through June 2012 for the 2014 rate). A hospital receives an excess readmission ratio for each disease calculated based on patient risk level and disease-specific risks and the payment for excess readmissions is calculated by operating payment multiplied by excess readmission ratio minus one. The aggregate payment amount of excess readmissions is added up as the hospital's excess readmission measure (Appendix I, Table A). The adjusted risk factors include patient demographics (i.e., age and gender), comorbidities and frailty. SES and race/ethnicity are not included in readmission measures in the interest of patients with high risk of these social factors. As stated by Harlan Krumholz,

> "Why did we decide not to include race or SES in the models? First, the purpose of the outcomes measures is to promote patients' interests. In addition to drawing attention to the performance of hospitals on outcomes that matter to patients, the intent is to promote improvement and equity. We considered it important to reveal differences in outcomes that may exist for disadvantaged populations on the basis of the hospitals they use. Adjustment for SES characteristics could obscure these differences and possibly create the impression that disparities do not exist."[24]

A concern raised by CMS and some researchers about the HRRP is that failing to adjust for SES may have undesired consequence. First of all, HRRP increases hospital financial burden for patients who have high medical costs.[22,25] This burden could unfairly penalize safety-net hospitals serving high populations of low-SES patients and further increase the total costs from society's perspective. On the other hand, the penalties for readmissions may not be high enough to incentivize hospitals to use observational stays. In the meantime, HRRP may reduce incentives for quality improvement for hospitals with a high share of low-SES patients and increase financial burden of those hospitals.[22,26] Low-SES patients are potentially more likely to be readmitted to the hospital, so that safety-net hospitals have accordingly higher readmission rates and therefore are disproportionally affected by HRRP.[13] According to CMS reports as well as other studies, safety-net hospitals were penalized every year for excessive hospital readmission rates and the amount of payment penalties were larger compared to non-safety-net hospitals.[13,26] This disproportionate burden could lead to bigger problems in improving quality of care for safety-net hospitals because of limited financial resources or decrease hospitals' incentives to treat low-SES patients.

Factors related to short-term readmissions

Important patient demographic factors. The Institute of Medicine (IOM) convened an expert team to evaluate the social risk factors in the Medicare payment system. Based on a broad literature review, the team found that age, gender, race/ethnicity and cultural context, and social relationship (including marital status and living alone) can influence healthcare use, the process of care, and health outcomes.[27] Most studies found that being of younger age, male, white, and having social support were negatively associated with short-term readmissions.[27] Social demographic factors along with pulmonary function levels at the time of index hospitalizations are useful predictors among Chronic Obstructive Pulmonary Disease (COPD) patients.[10]

However, some factors may have different effects for patient subgroups. For example, one study suggested that for patients discharged home, patients who were currently married had higher odds of being readmitted within 30 days than patients who were not married.[6]

Disease-related factors include comorbidities, continuity of care, number of hospitalizations in the past six months, satisfaction with care, and usual source of care. About 65% of Medicare beneficiaries have two or more chronic conditions and may be treated by multiple physicians every year.[28] Due to the fragmented system of care and poorly coordinated care, the number of different physicians patients had seen before the index hospitalization is an important factor that could contribute to patients' readmission through both the pre- and post-hospitalization period.[28] One study found that both visiting a physician regularly and having at least one hospitalization during the year before an index hospitalization were associated with higher 30-day readmissions.[6] Studies also found that disease comorbidities are important predictors of 30-day readmissions with or without social risk factors included in the prediction model, but unexplained variation remains.[29,30] The quality of care affects health outcomes as well. One study suggested that patients with primary care as their usual source of care have lower hospital readmission rates.[31] However, another study on myocardial infarction reported that having a usual source of care was not associated with differences in hospital readmission rates.[32]

Index hospitalization-related factors include surgical procedures, admission source, length of hospital stay, and care transitional plan (composed of comprehensive discharge plans and coordinated transitional care). A case analysis of four top-performing hospitals suggested that high quality of inpatient care, comprehensive discharge plans, well-coordinated transitional care, good patient/family education, and timely post-discharge follow-up all contribute to the low readmission rates in those hospitals.[33]

Hospital characteristics include teaching status, ownership, size, location (urban versus rural), safety-net status, and critical access hospital status. Studies suggest that hospitals with safety-net status had worse patient outcomes and smaller improvement of outcomes over time compared to non-safety-net hospitals.[14,26] However, these results were not adjusted for the SES status of patients served. Whitaker et al. found that safety-net hospitals had better performance on low-SES patients.[16]

Post-discharge factors include type of post-discharge care, whether the patient has a timely physician follow-up visit (e.g., within two weeks), and availability of home support services including the living situation (e.g., having adult children locally or in the home). Based on administrative data, about half (50.2%) of patients readmitted within 30 days did not have any physician follow-up visits between discharge and readmission, with higher rates for some specific diseases (e.g., 52.0% for heart failure patients).[3] Some studies suggest that having follow-up within 7 days following discharge has significantly decreased 30-day readmissions.[34–36] The IOM team identified that social support (including living with adult children) can affect care use and health outcomes.[27] One study suggested that patients discharged to SNFs had much higher readmission rates than average rates considering all discharges.[38] In total, the limited evidence suggests that types of post-acute care could be associated with patient outcomes.

Socioeconomic status (SES)

There is no uniform definition of SES across the literature. Most studies employ SES as the absolute or relative status of access to material and social resources in a stratified society to measure a person's economic and social position. SES captures the prestige- or rank-related characteristics of a person in the society, which is often measured by income, occupation, and education. Researchers are often interested in both social hierarchical status as well as resources to access services; therefore, income level is often also used instead of occupation, which is difficult to operationalize. Although prior occupation could be a relevant SES indicator for Medicare beneficiaries, economic status can decline over time after retirement. Besides economic factors and education level, other individual-specific information like insurance status (e.g., Medicaid vs. private insurance) has been used as an SES proxy and to reflect the access to health resources. Not only is the definition of SES not broadly agreed on, but the nomenclature can vary. A recent report from National Academy of Science (NAS) suggested that concepts of SES may be biased by prioritizing status over actual resources.[27] NAS employed the term of socioeconomic position (SEP) instead of SES.

Although measured in various ways, the concept of SES has been identified as a powerful tool for predicting health-related outcomes as well as hospital outcomes such as rehospitalization.[24,39] Krumholz and colleagues noted, "what is still unknown is whether this risk [of rehospitalization] is mediated entirely or in part by quality of care or other factors related to the health care system."[24] SES measured using household income is a positive predictor for hospital readmission risk for heart failure patients.[8] Furthermore, studies show that SES likely influences the type of PAC patients receive and the volume of care. Low-SES patients are more likely to be discharged to institutional facilities, including SNFs, than to be discharged home and have a lower number of care episodes during one year. [17,18]

SES measures vary over time and purpose. Variables used to reflect SES include individual income, household income, area-based income levels, property values, community property values, education level, employment status, occupations, and other factors. Medicaid insurance status is sometimes used as a proxy for SES in health outcome studies. For example, SES measured using household income level adjusted with education and other geographic characteristics was used to predict health behavior and disease mortality.[40] Being below the poverty level, having unskilled/semiskilled occupations, or living in rented homes have been used as SES factors.[9] Other researchers have used employment status and education level to divide patients into high- and low-SES groups and found the low-SES group had significantly higher hospital mortality rates.[41]

Many studies use SES indicators based on the socioeconomic characteristics of a person's geographic area or neighborhood environment. People who reside in the same area are likely to have similar income, access to health-related resources (e.g., healthy food or exercise opportunities), and healthcare services, so neighborhood SES may be predictive of health outcomes. Several studies reported that low neighborhood SES is a predictor for 30-day rehospitalization;[26,42,43] the magnitude of the effect is larger for the most disadvantaged neighborhoods.[44] Freburger and colleagues found that low SES (estimated by individual insurance type and area-based median household income) was associated with lower post-discharge rehabilitation care usage following hip fracture.[18] Neighborhood SES is also significantly associated with higher short-term all-cause readmission, an association that is consistent with individual SES measures.[8,44] Another study found, however, that combining individual SES with county-level SES does not improve the risk adjustment model for 30-day readmissions along with other important variables controlled.[45] Appendix I, Table B summarizes information about selected studies using area-based SES or mixed (individual and area) SES measures in medical/public health-related research.

Finally, safety-net hospitals tend to be more experienced with low-SES patients and may be able to achieve a lower hospital readmission rate among low-SES level patients.[16] However, they are the groups of hospitals disproportionately affected under HRRP. ASPE examined 10 safety-net hospitals in the United Sates in 2016 and reported that the hospitals were facing financial difficulties, especially those located in the Medicaid non-expansion states.[25] To better inform policy alternatives and evaluate the obstacles safety-net hospitals are facing, the association of SES with readmissions should be evaluated by hospital safety-net status.

Summary

This study aims to identify the association between SES and PAC outcomes following hospital discharge. Chapter 2 provides an overarching conceptual model for the study and descriptions of the data and statistical methods for each aim. This study achieves the research aims by analyzing the Medicare Current Beneficiary Survey merged with other data on hospital- and area-level measures. Chapter 3 assesses the associations between SES and the PAC locations. Chapter 4 examines the associations between SES and the likelihood of hospital readmission or death within 30 days, conditional on PAC location and censoring for hospice enrollment. Chapter 5 considers whether relationships estimated in Chapter 4 vary by whether the index hospitalization was at a safety-net hospital. Chapter 6 summarizes results from all aims and considers the relevance and possible implications of the results for hospital payment policy. In total, the study results provide information that may be helpful in policy analysis evaluating PAC use and outcomes and in developing policies according to different post–acute care pathways for patients following discharge. Although the period analyzed is prior to the implementation of the HRRP, the study results are likely still informative for consideration of policies to adjust hospital readmission rates by SES measures and/or hospital safety-net status. Such policies can help ensure appropriate reimbursement and improve quality of care.

CHAPTER 2. CONCEPTUAL MODEL AND METHODS

This chapter has three parts. The first describes the overarching conceptual model. The second presents the data sources, analysis sample definition including inclusion and exclusion criteria, and key measures. The third describes analysis techniques and statistical models for each aim.

Conceptual Model

The Andersen healthcare utilization model is a conceptual model built to describe the factors that affect health service use, including environment, population characteristics, and health behavior.[46] To examine the impact of SES on the type of post–acute care and hospital readmission, the model posits important factors that also contribute to these outcomes.[46,47]

Figure 2.1a lists the control variables included in the analytical model, which are rooted in the environment, individual characteristics, and health behavior components of the Andersen model. The middle panel lists the factors that are associated with care use and early hospital readmissions.[47] These factors can be divided into two groups, pre-discharge care and post-discharge care. Individual characteristics affect both pre- and post-discharge care, among which SES is the variable of interest in this study. SES is a factor that combines several individual characteristics and area-based SES, including income level, wealth, education level, and housing and employment status.[48] Control factors of the pre-discharge stage include hospital type along with index hospitalization– and disease-related factors that are influential to outcomes of pre-discharge care; other factors include environment, discharge process, patient care needs, and post-discharge care processes that are thought to be influential to outcomes of early return to hospital.

Figure 2.1b illustrates several pathways that a patient could follow after being discharged from an index hospital stay. Patients are categorized according to the discharge destination if discharged alive and the post-discharge care they receive, including home, home-health agency, SNF, or IRF or the result of death.[49] As illustrated in Figure 2.1b, Aim 1 examines the association between SES and the venue for post–acute care following discharge. Aim 2 examines the effects of PAC location on the association between SES and the likelihood of readmission to hospital or initiation of hospice or death within 30 days after discharge. Aim 3 examines the interactive effects of SES with type of post-discharge care and with hospital type (i.e., safety-net versus non-safety net hospital).

Data Sources, Study Sample, and Key Measures

Figure 2.2 illustrates the data sources and data file construction. The Medicare Current Beneficiary Survey (MCBS) was used as the main data source. The MCBS surveys Medicare beneficiaries to describe their characteristics and health information. It is a four-year rotating longitudinal panel survey with a nationally representative sample of the Medicare population. Each year, 4,000 new respondents are added and about one-fourth of the respondents are retired. The sample size is maintained to be approximately 15,000 persons every year. The MCBS has two components: access to care (ATC), which contains information on patient characteristics, access to care, satisfaction with care, and usual source of care, and cost and use (C&U), which provides a complete profile of health care usage and expenditure with linked administrative claim files. The C&U file also provides Medicare administrative claims files and inpatient hospital claims for Medicare Advantage plans. The years 1992 to 2011 were available at the start of the study. Given the available data, we focus on the period of pre-HRRP, which is before 2012.

The MCBS was ultimately selected for this study because it was considered to have the most features that were required for the study. Two other person-level data sources were considered as candidate data sets: the Health and Retirement Study (HRS) linked with Medicare claims data, and the Healthcare Cost and Utilization Project (HCUP). Table 2.1 provides a comparison of variables from the three person-level data sources that were considered. The HRS linked with Medicare (HRS/CMS) data was considered as a candidate dataset because it includes all the measures important for this study and follows individuals longer than the MCBS, however the sample size is estimated to be 19,692 persons, which is smaller than MCBS. The National Readmission Database created by the Healthcare Cost and Utilization Project (NRD-HCUP) can be used to analyze hospital readmissions. The dataset has a sample size of 35,580,348 discharges for 2013. However, the dataset is based on claims only and therefore is missing many variables critical for this study (e.g., individual SES measures and the claims necessary to construct the post-discharge care location variables).

Variables at three additional levels were merged from other sources with the MCBS records. For an *area-based SES index*, the Area Deprivation Index was used (HIPxChange, Health Innovation Program, University of Wisconsin, 2014). For variables of hospital characteristics, the Provider of Service (POS) file from CMS was used because it provides information on location, ownership, and hospital type. The Medicare hospital annual file for DSH adjustment, "DSH Adjustment and (Year) File," was used to measure hospital safety-net status.[50]

For information on area health resources, the Area Health Resources Files (AHRF) from the Health Resources and Services Administration was used at the county level. The AHRF provided data on county-level medical care professions, health facilities, and hospitals.

ASPE raised a very important issue in the report to Congress about whether the current data are sufficient to measure SES.[5] This study examined this issue by using analyses to indicate that whether adding a focus on comparing models estimated with a full set of variables versus claims-only variables. Therefore, this study examined models controlling for variables that were from claims data only versus models that added hospital measures, area health resources, and survey information from MCBS.

Study Sample

Overview of index hospitalizations

This observational study used data for Medicare Fee-for-Service (FFS) beneficiaries age 65.5 years or older at the time of index hospitalization and participated in the MCBS from 2006 to 2011. Index hospitalizations were identified as live hospital discharges for FFS beneficiaries who met additional inclusion criteria, primarily: 1) discharge to one of four types of post-discharge care (home with self-care or home with HHA, SNF, or IRF); and 2) continuous FFS enrollment during the six-month period prior to and three months after the index stay. To allow patients have six continous months of enrollment, the study inclusion age was defined as 65.5 and older. Figure 2.3 shows the implementation of the sample inclusion and exclusion criteria.

Because hospital claims are often not submitted for Medicare Advantage enrollees and PAC claims are not available for Medicare Advantage enrollees, the pre-hospitalization time period of six months was used to control for case-mix severity by constructing the Charlson index based on claims. Patients needed to be FFS for at least one month after hospital discharge to determine PAC use based on claims. The requirement of three months was more stringent than was needed to reserve some analysis flexibility for examining longer time period after discharge and also for analyzing whether physician claims for nursing home placement were filed during this period.

This study used all hospitalization and did not limit the index hospitalizations to the six primary diagnoses (PN, AMI, HF, COPD, THA/TKA, and CABG) that are included in HRRP. The main reason for considering all-cause hospitalizations as index hospitalizations was to achieve a larger sample size. Assessment of all-cause hospitalizations also expanded the study's generalizability by examining the full spectrum of diseases and thereby providing a full picture of post–acute care use and outcomes. The disease distributions (based on International Classification of Disease (ICD)-9 diagnoses as well as HRRP disease groups) did not differ significantly between safety-net hospitals vs. non–safety-net hospitals nor between PAC locations. (Appendix II, Memo 1) The time frame for this study is January 2006 to December 2011, which encompasses the period after Medicare Part D went into effect and before HRRP was launched. Because the HRRP was implemented as part of the Affordable Care Act, efforts to reduce readmissions may have been implemented prior to October 2012. This study time frame was defined after Part D started to represent the experience under the current Medicare benefit structure in a relatively recent time period. This study was limited to the period before HRRP started largely because the MCBS data availability when the study started, and to avoid the possible initial effects of HRRP. Future studies should address whether the HRRP changed the estimated relationships.

Post–acute care location

The major types of PAC locations reimbursed by Medicare are HHA, SNF, IRF, and long-term care hospitals (LTCH). Two sources were considered to identify PAC type. The first source was the MedPAR hospital record, which indicates the expected PAC locations reported by hospitals when patients were discharged. The second source was actual PAC claims based on the first PAC service use date within 30 days of hospital discharge. Inconsistencies were found for about 20% of comparisons between these two sources (Table 2.2). For example, among the 2,509 expected HHA cases, only 1,799 were found to have used HHA services through claims while 710 didn't use any type of PAC services. The discrepancy level was highest (29.6%) for HHA among all PAC locations. With all these discrepancies, the information from claims data was considered to be more reliable because the PAC claims represent actual PAC use paid for by Medicare compared to the discharge destination reported on the hospital reported claim, which might simply represent the expected or recommended discharge location or PAC use.

Physician claims were also assessed to determine if the patient appeared to be discharged to a non-skilled long-term care setting; the number of nursing home discharges (i.e., not to a SNF, IRF, or LTCH) was too small to enable analysis of the group (12 discharges in Table 2.2). Index hospitalizations reported by hospitals as discharged to hospice or LTCH were excluded because their likely prognosis (hospice discharge) or outcomes (LTCH discharges) differed substantially from for other PAC types. For patients not indicated as discharged to hospice by the hospital record, hospice claims were used to confirm hospice use for patients after hospital discharge, which was used as a post-discharge outcome in this study.

To define sample sizes, we examined the PAC locations and found that LTCH and ICF had to be excluded from this study. Figure 2.4 shows that patients reported by hospitals to be discharged to hospice or LTCH had much worse outcomes. Also, a large proportion of expected ICF cases (196/298) could not be identified based on Medicare physician claims within the 30-day post-discharge period. ICF services may be better reported by Medicaid rather than Medicare.[51] Therefore, LTCH and ICF cases were not included in this study.

PAC locations ultimately selected for analysis of Aim 1 included four types: home, home with care from HHA, SNF, and IRF. For Aim 2 and 3, 451 IRF cases were excluded because they had no hospital readmissions during the 30-day period and very low hospice/death rates (1.8%) (Figure 2.5), which suggested that IRF received patients with much lower case-mix severity than other PAC locations. Also, none of the IRF users had readmission during the 30-day post-discharge period, which creates difficulty in the propensity score weighing process. Therefore, IRF cases were excluded in post-discharge outcome analysis in Aims 2 and 3, but Aim 1 included IRF cases to examine PAC use.

Dependent variables

The four PAC locations were used as the dependent variable for Aim 1. PAC location served as a key explanatory variable in Aim 2 and Aim 3. Because PAC location is chosen jointly by the providers, patient, and family, propensity score methods (discussed later in this chapter) were used to try to adjust for selection bias from PAC locations.

Thirty-day post-discharge outcomes were defined as 1) readmissions, 2) initiating hospice or death, or 3) none of these events. Like PAC location, these outcomes were identified from the MCBS claims files. Readmissions were identified using short-term inpatient hospital claims, "Hospice" was from hospice claims files, and "death" was from date of death of the survey files. The outcome was defined as the first event that happened to the patient within 30 days of discharge from the index hospitalization. If no claims were found indicating one of these events within 30 days post-discharge, the patient was considered as having "no adverse event."

Key Explanatory Variables

SES measures

<u>SES</u> included individual-level status and area-level status variables. Individual-level SES measures reflect the resources that patients possess. Area-level SES reflects the resources

available in the patients' communities. These different constructs may have different associations with care choices (e.g., ability to be cared for at home) as well as outcomes such as readmission. Therefore, by including both dimensions, this study contributes by providing information at both levels.

Four factors are commonly considered important for measuring individual SES: income, dual eligibility, education level, and employment.[5] Among Medicare beneficiaries age 65.5 years and older, many are already retired when they participate in the MCBS. Therefore, employment status was not included as a covariate in this study. For measuring individual SES, *income, dual eligibility,* and *education* were included as separate dichotomous measures in all regressions.

A continuous measure of income was not possible because in the MCBS, income information was provided as either as a nine-category measure (which had substantial missing values) or a dichotomous measure with a cut-off value of $25,000. The median per capita income among Medicare beneficiaries was $26,200 in 2016 and this level was stable over years.[52] This study therefore defined individual annual income equal to or more than $25,000 as high income and income less than $25,000 as low income. Medicare and Medicaid dual eligible status included full Medicaid benefits, partial Medicaid benefit, or Qualified Medicare Beneficiaries–only (QMB) benefits. Low education level was defined as having less than a high school degree.

Area-level SES was measured using the area deprivation index (ADI), developed by Gopal Singh using 17 different markers of SES factors based on zip code in the 1990 U.S. Census data[53] and later updated using the 2000 U.S. Census data. The ADI is a composite value, constructed from a function of education, occupation, family income, property and mortgage, unemployment, poverty level, housing, and vehicle.[53] A higher ADI value indicated a more deprived area, which was a lower SES level. ADI has ready-to-use values, which allows us to assign each sample member a value using their zip codes or census block groups. The ADI makes individual SES more consistent and makes the research results more comparable with other studies. However, the most recent ADI is based on census data from 2000, and the ADI values might have changed a lot over the past decade. Kind and colleagues found that residence in the 15% most deprived ADI areas was a risk for higher hospital readmissions; the value for 15% highest ADI was 113.48.[24,44] We therefore used this threshold for creating a dichotomous ADI measure. Areas with index values of more than 113.48 were defined as deprived ADI areas (low SES status), and values equal to or less than 113.48 were defined as not-deprived ADI areas (high SES status).

Hospital safety-net status

Safety-net status indicates whether a hospital provided health services to a high proportion of low-SES (e.g., low-income, uninsured, Medicaid, etc.) patients during a year. Typical definitions of safety-net status for hospitals use information on uncompensated care and/or a hospital's care for the indigent population.[15,54] The hospital's disproportionate-share hospital (DSH) patient percent ratio, shown in the equation below, was used as a proxy for safety-net hospitals by CMS in the analysis of hospital readmission rates.[25]

$$DSH\ Patient\ Percent\ (\%) = \underbrace{\frac{Medicare\ SSI\ Days}{Total\ Medicare\ Days}}_{\text{(The Medicare Part)}} + \underbrace{\frac{Medicaid\ NonMedicare\ Days}{Total\ NonMedicare\ Days}}_{\text{(The non-Medicare Part)}}$$

The first part of this formula pertains to hospital stays covered by Medicare, and the second part pertains to hospital stays covered by Medicaid. The actual DSH adjustment status, which is made for a majority of hospitals, is defined by 1) a high proportion of DSH patient percent days under various circumstances (e.g., 15% for hospitals in urban area with 100 or more beds or in rural area with 500 or more beds), or 2) a high proportion of government payments for indigent patients (42 CFR 412.106).

Recently, CMS proposed to adjust the HRRP penalty process with hospital stratifications based on the quintiles of proportion of Medicare patients that are dual eligible (82 FR 19956 through 19985, April 28, 2017). The measure for this proposed rule is highly reflected in the first component of the DSH patient percent formula (the Medicare component). An ASPE report showed the distribution of this measure for 2013 and noted that the hospital-level DSH patient percent measure is highly correlated. Sheingold and colleagues reported substantial overlap in hospitals classified as safety-net using either of these measures.[55]

Therefore, a continuous measure of the percent of total Medicare patient days that are accounted for by SSI (i.e., the first component in the two-component DSH patient percent formula) was used as a hospital-level measure of low SES (or, essentially, having a high proportion of duals among the Medicare patients). The measure was available from annual hospital data files aggregated from MedPAR data by CMS for the purpose of calculating DSH adjustment, which are publicly available on the CMS Web site.[50] The typical proportion of low-SES stays to define safety-net hospital was 20%–25%, and Sheingold and colleagues reported that "the analytic results did not vary significantly based on whether the top 20 percent or top 25 percent was chosen to classify the hospitals."[25] In this study, the top 20% of hospitals ranked by the SSI ratio each year was used as the main measure of safety-net status, which allowed for some variation over time in the status of hospitals.

Other Control Variables

The important control variables include patient demographics, disease-related factors, index hospitalization–related factors, hospital characteristics, and area health resources. Among the disease-related factors, the Charlson index was employed as a measure of case-mix severity.[56,57] The ICD-9CM codes were used to construct the Charlson index score. The variable of *self-management skills* was measured according to questions relevant to activities of daily living. The variable of *general satisfaction to care* measures how satisfied one patient was during the year of survey. According to Barnett et al., there are 10 questions related to satisfaction in MCBS.[58] The full set of additional control variables are described in more detail in Chapters 3–5.

Living with children indicates whether the patient lived with adult children. In the MCBS, this variable may have been reported before or after the index hospitalization. The analysis assumes that if a patient has adult children living with him/her, they will likely be available to take care of the patient at home.

The Charlson comorbidity index is employed as a disease severity proxy using scores from values 0 to 9.[56] High disease severity (as measured by the Charlson index) is associated with early hospital readmissions,[7,10] but the Charlson index is a rough measure that is not able to capture many aspects of case-mix severity that may be associated with poor outcomes (e.g., uncontrolled disease).

Analytic Approach by Aim

Overview of Estimation Issues

This section provides an overview of the estimation approach used in each aim. We first consider several issues relevant to all estimations.

The implications of the survey cross-sectional weights, which are provided by MCBS to reflect the overall selection probability of age, gender, race, region, and metropolitan area status were explored.[59] The results from models with and without these weights were compared and similar results were found (Appendix I, Table C). Furthermore, no methodology was found to support using both multiple imputation and survey weights in the same model. With age, gender, region, and urban/metro status all controlled in the sample, adjustments to the regression models for the MCBS complex survey design did not seem necessary.

Several of the variables had missing values; multiple imputation by chained equation (n=20) was used to address this problem. In addition, several strategies were used to examine the sensitivity of the estimates to alternative specifications. In Aim 1, models used alternative sources for the explanatory variables: claims, hospital files, AHRF, or MCBC ATC. Initially, bivariate regression models of each of the four SES measures were used, and then sets of covariates were added in the following order: claims data, hospital status, area health resources, and MCBS survey information. This approach was used because the variables in claims data group (e.g., dual eligibility and ADI) are easily available while survey information costs more and takes time to collect. It is important to know whether claims data captured sufficient important information for outcome evaluation, so that the cost in collecting survey information could be avoided.

In Aims 2 and 3, variables from all four data sources were used to examine the associations of SES measures with post-discharge outcomes. Results between the models (regression coefficients as well as predicted probabilities) with and without PAC location adjusted were compared to assess how PAC location affected the associations.

Aim #1: To examine the association between SES and the post–acute care location after hospital discharge.

Hypothesis. Compared to persons with high SES, people with lower SES have different post-discharge sites of care (e.g., discharge to home with self-care, home with HHA, SNF, or IRF). According to Freburger and colleagues, low-SES patients were less likely to use IRF and SNF compared to higher SES patients, although the explanatory effect was modest.[60] SES at the individual- and area-level may give opposite effects. Individual low SES level is more likely to associated with institutionalize PAC location use (e.g., SNF, IRF), and area low SES level could lead to less institutionalized PAC location use if areas with lower SES have fewer post–acute care facilities available.[61]

Research Design. The dependent variable is a categorical measure of the patient's first site of post-discharge care (i.e., home, HHA, SNF, or IRF). The key explanatory variables are the SES measures. The model for Aim 1 is estimated using multinomial logistic regression represented with the following general equation:

$$prob\left(Y_{ij} = \mathrm{j}\right) = \frac{\mathrm{e}^{\mathrm{X}_i \beta_j}}{1 + \sum_{k=2}^{J} \mathrm{e}^{\mathrm{X}_i \beta_k}} \quad (1.1)$$

where j indicates the PAC location, and β_1 is indexed to 0.

$$\mathrm{X}\beta_j = X^{SES}\beta_j^{SES} + X^{PATCHARS}\beta_j^{PATCHARS} + X^{INDXCHARS}\beta_j^{INDXCHARS} + X^{HSPTLCHARS}\beta_j^{HSPTLCHARS} + X^{AHRF}\beta_j^{AHRF} \quad (1.2)$$

where the superscripts on the X and β terms denote specific subsets of the covariates—the SES index, patient characteristics (e.g., sex, race, age), index hospital stay–related characteristics (e.g., stay length, DRG weights, Charlson index), hospital-level factors (e.g., teaching status, total bed size, DSH status), area health resources (e.g., area total number of physicians, total number of nurse practitioners, total number of short-term care hospitals/SNFs/LTCHs), and PAC locations.

Aim #2: To examine the change in associations between SES and the outcomes of pos–-acute care (i.e,. no event, readmission, or hospice/death) within 30 days after discharge with and without adjusting for type of PAC.

Hypotheses. Overall, low-SES patients are more likely to have hospital readmissions and/or hospice/deaths within 30 days post-discharge than high-SES patients. However, the effect of SES varies with and without adjustment for PAC location. We hypothesized that controlling for PAC locations will decrease the effect of SES measures.

Research Design. The dependent variable is the first event patient experienced within 30 days (readmission or hospice/death). As noted earlier, IRF cases are excluded from Aim 2 because none of the 451 patients discharged to IRF were readmitted to the hospital within 30 days post-discharge (Figure 2.5), which created problems in the propensity score weighting process and makes a minimum benefit to estimate the multinomial logit model for three outcomes. The key independent variables are the SES measures. The model is also estimated using multinomial logistic regression (see Equation 1.1) where *j* indicates the outcome (i.e., readmission, hospice/death, or neither of the events):

$$\mathrm{X}\beta_j = X^{SES}\beta_j^{SES} + X^{PATCHARS}\beta_j^{PATCHARS} + X^{INDXCHARS}\beta_j^{INDXCHARS} +$$

$$X^{HSPTLCHARS}\beta_j^{HSPTLCHARS} + X^{AHRF}\beta_j^{AHRF} + X^{PAC}\beta_j^{PAC} \quad (2.1)$$

In addition to the SES index and the four categories of variables for Aim 1, $X\beta$ also includes the PAC location. Sequential regressions are explored by adding sets of variables to examine how adding key sets of measures such as PAC location affects the association of SES measures with outcomes.

A propensity score weighting approach was used to address possible selection of PAC location based on observed aspects of patient case-mix severity. First, a propensity score for each PAC location (i.e., home, HHA, SNF) was calculated from likelihood of being discharged to these locations using a multinomial logistic model. The same methodology in Aim 1 was employed for calculating the likelihoods but with IRF users dropped. Second, the inverse probability weights were calculated from propensity score using the algorithm of:

$$IPW=1/\hat{p}_i \text{ if } dschr==i \quad (2.2)$$

Where i indexes PAC locations; IPW, inverse probability weights; $\hat{p}$, propensity score.

The descriptive results of propensity scores and the IPW values for each PAC location were listed in Appendix I Tables E-F. This method was used for both Aim 2 and Aim 3.

Power calculation. Kind et al. reported that among Medicare beneficiaries discharged with primary diagnosis of HF, AMI, and PN, the percentage of patients readmitted within 30 days was 21%; among the most disadvantaged SES patients, the percentage was 24%.[44] Stata *powerlog* was used for a power analysis that indicates that with $\alpha = 0.05,\ power = 0.8$, the required sample size is at least 3,401 index hospital admissions.

Aim #3: To examine the association between SES and the post-discharge outcomes by hospital safety-net status.

Hypothesis. Low-SES patients have lower probabilities of readmission or hospice/death if their index hospitalization was in a safety-net hospital compared to persons whose index hospitalization was in a non–safety-net hospital. This hypothesis was based on the study results that low-SES patients received better outcomes in safety-net hospital after colorectal cancer surgery.[16]

Research Design. The sample for this analysis and the dependent variable was the same as Aim 2. The key explanatory variable was the SES measures. Multinomial logistic regression was used, similar to the equation for Aim 1 (Equation 1.1). However, for Aim 3, the index *j* indicates the post-discharge outcome (i.e., readmission, hospice/death, or neither of the events).

The $X\beta$ includes the same variable sets as Aim 2 except that the dichotomous safety-net indicator is added both to the equation predicting type of PAC as well as the outcome equation. Also, we include the interaction terms of SES measures and PAC locations with safety-net status.

$$X\beta_j = X^{SES}\beta_j^{SES} + X^{PATCHARS}\beta_j^{PATCHARS} + X^{INDXCHARS}\beta_j^{INDXCHARS} + X^{HSPTLCHARS}\beta_j^{HSPTLCHARS} + X^{AHRF}\beta_j^{AHRF} + X^{SFTNT}\beta_j^{SFTNT} + X^{SFTNT\times PAC}\beta_j^{SFTNT\times PAC} + X^{SFTNT\times SES}\beta_j^{SFTNT\times SES} \quad (3.1)$$

As described in Aim 2, the outcomes model for Aim 3 will also be estimated using propensity score weights similar with the Aim 1 estimation but without IRF users.

Summary

This study uses MCBS data from 2006 to 2011, along with other data sets to control for hospital-level and area-level variables. SES was measured at the individual level (using dual eligibility, income, and educational level) and area level (using the ADI). Three 30-day outcomes were defined: hospital readmission, hospice/death, or neither (no event). PAC locations based on Medicare claims included home health agency assistance, skilled nursing facility, or home with neither service. Multinomial logistic regressions of outcomes were used in all aims. Aim 1 examined association between SES and PAC location use, with the change in the associations examined using sequential models. Aim 2 examined the associations between SES and post-discharge outcomes with and without PAC locations adjusted. Aim 3 examined the associations between SES and PAC locations between safety-net and non–safety-net hospitals. For both Aims 2 and 3, inverse probability weights from a multinomial logistic model of the likelihood of using different PAC pathways were used to address selection of PAC location based on observed aspects of patient case-mix severity.

Figure 2.1a. Andersen Model Adapted for Assessing Pathways after Hospital Discharges [a,b]

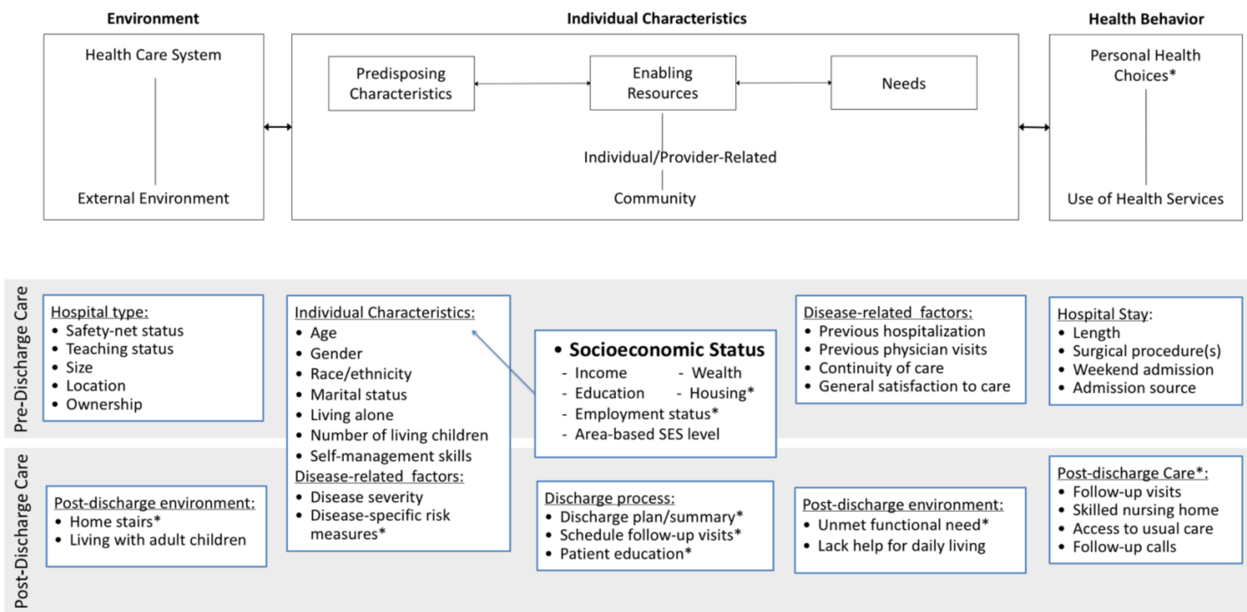
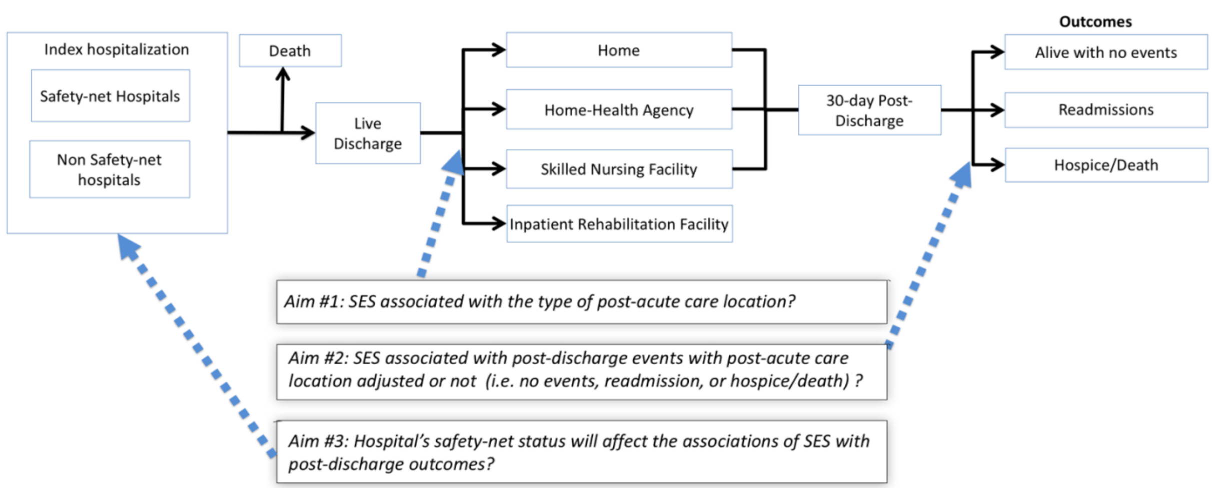


Figure 2.1b. 30-Day Hospital Post-Discharge Outcomes



* Factors/components that are unobservable or not included in this study.

a. Andersen, Ronald M. "Revisiting the behavioral model and access to medical care: does it matter?" *Journal of health and social behavior* (1995): 1-10.

b. Arbaje, Alicia I., et al. "Postdischarge environmental and socioeconomic factors and the likelihood of early hospital readmission among community-dwelling Medicare beneficiaries." *The Gerontologist* 48.4 (2008): 495-504.

Figure 2.1. Pathways of hospital discharge and factors impacting hospital post-discharge outcomes.

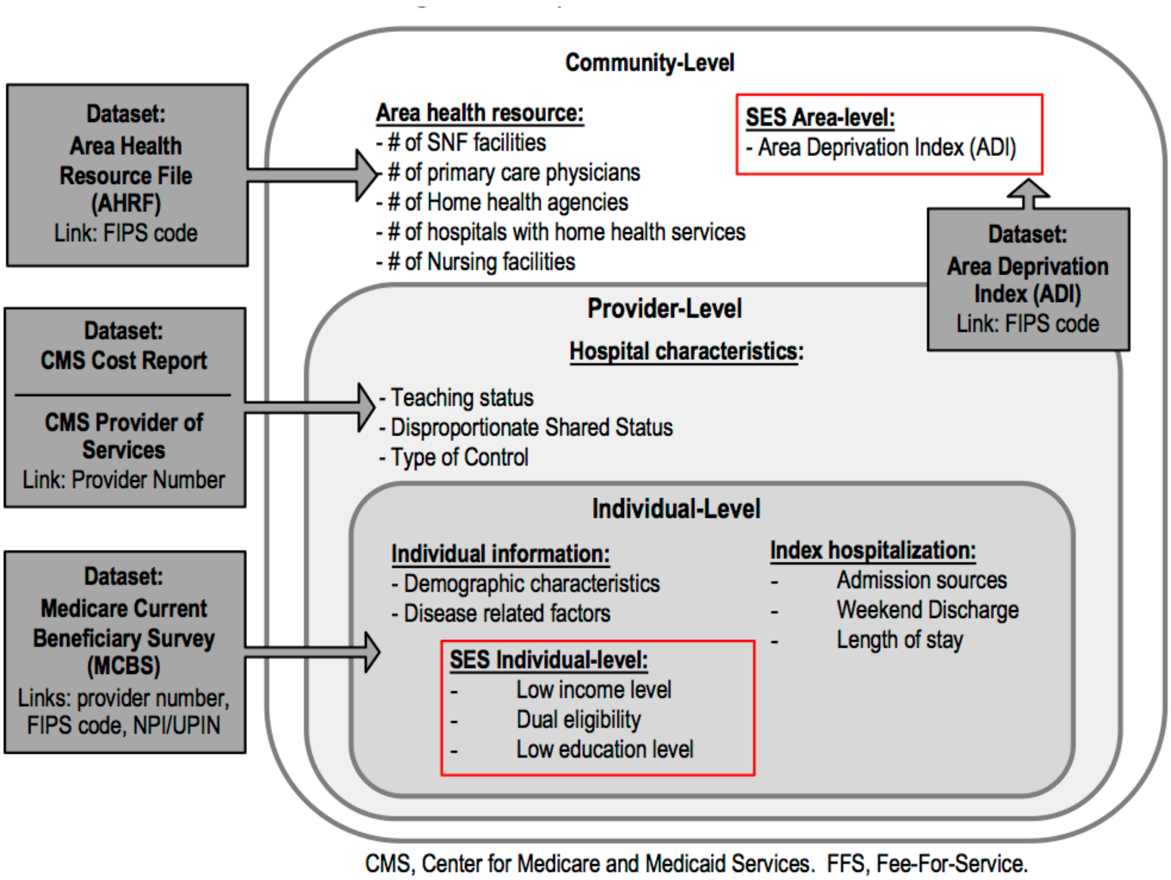


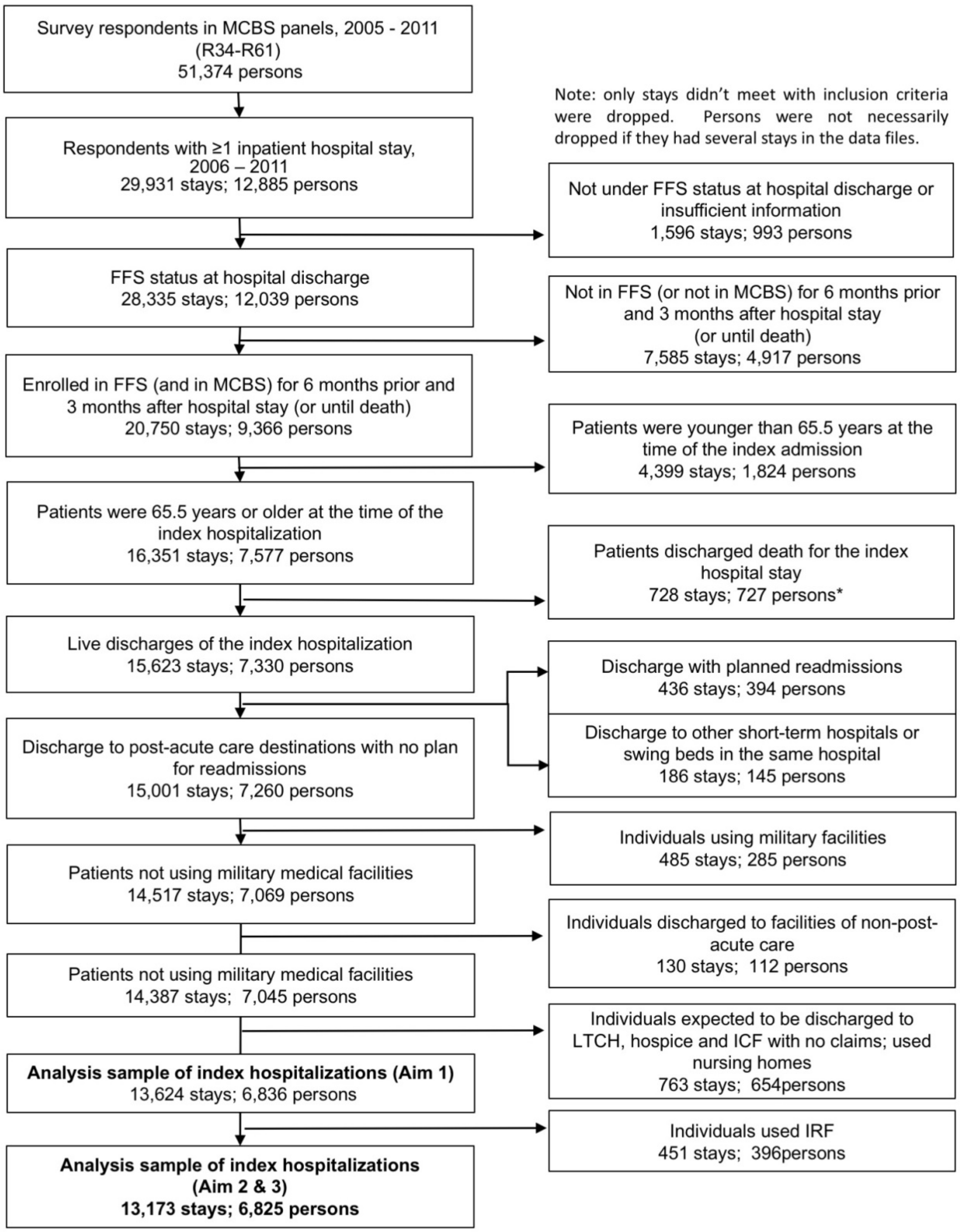
Figure 2.2. Analysis factors and data construction.

Table 2.1. Key Variables and Data Sets

Variable Names	Variable Labels	Property	MCBS	HRS/ CMS	NRD- HCUP
Hospital early readmission	1= patient readmitted to hospital within 30 days of post-discharge	Binary	Yes	Yes	Yes
Hospice admission	1= patient was admitted into hospice	Binary	Yes	Yes[Δ]	No
Return to the same hospital	1= same hospital as the index hospitalization	Binary	Yes	Yes[Δ]	No
Early death	1= death within 30-day of post-discharge	Binary	Yes	Yes	Yes
Year/Month	The time when patients returned to hospital	Categorical	Yes	Yes	Yes
SES measures					
Income level	Ordered value based on income level (in $ 5,000 increments)	Ordered	Yes	Yes	Yes
Education level	Highest grades one completed (no diploma, high school diploma, associate degree, bachelor's, post graduate degree) [a]	Categorical	Yes	Yes	No
Area-based SES index	SES level of the area where the patient resided	Numeric	Yes	Yes[Δ]	Yes
Patient demographics					
Age	Years of age[a]	Numeric	Yes	Yes	Yes
Sex	Biological sex[a]	Dichotomous	Yes	Yes	Yes
Race/ethnicity	Asian, African American, White, American Indian or Alaska Native, Other race, More than one	Categorical	Yes	Yes	Yes
Marital status	The patient was married or not[a]	Categorical	Yes	Yes	No
Living alone	The patient was living alone or not[a]	Binary	Yes	Yes	No
Self-management skills	General ability level to manage one's daily function[a]	Ordered	Yes	Yes	No
Number of living children	Number of living adult children both lived together and apart[a]	Numeric	Yes	Yes	No
Patient disease-related factors					
General satisfaction to care	General satisfaction level to health care service the patient received[a]	Ordered	Yes	Yes	No
Diagnoses	Diagnoses one patient had during the index hospitalization	Categorical	Yes	Yes[Δ]	Yes
Charlson index score	Disease severity measure during the index hospitalization	Numeric	-	-	-
Continuity of care index	Care continuity and concentration over one year before index hospitalization.	Numeric (0-1)	Yes	Yes[Δ]	No
Usual source of care	The usual type of care patient saw[a]	Binary	Yes	Yes	No

Index hospitalization-related factors					
Surgical procedures	Surgical procedures one received during the index hospitalization	Categorical	Yes	Yes[Δ]	Yes
Weekend admission	The patient was admitted during weekend	Binary	Yes	Yes[Δ]	Yes
Admission sources	Types of facilities or home the patient was admitted from	Categorical	Yes	Yes[Δ]	Yes
Hospital stay length	Days the patient stayed in inpatient unit	Numeric	Yes	Yes[Δ]	Yes
Hospital Characteristics					
Safety-net status	Safety-net hospital or not	Binary	-	-	Yes
Teaching status	Teaching hospital or not	Binary	-	-	-
Home health service	Whether the hospital has a home health service	Binary	-	-	-
Size	Hospital size by bed	Numeric	-	-	-
Location	Rural or urban	Dichotomous	Yes[+]	Yes[+]	Yes[+]
Ownership	State/local health department, Non-profit, for-profit	Categorical	-	-	-
Critical access status	Critical access status	Binary	-	-	-
Post-discharge environment factors					
Type of post-discharge Care	Location where patient receives post-discharge care	Categorical	Yes	Yes[Δ]	No
Early physician visits	Have first follow-up physician visit within 14-days of post-discharge	Binary	Yes	Yes[Δ]	No
Living with children	Patient lived with adult children or not (home discharge only)[a]	Binary	Yes	Yes	No
Area health resources factors					
Supply of hospitals and facilities	Ratio of facility beds to population within a county	Numeric	Yes[++]	Yes[++]	No
Supply of LTC beds	Ratio of LTC beds to population aged 65+ within a county	Numeric	Yes[++]	Yes[++]	No
Supply of home health	Number of home health agencies within a county	Numeric	Yes[++]	Yes[++]	No

Δ Data from linked Medicare
a, at the year of index hospitalization
+, data from hospital profile data
++, data from Area Health Resources File



* Two claims filed for "death" discharges within the same hospital and for the same patients on two different days 3 days apart. The payment amount was different and the Diagnosis codes are slightly different. The patients died during the month of discharge.

Figure 2.3. Flow of target study sample selection.

Table 2.2. Differences in PAC Locations Between Hospital Reported and Identified by PAC Services Use Claims

PAC Locations (Hospital Reported)	First PAC Location within 30 days of hospital discharge						Total		Discrepancy
	Home	HHA	SNF	IRF	NH	Other *		Hospice +	
Home/self-care	**6,191**	579	78	3	3	-	6,854	57	9.67%
HHA	710	1,799	44	3	-	-	2,556	31	29.62%
SNF	442	34	3,121	17	8	-	3,622	128	13.83%
IRF	20	5	49	428	-	-	502	1	14.74%
ICF	-	13	88	-	1	196	298	22	-
LTCH	-	-	13	-	-	126	139	22	-
Hospice+	396	7	12	1	-	-	416	118	71.6%
Total	7,363	2,437	3,405	452	12	718	14,387	379	average: 27.90%

*No claims were available for these PAC locations but patients were very unlikely to be discharged home.
+Hospice and other pathways were not mutually exclusive.

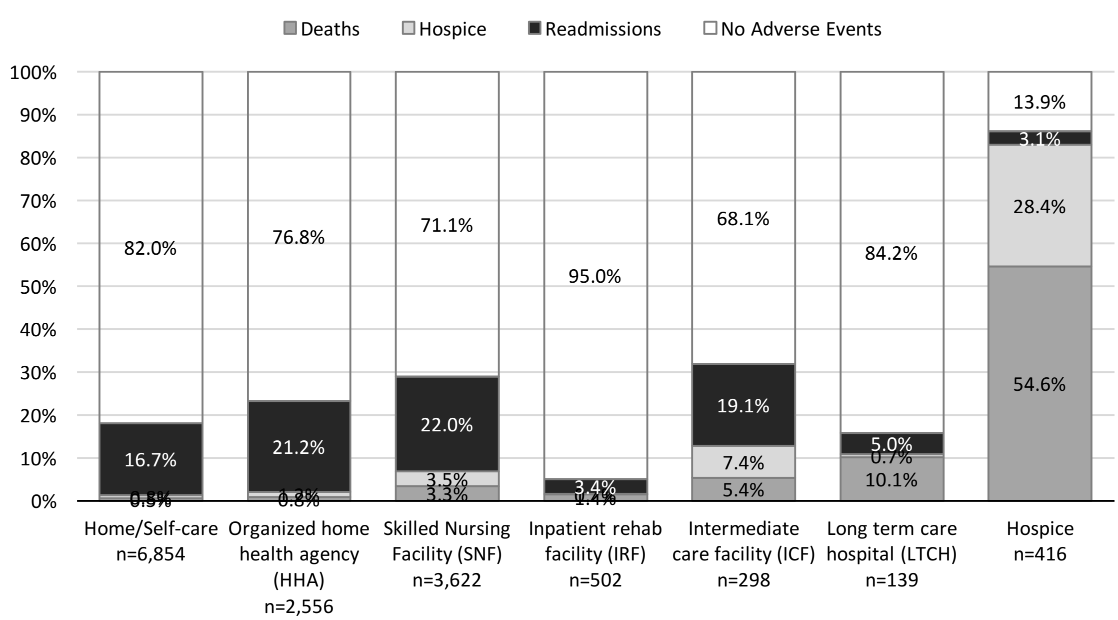


Figure 2.4. Percentage of post-discharge events by type of post–acute care.

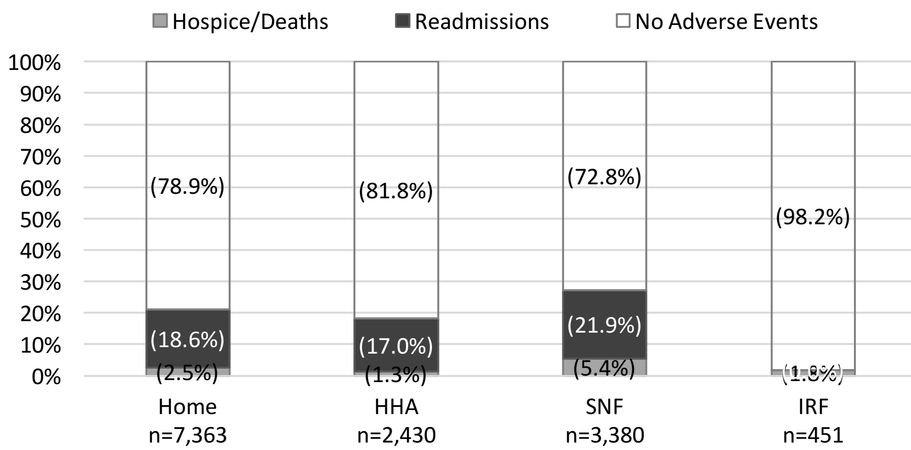


Figure 2.5. Percentage of post–acute events by post–acute care.

CHAPTER 3. THE ASSOCIATIONS BETWEEN SOCIOECONOMIC STATUS AND POST–ACUTE CARE LOCATIONS

Introduction

Post–acute care (PAC) spending has been identified as one of the highest and most rapidly increasing cost for Medicare. In 2012, the Medicare program spent more than $62 billion for post–acute services provided by home health agencies (HHA), skilled nursing facilities (SNF), inpatient rehabilitation hospitals (IRF), and long-term care hospitals (LTCH).[62] Post–acute care spending grew by 5% to 9% per year between 1994 and 2009, which was faster than most other categories and drove the largest geographic variation in Medicare's expenditures for providers.[63,64] PAC is considered to be a new healthcare reform frontier for controlling Medicare spending.[62]

Despite the high spending, the factors associated with the type of PAC used are not well understood. Studies suggested that Medicare and Medicaid dual-enrollment was associated with more use of SNF.[5] Others found that having low income was associated with less use of HHA, IRF, and LTCH;[17,60] studies of specific conditions such as hip fracture have also found that low socioeconomic status (SES) was associated with lower volume of care, lower odds of using institutional care compared to home/self-care, and lower post-discharge IRF use compared to SNF.[18] Lower SES was also associated with worse post-discharge outcomes including higher likelihood of 30-day hospital readmission.[6,7] Other factors including minority race, rurality, and presence of disabilities were associated with poorer outcomes of post–acute care.[67] However, the current literature lacks a more comprehensive assessment of the relative value of individual measures of SES easily available from claims (such as dual status) versus other measures that could only be obtained by undertaking additional data collection efforts (such as education or income).

Recent legislation has increased the significance of SES. The Improving Medicare Post-Acute Care Transformation (IMPACT) Act of 2014 was implemented to enable, among other things, a broader assessment of the role of SES in affecting providers' ability to achieve good outcomes and fair reimbursement. A report mandated on the IMPACT Act from the Assistant Secretary for Planning and Evaluation recognized social risk factors as important players in the process of health care that influences health outcomes. This report introduced that social risk factors levels were different between SES and HHA.[5] More evidence on the association of various measures of SES with type of post–acute care use is needed, however, to fully understand the implications of SES for examining the disparities in PAC usage and post-discharge outcomes.

One of the most important challenges in studying the PAC use is to control sufficiently for differences in patient case-mix severity that may affect the type of PAC used. Different PAC types may specialize in patients with different natures of disease. For example, IRFs may accept patients with high need for rehabilitation services while many SNFs may treat a wider range of patients with complex nursing needs and multiple chronic conditions as well as patients requiring rehabilitation. Besides the case-mix severity, social resources at the individual and community levels could influence PAC type as well. Therefore, this study will control for observed patient, hospital, and area characteristics in assessing if low SES measures are associated with the type of PAC used (e.g., SNF) following hospital discharge.

Methods

This observational study used data for Medicare Fee-for-Service (FFS) beneficiaries age 65.5 years or older who participated in the Medicare Current Beneficiary Survey (MCBS) from

2006 to 2011. Index hospitalizations were identified as live hospital discharges for FFS beneficiaries who met the following inclusion criteria: 1) discharge to one of four types of post-discharge care (home with self-care, home with HHA, SNF, or IRF), and 2) continuous FFS enrollment during the six-month period prior to and three months after the index stay. To allow patients have six continous months of enrollment, the study inclusion age was defined as 65.5 and older.

The key explanatory variables were SES measured at the individual level (using dichotomous measures of low income, low education, and Medicare & Medicaid dual eligibility) and at the area level using the Area Deprivation Index (ADI) measured at the Federal Information Processing Standard (FIPS) State & County Code level.[53] Both of the dimensions were important to include in the model because they reflect different types of resources. Dual eligible status included full Medicaid benefits, partial Medicaid benefits, or Qualified Medicare Beneficiaries–only (QMB) benefits. The median per capita income among Medicare beneficiaries was $26,200 in 2016 and this level was stable over years.[52] Therefore, in this study, low income was defined as individual annual income less than $25,000. Low education was defined as less than a high school degree. Based on work by other researchers, highly deprived areas (low SES) were defined as having an ADI value of more than 113.48.[24,44] The analysis controlled for patient demographics, disease-related factors, hospital characteristics, and area characteristics using multiple data sets (Figure 2.1 in Chapter 2). Hospital characteristics were identified from Medicare Cost Reports and Provider of Service files from the Centers for Medicare & Medicaid Services, linked by provider numbers. Area health resources were captured using the Area Health Resource File (AHRF) linked by FIPS Code.[68]

PAC type was identified by Medicare PAC claims (HHA, SNF, or IRF) within 30 days of hospital discharge. Physician claims were also assessed to determine if the patient appeared to be discharged to a non-skilled long-term care (LTC) setting. Hospice claims were used to confirm hospice status for persons indicated as discharged to hospice. Some patient groups were excluded due to other information: 1) patients reported by hospitals to be discharged to a long-term care hospital or hospice, 2) patients who were reported as discharged to Intermediate Care Facilities (ICF) and but had no PAC claims, and 3) persons for whom we found physician claims in a nursing home but with no SNF claims. Other persons without a PAC claim within 30 days were assumed to be discharged to home with self-care. The associations between four measures of SES and discharge to different types of PAC while controlling for important observable factors including case-mix severity were examined.

Multinomial logistic regression models were used to estimate the associations. Correlations between the various SES measures were assessed to understand the degree of multicollinearity. Multiple imputation accounted for missing values in the explanatory variables. A model-based approach that controlled for numerous factors rather than using the MCBS sample weights was used. A sequence of regressions controlling for SES measures first and then adding claim-level, hospital-level, area-level, and survey-based measures was examined. Odds ratios (OR) with standard errors corrected for clustering of multiple hospitalizations at the person level were reported. Analysis files were constructed using SAS 9.3 (SAS Institute Inc., Cary, NC), and analyses were performed using Stata 12 (StataCorp LP, College Station, TX).

Results

Table 3.1 provides descriptive statistics for the 13,624 index hospital stays. About one-fifth (20.8%) were for patients with dual eligibility, about 4.9% of the hospitalizations were for patients living in highly deprived areas, more than half of the index hospital stays (60.3%) were for patients with annual income of less than $25,000, and 33.33% of hospitalizations were for patients with less than a high school degree. Almost all the variables included in this study had statistically different distributions among the PAC locations (Appendix I, Table C).

Table 3.2 shows that the correlations among the four SES measures were modest. The highest correlations were between individual-level measures—income, education, and dual eligibility (correlation coefficients between 0.32 to 0.38)—while the correlations between the area measure of ADI and either income or dual status were the lowest (correlation coefficient < 0.1). Therefore, the area measure of SES may reflect something different from individual measures of current financial position.

The impact of controlling for additional covariates available from different sources on the likelihood of PAC locations was examined by comparing a series of sequential models. Figure 3.1 lists the estimated odds ratios from these sequential models of discharge to various PAC locations for dual eligibility (Figure 3.1a) and living in a deprived ADI area (Figure 3.1b), using home/self-care as a comparison group. The odds ratios are from sequential models that control for increasing sets of variables from different sources. For patients with dual eligibility, the odds of using SNF were significantly higher than the likelihood of being discharged to home with self-care for all models. Relative to the unadjusted model, the odds increased when adjusting for claim data, hospital data, and health resource data. When adding survey data in the adjustment, however, the odds of using SNF decreased relative to the other models, and the odds of using HHA (versus home with self-care) were significantly lower for duals compared to non-duals. In Figure 3.1b on area deprivation, the unadjusted odds of using PAC services (HHA, SNF, or IRF) compared to going home with self-care were all significantly lower for persons living in deprived areas versus non-deprived areas. After adjusting for area or survey variables, the odds were significantly lower only for use of SNF versus home with self-care for people in deprived versus non-deprived areas.

To ascertain the effect of survey information, this study employed two models—one with claims only and one with a full set of variables. If survey information did not contribute to the model, then we would expect the coefficient to be similar. Table 3.3 lists full regression results for models using only claims data (left three columns) and a fully specified model with variables from all sources (right three columns). If using claims data only, residents of the deprived ADI area had significantly lower odds of using all three PAC locations (OR=0.74, OR=0.66, and OR=0.70) while dual eligibility was significantly associated with higher odds of SNF use (OR=1.992). The right three columns of Table 3.3 show that some but not all SES measures were associated with the type of post–acute care received. Compared to being discharged home with self-care, low income level was associated with a higher odds of discharge to SNF (OR=1.23) and IRF (OR=1.15) while dual eligibility was significantly associated with lower odds of using HHA (OR=0.86) but higher odds to be discharged to SNF (OR=1.48). Ceteris paribus, low education level was associated with lower odds of using IRF (OR=0.66). Living in more deprived areas (greater ADI) was associated with a lower likelihood of using a SNF (OR=0.64) relative to being discharged home with self-care.

The predicted probabilities of PAC type for patients with high- and low-SES status using the full variable regression, controlling for all covariates*,* are presented in Figure 3.2a–d. Dual eligibility (versus non-dual) was associated with a decrease in the predicted probability of being discharged to home self-care from 54.7% to 51.5%, a decrease from 18.7% to 15.0% for HHA, and an increase in the predicted probability of discharge to SNF to 23.2% from 30.4%. Being in a more deprived area (low-SES status) was associated with an increase of being discharged home with self-care increased from 53.7% to 60.5% but a decrease of using SNF from 25.1% to 19.5%. Having income less than $25,000 was associated with a decrease in the predicted probability of being discharged to home self-care from 56.0% to 52.9% and an increase in the predicted probability of SNF from 23.0% to 25.8%. Finally, having less than a high school degree (versus higher education) was associated with a decrease of using IRF from 3.68% to 2.53%.

The right three columns of Table 3.2 also show the regression coefficients (odds ratios) from the model with all variables for the relationships of other factors to the likelihood of PAC type (compared to discharged home with self-care). Race, which is often used as a proxy for SES, was associated with type of post–acute care. People of "other race" (non-black and non-white) had lower odds of using SNF (OR=0.63; 95%CI= 0.54, 0.72). Patients discharged from safety-net hospitals had lower odds of using HHA (OR=0.85; 95%CI=0.75, 0.97) and SNF (OR=0.71; 95%CI=0.57, 0.88). Among variables to adjust for case-mix severity, patients admitted from the emergency room had lower odds of using HHA but higher odds of using SNF. Patients hospitalized for conditions with higher Diagnosis Related Group (DRG) weights had higher odds of using all three PAC services. Patients with more functional limitations (higher activities of daily living (ADL) score) had higher odds of using all PAC services. In addition to ADL and instrumental activities of daily living (IADL), patients with more unmet needs had higher odds of using HHA and SNF. However, length of hospital stay, self-reported health status, and Charlson index of the hospital stay were not associated with different likelihood of using PAC versus home with self-care.

Discussion

This study suggests that after controlling for pre-specified covariates, all four measures of low SES levels were associated with different odds of using of PAC services versus home with self-care. Individual SES measures of income and dual eligibility were associated with higher use of SNF while the area-level SES measure (ADI) was associated with lower use of SNF and increased use of home with self-care. Dual eligibility and ADI were associated with the largest changes in the predicted probabilities of using home, HHA, and SNF while other SES measures associated with smaller changes in predicted probabilities for just one or two types of PAC.

In the model using the full set of variables, this study used four measures for SES whereas most previous studies used a more limited set of measures. Income and education, which were self-reported for the study, are not typically collected by Medicare. In contrast, dual status is determined by the Medicare program, and information about the degree of deprivation in an area (which can be linked to claims by nine-digit zip code) has been shown to be importantly related to health outcomes.[53] Results from the full set model and the claims only model were very similar in terms of estimated odds ratios, statistical significance, and predicted probabilities of PAC locations (Appendix I, Table E). Therefore, consideration of only dual eligibility and ADI as SES measures using claims data could be sufficient for modeling outcomes and possible incorporation into payment models.

It is important to note that dual eligibility and ADI had opposite effects on the likelihood of SNF use versus home with self-care (Figures 3.2a and 3.2b). This finding implies that considering both individual and area dimensions of SES could be important in studies. With respect to the issue of area deprivation, a recent report from National Academy of Science (NAS) suggested that concept of socioeconomic position (SEP) should be used by prioritizing status over actual resources.[69] A set of regression models sequentially added additional measures to assess their effect on the associations of dual eligibility and ADI (i.e., easily available measures of SES) with PAC service type. Results from this study showed that the association of ADI with PAC use did not vary much across models that controlled for claims measures only versus models that added area health resource measures (Table 3.3 or Figure 3.1b).

In contrast, the likelihood of SNF use rather than home with self-care for duals versus non-duals varied more substantially across the models controlling sequentially for additional data sources (Figure 3.1a). Adding area health resource measures resulted in the highest odds for duals versus non-duals of SNF use rather than home with self-care; the odds of using SNF only decreased once MCBS survey measures (e.g., functional status, case-mix severity, and caregiver resources) were included. Although the absence of survey information could cause estimates of the associations of SES measures such as dual status with PAC use to change, the larger question for policy is whether easily observed SES measures such as dual status and ADI are sufficient to better reflect underlying patient needs, especially given the time and effort involved in collecting survey information.

This study had several limitations. First, even the models using all data sources have unobserved factors that might affect PAC choice—for example, personal preferences of patients, family members, or physicians. Second, the comorbidity information was based only on diagnoses from claims, so some chronic conditions may not have been controlled. However, we included self-reported health status and functional impairment variables (e.g., ADL and IADL) to estimate the overall health conditions. Third, the best available measure of income was dichotomous rather than continuous. The high income level of more than $25,000 annually may include random measurement error that attenuates the estimated coefficients (biases them toward zero). However, dual eligibility was included in the model, which captured the patient's relative income status among the Medicare population. Relative income (e.g., dual eligibility) was found to be more important than absolute income (e.g., actual amount of income).[70] Therefore, the dichotomous feature of income may have been superfluous in this study given dual eligibility captured most of the important information.

Previous studies showed that lower SES is associated with worse post-discharge outcomes including higher likelihood of 30-day hospital readmission, both overall and across different types of post–acute care.[6,8,938] Because this study found that SES were associated with the probabilities of using different PAC services, future studies of SES and post-discharge outcomes might fruitfully consider the implications of SES for both PAC choice and subsequent outcomes. Furthermore, this study provided information that may be relevant for Medicare's value-based purchasing programs. Ultimately, the study results can contribute to the development of policies to ensure equitable payment and avoidance of inappropriate financial penalties for hospitals serving low-income patients. However, careful evaluation and rationale are needed about the policy alternation of folding SES into adjustment for outcome evaluation.

Conclusion

This study provided information for the distribution of post-discharge care use based on the SES levels. This study found that SES levels were associated with the type of PAC used. This study also suggested that including both an individual SES measure (i.e., dual eligibility) and an area-level SES measure (i.e., ADI) may be important because these measures had associations with SNF versus home with self-care that were opposite in direction. Hospital and area health resource measures only had very modest effects on the association of SES measures with PAC type. Controlling for the many additional measures from the MCBS survey did have greater effect on some associations (such as SNF use for duals versus non-duals). In conclusion, SES measures from claims data may be sufficient for consideration of the incorporation of SES measures into payment policy, especially given the time and effort involved in the survey data collection. These findings can be used to suggest the possible direction for payment policy and research in examining care use.

Table 3.1. Selected Characteristics of Index Hospital stays, N=13,624

VARIABLES		Descriptive Statistics mean (sd), n (%)	Missing n (%)	Data Source
SES Measures				
Dual eligibility		2,829(20.8%)	0(0%)	Claims
Area Deprivation Index		670(4.9%)	2(0%)	Claims
Person's income level < $25,000		8,200(60.3%)	29(0%)	Survey
Person's Education under high school		4,403(33.3%)	395(3%)	Survey
Individual Characteristics				
Race	**White**	11,784(86.6%)	20(0%)	Claims
	Black	1,352(9.9%)		
	Other	468(3.4%)		
Age at Index Hospital Stay		80(7.79)	0(0%)	Claims
Gender, male		5,571(40.9%)	0(0%)	Claims
Currently Married		5,502(40.5%)	20(0%)	Survey
living with helper		4,508(33.1%)	0(0%)	Survey
Number of Children	**No child**	1,197(8.9%)	196(1%)	Survey
	<= 3 children	7,937(59.1%)		
	> 3 children	4,294(32.0%)		
Person living in metro area		9,862(72.4%)	0(0%)	Survey
Claim Years	**2006**	2,858(21.0%)	0(0%)	Claims
	2007	2,720(20.0%)		
	2008	2,349(17.2%)		
	2009	2,183(16.0%)		
	2010	2,133(15.7%)		
	2011	1,381(10.1%)		
Index Hospitalization-Related Factors				
Admitted from ER		6,531(47.9%)	0(0%)	Claims
hospital stay length		2.98(1.85)	0(0%)	Claims
weekends discharge		2,471(18.1%)	0(0%)	Claims
DRG weights		1.45(1.15)	327(2%)	Claims
Charlson index		1.88(1.83)	0(0%)	Claims
Health Related Factors				
General health status	**Excellent**	668(5.9%)	2,384(21%)	Survey
	Very good	2,045(18.2%)		
	Good	3,671(32.7%)		
	Fair	2,986(26.6%)		
	Poor	1,870(16.6%)		
With family helper or not		6,203(45.5%)	0(0%)	Survey
With health professional helper or not		546(4.0%)	0(0%)	Survey
Smoking status		987(7.3%)	41(0%)	Survey
Unmet needs of function impairment		2.51(2.17)	4146(44%)	Survey
ADL index		1.35(1.64)	2498(22%)	Survey
iADL index		0.89(1.39)	2388(21%)	Survey
total number of visits prior 6 months		5.93(12.71)	0(0%)	Claims
Hospital Characteristics				
Hospital Types of Control	**Non-profit**	8,988(68.1%)	425(3%)	Hospital Report
	For-profit	2,310(17.5%)		
	Government	1,901(14.4%)		
DSH hospital		10,113(76.8%)	463(4%)	Hospital Report
Hospital's teaching status		6,043(45.8%)	425(3%)	Hospital Report

Total inpatient bed size(size in 100)	3.04(2.38)	429(3%)	Hospital Report
Safety-Net Status	1466(11.7%)	1,066(8%)	Hospital Report
Area Health Resources			
Physicians+	0.72(0.29)	0(0%)	AHRF
Nurse Practitioner+	0.36(0.25)	0(0%)	AHRF
Beds Nursing Facilities+	0.25(1.03)	0(0%)	AHRF
Home Health Agencies /10,000 persons	0.34(0.39)	0(0%)	AHRF
Beds Skilled Nursing Facilities+	5.91(3.22)	0(0%)	AHRF
Beds Long Term Care hospital+	0.25(0.85)	0(0%)	AHRF
Beds Short-term community hospital+	2.65(1.50)	0(0%)	AHRF
Area			
Census Divisions – **New England**	522(3.8%)	0(0%)	AHRF
Middle Atlantic	2,022(14.8%)		
East North Central	2,554(18.7%)		
West North Central	1,005(7.4%)		
South Atlantic/Puerto Rico	2,918(21.4%)		
East South Central	1,428(10.5%)		
West South Central	1,429(10.5%)		
Mountain	683(5.0%)		
Pacific	1,063(7.8%)		

AHRF, Area Health Resource File.
+ Number of providers/beds in 1,000 populations at county level.
* p<0.05, ** p<0.01

Table 3.2. Correlations Between SES Measures (and Source of Information)

	Low Income (MCBS Survey)	**Deprived ADI Area (Merged by County)**	**Dual Eligible (Medicare Files)**	**Low Education (MCBS Survey)**
Low Income	1.0000	-	-	-
Deprived ADI Area	0.0755 *	1.0000	-	-
Dual Eligible	0.3835*	0.0693 *	1.0000	-
Low Education	0.3247*	0.1038*	0.3318 *	1.0000

* p<0.001

Table 3.3. Multinomial Logit Regression Results for Associations Between SES Measures and PAC Locations, N=13,624

		Multinomial logistic regression using claims data (Reference group: Home/Self-care, n=7,363)			**Multinomial logistic regression using claims + hospital reports + AHRF + survey (Reference group: Home/Self-care, n=7,363)**		
		HHA n=2,430	**SNF n=3,380**	**IRF n=451**	**HHA n=2,430**	**SNF n=3,380**	**IRF n=451**
VARIABLES		Odds Ratio (se)	Odds Ratio (se)	Odds Ratio (se)	Odds Ratio (se)	Odds Ratio (se)	Odds Ratio (se)
SES Measures							
Dual eligibility		1.004(0.003)	1.992**(0.002)	0.950(0.072)	0.863*(0.007)	1.482**(0.006)	1.006(0.033)
Area Deprivation Index		0.744**(0.019)	0.662**(0.007)	0.704**(0.008)	0.806(0.024)	0.643**(0.008)	0.848(0.032)
Person income <$25,000		- -	- -	- -	1.073(0.003)	1.232**(0.002)	1.148**(0.004)
Less than HS degree		- -	- -	- -	1.013(0.008)	0.955(0.003)	0.661**(0.012)
Individual Characteristics							
Race	**White**		Reference			Reference	
	Black	1.081(0.017)	0.806**(0.006)	0.782(0.046)	1.032(0.013)	0.937(0.006)	0.768(0.028)
	Other	1.197(0.035)	0.520**(0.004)	0.613(0.155)	1.173(0.047)	0.625**(0.006)	0.698(0.240)
Age at Index Hospital Stay		1.032**(0.000)	1.086**(0.000)	1.041**(0.000)	1.022**(0.000)	1.068**(0.000)	1.032**(0.000)
Gender, male		0.661**(0.001)	0.690**(0.003)	0.713*(0.027)	0.757**(0.001)	0.808**(0.004)	0.870(0.047)
Currently Married		- -	- -	- -	0.843**(0.006)	0.965(0.007)	0.790*(0.022)
living with helper		- -	- -	- -	0.935(0.004)	0.620**(0.005)	1.170(0.017)
Number of Children	**No child**		-			Reference	
	<= 3 children	- -	- -	- -	0.829**(0.005)	0.725**(0.007)	0.925(0.067)
	> 3 children	- -	- -	- -	0.754**(0.004)	0.588**(0.013)	0.788(0.029)
Person living in metro area		- -	- -	- -	1.154**(0.003)	1.231**(0.008)	1.160(0.019)
Claim Years	**2006**		Reference			Reference	
	2007	0.901(0.014)	0.950(0.002)	0.801(0.084)	0.901(0.014)	0.950(0.002)	0.801(0.084)
	2008	1.086(0.011)	0.859(0.015)	0.892(0.031)	1.086(0.011)	0.859(0.015)	0.892(0.031)
	2009	1.134*(0.006)	1.063(0.003)	0.920(0.060)	1.134*(0.006)	1.063(0.003)	0.920(0.060)
	2010	1.012(0.004)	1.033(0.004)	0.959(0.111)	1.012(0.004)	1.033(0.004)	0.959(0.111)
	2011	0.981(0.002)	1.206**(0.004)	1.437(0.178)	0.981(0.002)	1.206**(0.004)	1.437(0.178)
Index Hospitalization-Related Factors							
Admitted from ER		0.796**(0.005)	1.192**(0.003)	0.889(0.073)	0.796**(0.005)	1.192**(0.003)	0.889(0.073)
hospital stay length		1.012(0.000)	1.018(0.000)	1.007(0.002)	1.012(0.000)	1.018(0.000)	1.007(0.002)
weekends discharge		0.822**(0.007)	0.479**(0.004)	0.486**(0.014)	0.822**(0.007)	0.479**(0.004)	0.486**(0.014)

DRG weights		1.280**(0.003)	1.401**(0.000)	1.605**(0.004)	1.280**(0.003)	1.401**(0.000)	1.605**(0.004)
Charlson index		1.028**(0.000)	1.026**(0.001)	1.001(0.001)	1.028**(0.000)	1.026**(0.001)	1.001(0.001)
<u>Health-Related Factors</u>							
General health status	**Excellent**		-			Reference	
	Very good	- -	- -	- -	1.077(0.029)	0.982(0.016)	1.381(0.329)
	Good	- -	- -	- -	1.111(0.021)	1.007(0.022)	1.089(0.132)
	Fair	- -	- -	- -	1.071(0.017)	1.077(0.031)	1.140(0.101)
	Poor	- -	- -	- -	1.044(0.010)	0.891(0.027)	1.027(0.196)
With family helper or not		- -	- -	- -	1.307**(0.008)	0.535**(0.003)	0.888(0.024)
With health professional helper or not		- -	- -	- -	1.342**(0.007)	0.990(0.013)	0.999(0.114)
Smoking status		- -	- -	- -	0.856(0.013)	0.706**(0.003)	0.752(0.052)
Unmet needs of function impairment		- -	- -	- -	1.104**(0.000)	1.095**(0.001)	1.110(0.006)
ADL index		- -	- -	- -	1.070**(0.001)	1.144**(0.000)	1.135**(0.003)
iADL index		- -	- -	- -	1.037(0.001)	1.075**(0.000)	1.058(0.004)
Number of physician visits in prior 6 months		1.000(0.000)	1.012**(0.000)	0.882**(0.000)	0.999(0.000)	1.009*(0.000)	0.885**(0.000)
<u>Hospital Characteristics</u>							
Hospital Types of Control	**Non-profit**		-			Reference	
	For-profit	- -	- -	- -	1.221**(0.004)	1.083(0.005)	1.325**(0.029)
	Government	- -	- -	- -	0.951(0.005)	0.996(0.005)	1.150(0.061)
DSH hospital		- -	- -	- -	0.786**(0.004)	0.953(0.003)	1.055(0.023)
Hospital's teaching status		- -	- -	- -	0.936(0.006)	0.896(0.012)	1.152(0.014)
Total inpatient bed size(in 100)		- -	- -	- -	0.997(0.000)	0.972**(0.000)	1.047*(0.000)
Safety-Net Status		- -	- -	- -	0.853*(0.008)	0.707**(0.017)	0.720(0.101)
<u>Arear Health Resources</u>		- -	- -	- -			
Physicians+		- -	- -	- -	0.768**(0.005)	0.974(0.009)	1.026(0.021)
Nurse Practitioner+		- -	- -	- -	1.588**(0.067)	1.292**(0.009)	0.901(0.063)
Beds Nursing Facilities+		- -	- -	- -	0.982(0.002)	0.955(0.001)	0.934(0.005)
Home Health Agencies /10,000		- -	- -	- -	1.121**(0.002)	1.095(0.013)	0.835(0.027)

persons										
Beds Skilled Nursing Facilities+		-	-	-	-	-	-	1.001(0.000)	1.044**(0.000)	1.012(0.000)
Beds Long Term Care hospital+		-	-	-	-	-	-	0.959(0.002)	0.996(0.001)	1.054(0.002)
Beds Short-term community hospital+		-	-	-	-	-	-	0.969(0.001)	0.931**(0.000)	1.010(0.002)
<u>Area</u>										
Census Divisions	**New England**			-					Reference	
	Middle Atlantic	-	-	-	-	-	-	1.016(0.063)	0.661**(0.013)	2.193**(0.276)
	East North Central	-	-	-	-	-	-	0.809(0.029)	0.585**(0.003)	2.773**(0.432)
	West North Central	-	-	-	-	-	-	0.569**(0.038)	0.514**(0.016)	2.874**(0.375)
	South Atlantic/Puerto Rico	-	-	-	-	-	-	0.789(0.058)	0.518**(0.007)	1.639(0.219)
	East South Central	-	-	-	-	-	-	0.657(0.092)	0.610**(0.032)	1.594(0.284)
	West South Central	-	-	-	-	-	-	0.791(0.058)	0.525**(0.045)	4.456**(0.974)
	Mountain	-	-	-	-	-	-	0.779*(0.019)	0.540**(0.007)	3.030**(0.590)
	Pacific	-	-	-	-	-	-	0.605**(0.020)	0.697*(0.031)	1.059(0.199)
Log Pseudolikelihood[a]				-13969.407					-13314.861	
AIC				27982.81					26671.72	
BIC				28148.24					26829.63	

* p<0.05, ** p<0.01

a Log likelihood was calculated from the 1st imputation.

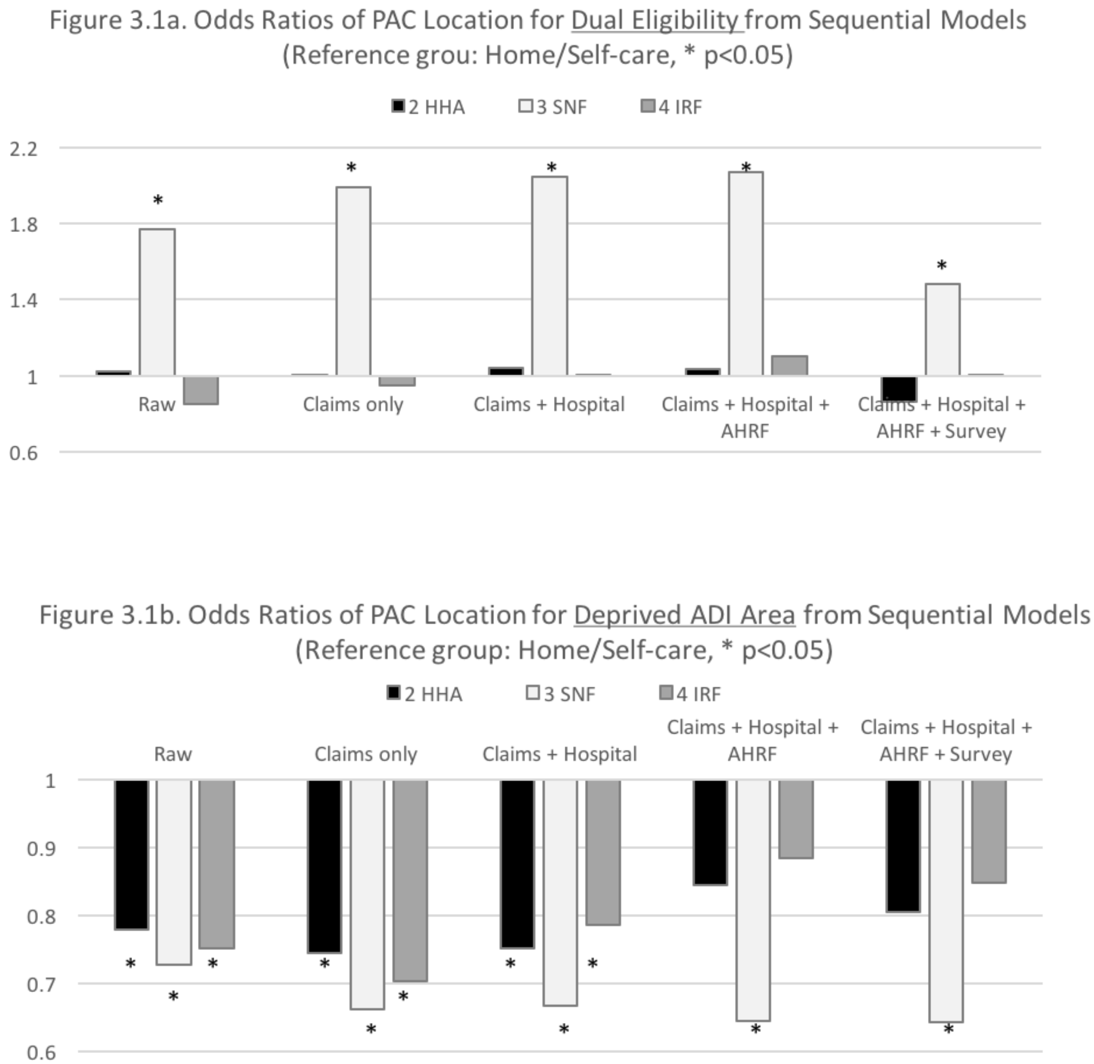
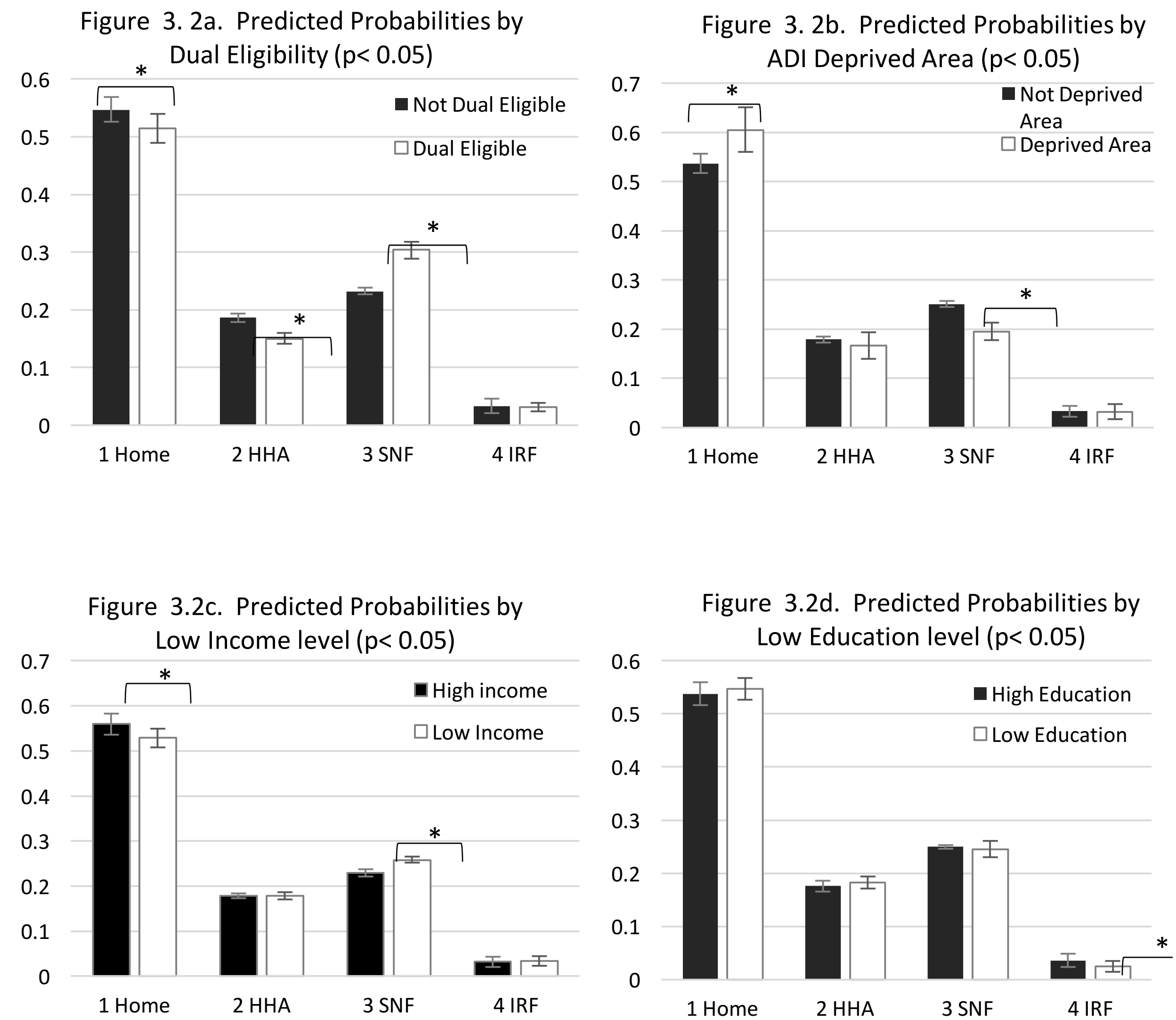


Figure 3.1. Odds ratios of PAC location from sequential models.



Note: all predictions were from full variable regression, controlling for patient characteristics, index hospitalization-related factors, hospital status, area health resources and survey information.

Figure 3.2. Predicted probabilities of first 30-day PAC locations

CHAPTER 4. ASSOCIATIONS OF SOCIOECONOMIC STATUS AND POST–ACUTE CARE LOCATION WITH POST-DISCHARGE OUTCOMES

Introduction

Short-term (30-day) hospital readmissions may reflect poor quality of care and are a major financial burden for the Medicare system.[1] The Centers for Medicare and Medicaid Services started a Hospital Readmissions Reduction Program (HRRP), which penalizes hospitals with higher than expected standardized 30-day readmission rates to provide incentives to improve quality of care and decrease hospital readmissions.[71] This program adjusted expected readmission rates for risk factors that are associated with worse post-discharge outcomes, such as age, gender, and patient frailty. However, socioeconomic status (SES) was not among the risk factors to be adjusted.

Reasons for not adjusting SES are provided by Krumholz:

> "First, the purpose of the outcomes measures is to promote patients' interests. In addition to drawing attention to the performance of hospitals on outcomes that matter to patients, the intent is to promote improvement and equity. We considered it important to reveal differences in outcomes that may exist for disadvantaged populations on the basis of the hospitals they use. Adjustment for SES characteristics could obscure these differences and possibly create the impression that disparities do not exist."[24]

Concerns were raised, however, that improving quality of care for low-SES patients was hindered by a number of influential factors that are beyond the control of hospital providers, for example, the quality of care provided in post–acute care (PAC) facilities.[24,39]

The quality of PAC is one of the most critical factors largely beyond the providers' control under most clinical scenarios. Previous studies showed that type of PAC is associated with early readmissions but much of the prior evidence was limited to either disease-specific or care-specific analyses.[18,60] Outcomes varied among different types of PAC. For example, one study found that IRF and SNF reduced mortality and institutionalization rates at 120 days post-discharge for stroke and hip fracture patients, but IRF or SNF were far more expensive than home discharge.[72] Studies also found that quality varies within the same type of PAC. For example, one study found that SNFs that accepted Medicaid reimbursement provided less information to other providers when patients were admitted to emergency rooms compared to SNFs that did not accept Medicaid, possibly resulting in lower quality and continuity of care for Medicaid SNF patients.[65]

Results from Aim 1 of this study showed that SES is associated with the probability of discharge to different types of post-discharge care. Separately but potentially related, patients with more severe case-mix were more likely to use certain types of PAC; for example, many IRFs specialize in rehabilitation while long term care hospitals (LTCHs) admit extremely ill patients requiring a very high levels of skilled care. One study suggested that patients discharged to SNFs had much higher readmission rates than average rates for other PAC types.[38] These study results suggested that patients with different SES levels had different possibilities of using different PAC locations. Therefore, this study makes a contribution by including this possibility when examining the association and providing better estimations.

This study was designed to explore the relationship between SES and the probabilities of 30-day post-discharge outcomes for the three most common types of PAC location: home with self-care, home with home health service agencies (HHA) care, and skilled nursing facility

(SNF). The analysis explicitly considered the extent to which the associations between SES measures and outcomes changes once the PAC location is included in the estimation models.

Methods

This observational study identified index hospitalizations for Medicare Fee-for-Service (FFS) beneficiaries age 65.5 years or older who participated in the Medicare Current Beneficiary Survey from 2006 to 2011. Individuals who used veterans' health facilities or who died while in the hospital were excluded from this study. Index hospitalizations were identified as live hospital discharges for FFS beneficiaries that met additional inclusion criteria, primarily: 1) discharge to one of three types of post-discharge care: home with self-care, home with HHA, and SNFs; and 2) continuous FFS enrollment during a six-month period prior to and three months after the index stay. To allow patients have six continous months of enrollment, the study inclusion age was defined as 65.5 and older.

The key explanatory variables were SES measured at the individual level (using dichotomous measures of Medicare & Medicaid Dual eligibility, low income level, and low education level) and at the geographic area level for the Area Deprivation Index (ADI), which was matched using the Federal Information Processing Standard (FIPS) State and County Code.[53] Hospital characteristics were identified from Medicare Cost Reports and Provider of Service files from the Centers for Medicare & Medicaid Services, linked by provider numbers. Area health resources were captured using the Area Health Resource File (AHRF) linked by FIPS Code.[68] Dual-eligible status included full Medicaid benefits, partial Medicaid benefits, or Qualified Medicare Beneficiaries–only (QMB) benefits; low income was defined as individual annual income less than $25,000; and low education was defined as less than a high school degree. Based on work by other researchers, highly deprived areas (low SES) were defined as having an ADI value of more than 113.48.[24,44]

Since dual eligibility and ADI and other claims variable measures are more easily determined from Medicare administrative files, the regression models were analyzed with a full set of variables (including all four SES measures), and the claims data variables only (with dual status and ADI only). This full set variable model analysis controlled for patient demographics, disease-related factors, index hospital–related characteristics, and area characteristics using multiple datasets (Figure 2.1 in Chapter 2). Sensitivity analysis was conducted to examine the contribution of each component of variables and to confirm the strategies of using full set vs. claims-only variables. A set of sequential models were employed by starting from associations between each SES measures alone and post-discharge outcomes and then adding control variables of claims only variables, hospital status variables, AHRF variables, and survey information one at a time. Odds ratios of dual eligibility and living in ADI-defined deprived areas were compared.

PAC location served as a key explanatory variable in this study. PAC locations were based the first Medicare PAC claim (i.e., HHA or SNF) during the 30-day post-discharge period. If no claims were identified during this period, PAC location was defined as home with self-care. Three 30-day outcomes were defined: hospital readmission, hospice/death, or neither (no event). The claims data only model controlled for a very limited set of patient demographics and disease-related factors with no hospital, area health resources information, or survey information.

Multinomial logistic regression models were used to estimate the associations. Multiple imputation accounted for missing values in the explanatory variables. Propensity score weighting was used to adjust for possible bias from PAC selection based on observed variables. The weights were calculated from the inverse values of probabilities of using each type of PAC services predicted by a multinomial regression model, which share same variables with regression models in this study.

The results were compared between the models (regression coefficients as well as predicted probabilities) with and without PAC location adjusted to assess how controlling for PAC location affected the associations. The differences were also compared between models using the full set of variables versus claims-only variables (referred to as full model vs. claims model hereafter), to assess the role of dual status and ADI as well as the contribution of hospital-, area-, and survey-level data to the outcome analysis.

Odds ratios (OR) were reported with standard errors corrected for clustering at the person level. Because fully specified regression models were used in estimation, complex survey weights or design effect adjustments were not adjusted for the standard errors, though estimations using these results (not presented) were similar to the estimated results using multiple imputation. Analysis files were constructed using SAS 9.3 (SAS Institute Inc., Cary, NC), and analyses were performed using Stata/SE 14.1 (StataCorp LP, College Station, TX).

Results

This study identified 13,173 index hospitalizations. Descriptive statistics provided in Table 4.1 show: about one-fifth (20.9%) of hospitalizations were for patients with dual eligibility; about 4.9% of the hospitalizations were for patients living in highly deprived areas; 60.4% of index hospital stays were for patients with annual income of less than $25,000; and 33.6% of hospitalizations were for patients with less than a high school degree.

The sensitivity analysis suggested that using the sequential models, the associations between SES measures and post-discharge outcomes didn't change profoundly compared to models with claims-only, hospital status, and AHRF variables. However, adding survey information changed the significance of dual eligibility without changing much of the magnitude of the association (Figure 4.1a) and changed the associations between ADI-defined deprived area and post-discharge outcomes from positive to negative though the difference was not significant (Figure 4.1b).

This study compared multiple regression results using various combinations of SES measures, PAC locations and variable selections (Table 4.2):

- For the full model with PAC locations adjusted (columns a and b), the results suggested that SES measures were not associated with post-discharge outcomes. HHA was associated with lower hospice/death rates (OR=0.54).
- For the full model with no PAC locations (columns c and d), the results suggested that deprived ADI levels were associated with lower hospital readmission level (OR=0.81).
- For the claims model with PAC locations adjusted (columns e and f), dual eligibility was associated with higher readmission (OR=1.32) and hospice/death rate (OR=1.64), deprived ADI levels were associated with higher hospice/death rate, (OR=1.56) and HHA were associated with lower hospice/death rate (OR=0.53).
- For the claims model with no PAC locations (columns g and h), results suggested that deprived ADI area level was associated with higher readmission rates (OR=0.82) and dual eligibility was associated with higher readmission rate (OR=1.32) and higher hospice/death rate (OR=1.67).

In conclusion, PAC location adjustment decreased the associations between living in deprived ADI areas and post-discharge outcomes when the full set of variables was included in the analysis. PAC locations did not change the associations between SES measures and post-discharge outcomes when only claims variables were included. Also, compared to the full model, including only the claims variables increased the association of dual eligibility and the post-discharge outcomes and changed the association of deprived ADI areas with the outcomes.

While comparing the association of PAC location and outcomes, patients who used HHA had lower odds of hospice/death (OR=0.54 and 0.53). These associations did not vary with the selections of control variables.

The predicted probabilities of each category of post-discharge outcomes were calculated and the differences between the probabilities were examined (Appendix I, Table G). The differences in predicted probabilities of post-discharge outcomes were compared between different regression models by dual eligibility and deprived ADI status. Figure 4.1a illustrates that for patients with sual eligibilities, bigger differences in all types of outcomes were found in models with claims-only variables compared to full sets of variables, ceteris paribus. No big changes in the differences were found between models with and without PAC location adjusted. Figure 4.1b illustrates that using claim-only variables somewhat decreased the differences in predicted probabilities. Adjusting for PAC location affected the differences in probabilities for models with full set of variables. If only using claims variables, no change in the differences of probabilities were found with and without PAC location adjusted.

The probabilities of developing post-discharge outcomes were examined using the full-set variable regression (Table 4.2). Results suggested that compared to HHA, SNF users experienced higher probabilities of readmissions (0.203 vs. 0.172, $p<0.0001$) or hospice/death (0.036 vs. 0.019, $p<0.0001$) and a lower probability of no events (0.0761 vs. 0.172, $p<0.0001$) within 30 days post-discharge period (Figure 4.1). HHA users had lower probabilities of hospice/death compared to home/self-care (0.019 vs. 0.032, $p=0.002$). The predicted probabilities were very similar for the models including claims data only (not shown). This finding suggested that PAC locations contributed to the outcome predictions significantly, and

SNF patients had significantly different post-discharge outcomes from either home/self-care patients and HHA patients.

Discussion

This study suggested that the selection of variables influenced the effects of SES measures and the post-discharge outcome estimations. Claims model using dual eligibility and ADI levels may increase the statistical significance of estimations for both associations between low SES levels and post-discharge outcomes as well as result in bigger differences in predicted probabilities of post-discharge outcomes. In the models using the full set of variables, which included hospital-, area-, and survey-level information, income level and education level, which were from survey data, did not contribute sufficient additional explanatory power in the estimations. When examining predicted probabilities, the full-set variable model gave 1–2 percentage points of lower probabilities change between dual and non-dual patients in readmission compared to claims only models, and about 1 percentage point of lower probabilities in hospice/death. For people living in ADI-defined deprived areas, using the full set of variables not only increased the magnitude of differences in predicted probabilities but also changed the direction of differences. To be specific, using the full set of variables predicted that patients living in deprived areas had lower probabilities of readmissions while using claims-only variables predicted that patients living in the deprived area had higher probabilities of readmissions and hospice/death. However, the differences were not significant enough to necessarily justify the time and effort to obtain them through full data collection (i.e., survey information).

This study found that controlling for PAC location modified the association of SES measures with post-discharge outcomes. Although some differences were found based on whether PAC location was controlled or whether the full set of variables (versus claims variables only) was used, the magnitudes of the difference from controlling for PAC location was very modest.

In the estimation using the full set of variables, the association between living in a deprived area as measured by the ADI was attenuated slightly but did become statistically significant ($p<0.05$) by controlling for PAC locations. Therefore, geographic disparities in access to or quality of PAC may affect both PAC use as well as outcomes.[61] Also, the ADI was based on real economic measures (e.g., median home value, median family income, employment rate) and does not address health resources. This study did control directly for area health resources (e.g., hospital numbers, total SNF bed numbers), other market-level factors, and organizational factors that could impact the outcomes as well.

When models both adjusted for PAC locations, the changes in predicted probabilities of readmission for models using the full set of variables or not were up to 1.1% pertaining to dual eligibility and 2.5% pertaining to ADI level (Table 4.3). No changes occurred when not adjusting for PAC locations. Compared to previous studies by Zuckerman and colleagues, the risk-adjusted readmission rate for non-targeted conditions decreased by 2.0% from 2007 to 2015.[55] This study suggested that including PAC locations could affect the outcome prediction at a level comparable to hospital's average performance change when using full-set models, which could potentially affect the hospital's penalty levels, especially for hospitals with a high proportion of low-SES patients. However, if only claim variables were used, PAC location didn't provide significance to the model.

This analysis controls for differences in case mix leading to discharge to different PAC locations by using available measures as well as propensity score adjustment to better account for underlying differences in patient case mix. The advantage of this method was to address treatment (PAC) selection based on observable variables and hopefully reduce bias from selection in the estimation for the treatment effect of PAC locations.

This study has several limitations. First, we were not able to measure the quality of PAC services. We considered using the SNF or HHA star-rating, but this measure was not available for a number of SNFs or HHAs during the study period. Previous studies suggested that low-SES patients were more likely to receive care from SNFs with lower star-ratings[65] and that the quality of SNF was associated with the post-discharge outcomes.[73] Controlling for PAC quality could be helpful in future research but was unobservable in this study.

Second, although we attempted to control for PAC selection using the propensity score weighting approach based on observed covariates, the estimates may still be subject to bias from unobserved variables. For example, the disease severity for chronic diseases was unavailable (e.g., pulmonary function for COPD, Hb1Ac for diabetic patients, and so on). However, we used multiple case-mix variables (e.g., Charlson index, physician visits within six months prior to the index hospitalizations, self-reported health status, admitted from ER or not, etc.) and propensity score weighting methods to estimate and control for disease severity to the extent possible.

Third, the study time frame was from 2006 to 2011, which was entirely pre-HRRP period. The advantage of this strategy was to better reflect the associations and outcome predictions with minimized underlying effects of HRRP. However, the disadvantage was that these associations could have changed since the implementation of HRRP.

This study provided information that may be helpful in developing policies looking at the post-discharge outcomes according to different post–acute care pathways for patients following discharge. In particular, the study results can contribute to assessment of the need to develop policies regarding adjustment of hospital readmission rates by SES measures, in which PAC location may need to be controlled, to ensure appropriate reimbursement and improve quality of care.

Conclusion

This study found that variable selection for models influenced the associations between SES measures and 30-day post-discharge outcomes. Models using claims data only suggested more significant and smaller differences in associations before and after PAC locations were adjusted. Dual eligibility was significant in the claims-only model but was not significantly associated with post-discharge outcomes when controlling for the full set of variables. Although decisions about whether to adjust payment require more deliberation, dual eligibility and geographic deprivation appear to provide important indications of low SES that are associated with post-discharge outcomes and would avoid the need for additional collection of individual SES measures. This study provided information that low-SES patients had worse outcomes of higher readmission rates that might be better reflected by dual status. This implied a very important consideration that lower SES patient may need more resources to improve outcomes, and if the hospital treating these patients cannot provide these resources, the readmission rates will be high. Research examining post-discharge outcomes should consider further investigation into to what extent dual patients had higher demand of care and how this might affect hospitals treating them.

Table 4.1. Descriptive Statistics for Index Hospital Stays, N=13,173

VARIABLES		Descriptive Statistics mean (sd), n (%)	Missing n (%)
SES Measures			
Dual eligibility		2,757 (20.9%)	0
Area deprivation index		651 (4.9%)	2 (0.0%)
Person's income level < $25,000		7,937 (60.4%)	29 (0.2%)
Person's education under high school		4,294 (33.6%)	390 (3.1%)
PAC locations	**Home/Self-care**	7,363 (55.9%)	0
	HHA	2,430 (18.4%)	
	SNF	3,380 (25.7%)	
Individual Characteristics			
Race	**White**	11,381 (86.5%)	19 (0.1%)
	Black	1,315 (10.0%)	
	Other	458 (3.5%)	
Age at index hospital stay		80.07 (7.81)	0
Gender, male		5,391 (40.9%)	0
Currently married		5,323 (40.5%)	36 (0.3%)
Living with helper		4,324 (32.8%)	0
Number of Children	**No child**	1,163 (9.0%)	193 (1.5%)
	<= 3 children	7,662 (59.0%)	
	> 3 children	4,155 (32.0%)	
Person living in metro area		9,523 (72.3%)	0
Claim Years	**2006**	2,756 (20.9%)	0
	2007	2,641 (20.0%)	
	2008	2,271 (17.2%)	
	2009	2,116 (16.1%)	
	2010	2,069 (15.7%)	
	2011	1,319 (10.0%)	
Hospital Stay Factors			
Admitted from ER		6,341 (48.1%)	0
Hospital stay length		2.982 (2.98)	0
Weekends discharge		2,420 (18.4%)	0
DRG weights		1.420 (1.09)	323 (2.5%)
Charlson index		1.880 (1.83)	0
Health Related Factors			
General health status	**Excellent**	648 (6.0%)	2,332 (21.5%)
	Very good	1,966 (18.1%)	
	Good	3,555 (32.8%)	
	Fair	2,875 (26.5%)	
	Poor	1,797 (16.6%)	
With family helper or not		5,964 (45.3%)	0
With health professional helper or not		526 (4.0%)	0
Smoking status		960 (7.3%)	40 (0.3%)

Unmet needs of function impairment		2.486 (2.17)	4,039 (44.2%)
ADL index		1.338 (1.64)	2,445 (22.8%)
iADL index		0.878 (1.38)	2,336 (21.6%)
Total number of visits (prior 6 months)		6.092 (12.84)	0
<u>Hospital Characteristics</u>			
Hospital types of control	**Non-profit**	8,690 (68.2%)	425 (3.3%)
	For-profit	2,223 (17.4%)	
	Government	1,835 (14.4%)	
DSH hospital		9,750 (76.7%)	463 (3.6%)
Hospital's teaching status		5,792 (45.4%)	425 (3.3%)
Total inpatient bed size(in 100)		3.026 (2.38)	429 (3.4%)
<u>Arear Health Resources (County level)</u>			
Physicians*		0.716 (0.29)	0
Nurse practitioner*		0.362 (0.25)	0
Beds in nursing facilities*		0.251 (1.04)	0
Home health agencies /10,000 population		0.340 (0.39)	0
Beds in skilled nursing facilities*		5.907 (3.21)	0
Beds in long-term care hospital*		0.250 (0.85)	0
Beds in short-term community hospital*		2.654 (1.51)	0
<u>Area</u>			
Census divisions	**New England**	515 (3.9%)	0
	Middle Atlantic	1,960 (14.9%)	
	East North Central	2,455 (18.6%)	
	West North Central	963 (7.3%)	
	South Atlantic/Puerto Rico	2,847 (21.6%)	
	East South Central	1,396 (10.6%)	
	West South Central	1,338 (10.2%)	
	Mountain	653 (5.0%)	
	Pacific	1,046 (7.9%)	

* Number of providers/beds in 1,000 population at county level.

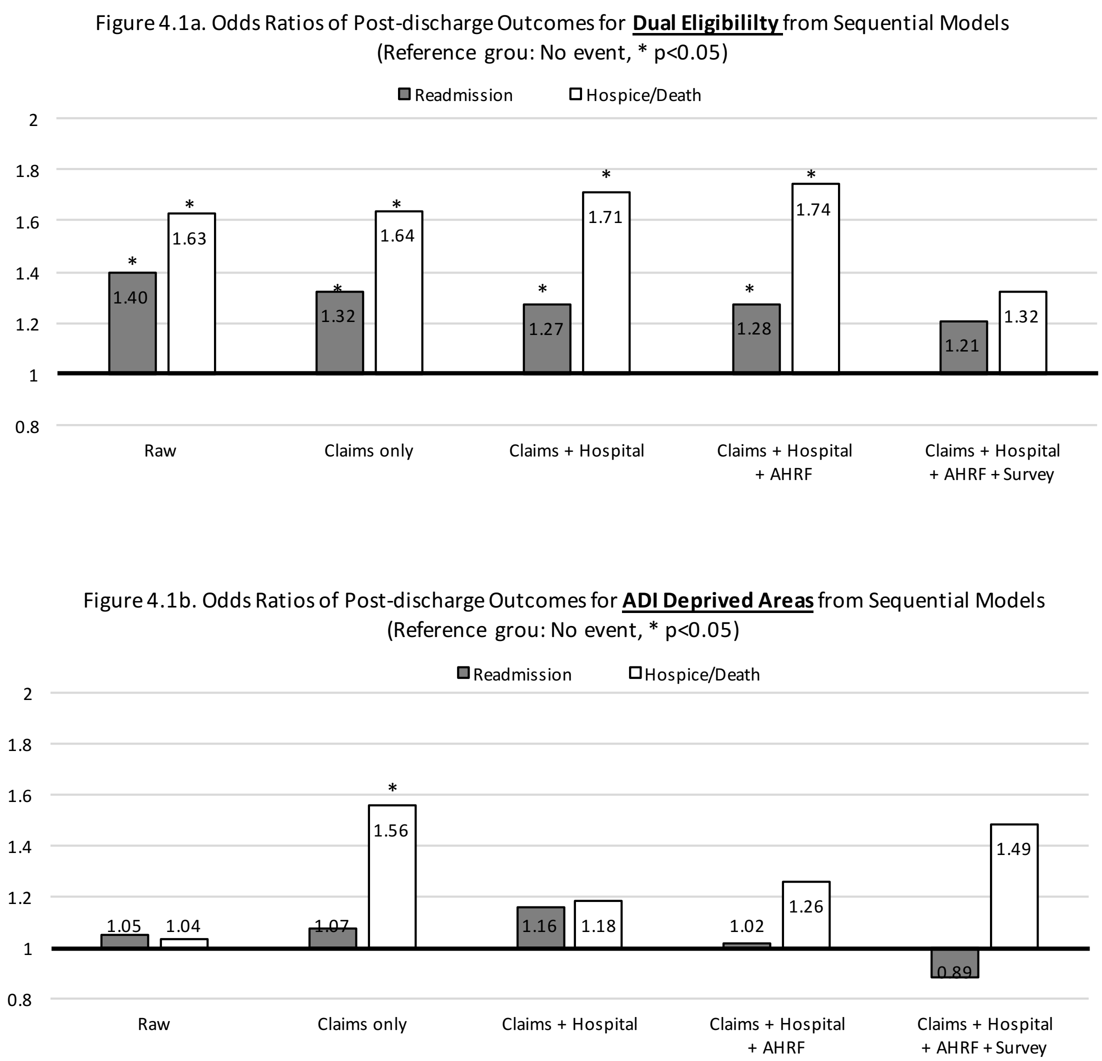
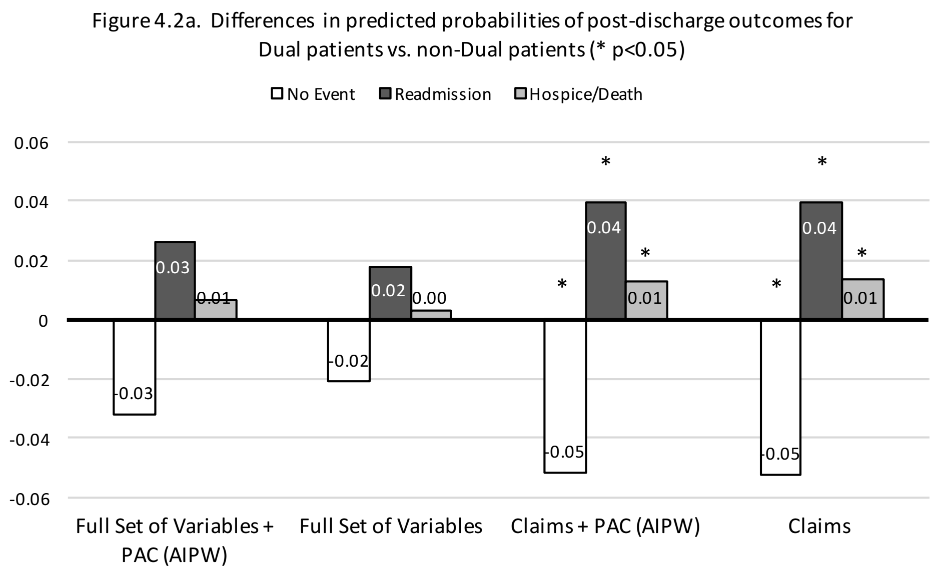


Figure 4.1. Odds ratios of post-discharge outcomes.

Table 4.2. Associations Between SES Measures with Post-Discharge Outcomes (i.e., No Event, Readmissions, Hospice/Death) with PAC Location Adjusted or Not, Multinomial Logit Regression, n=13,173

	Full Set of Variables				Claims-Only Variables			
	SES measures with PAC adjusted		**SES Measures only**		**Dual & ADI with PAC adjusted**		**Dual & ADI only**	
	Reference Group: no events during the 30-day post-acute period							
Column	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Outcomes	**Readmission**	**Hospice/Death**	**Readmission**	**Hospice/Death**	**Readmission**	**Hospice/Death**	**Readmission**	**Hospice/Death**
Variable Labels	Odds Ratio (95% CI)	Odds Ratio (95% CI)	Odds Ratio (95% CI)	Odds Ratio (95% CI)	Odds Ratio (95% CI)	Odds Ratio (95% CI)	Odds Ratio (95% CI)	Odds Ratio (95% CI)
Dual eligibility	1.209 (0.953 - 1.533)	1.322 (0.994 - 1.759)	1.135 (0.943 - 1.366)	1.157 (0.961 - 1.393)	1.324* (1.025 - 1.709)	1.639** (1.366 - 1.966)	1.323* (1.027 - 1.703)	1.672** (1.380 - 2.025)
Deprived ADI area	0.887 (0.745 - 1.056)	1.485 (0.780 - 2.829)	0.814** (0.725 - 0.915)	1.244 (0.731 - 2.115)	1.073 (0.801 - 1.436)	1.556** (1.123 - 2.157)	1.072 (0.797 - 1.441)	1.550** (1.123 - 2.137)
Person's income level < $25,000	0.864 (0.740 - 1.009)	0.943 (0.668 - 1.330)	0.961 (0.846 - 1.091)	1.160 (0.883 - 1.524)	-	-	-	-
Person's Education < high school	1.096 (0.999 - 1.202)	0.973 (0.767 - 1.235)	1.042 (0.908 - 1.197)	1.029 (0.836 - 1.266)	-	-	-	-
PAC Locations: Home / Self-care	Reference		-		Reference		-	
PAC Locations: HHA	0.908 (0.757 - 1.088)	0.541* (0.320 - 0.916)	-	-	0.912 (0.770 - 1.080)	0.525* (0.309 - 0.892)	-	-
PAC Locations: SNF	1.156 (0.953 - 1.403)	1.183 (0.885 - 1.582)	-	-	1.176 (0.974 - 1.421)	1.223 (0.901 - 1.659)	-	-
AIC#	43384.79		43519.42		43659.93		45078.43	
BIC#	43541.99		43676.63		43816.58		45235.63	

* p<0.05, ** p<0.01
# AIC and BIC were estimated from the 1st imputations.
Control variables including patient characteristics, hospital characteristics, area health resource, et al.



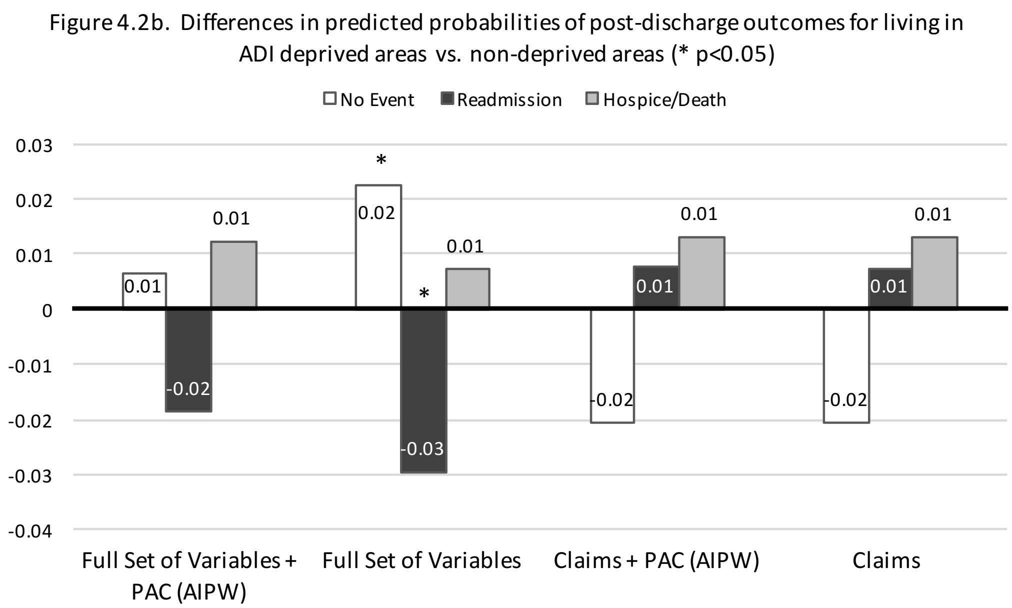


Figure 4.2. Differences in predicted probabilities of post-discharge outcomes.

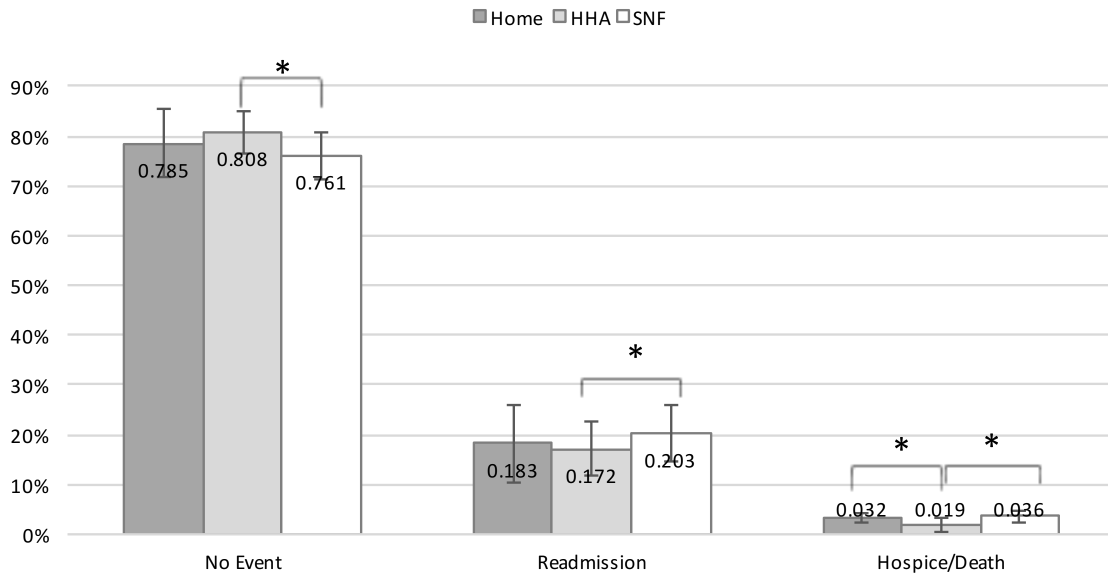


Figure 4.3. Predicted probabilities of post-discharge outcomes by PAC locations. (*p<0.05, full set of variables + PAC locations)

Table 4.3. Changes in Predicted Probabilities for Models with Full Variable Set Compared to Models with Claims-Only Variables

		PAC location adjusted			**PAC location not adjusted**		
		No Events	**Readmission**	**Hospice/ Death**	**No Events**	**Readmission**	**Hospice/ Death**
Dual Eligibility	No	-0.3%	0.3%	0.1%	-0.1%	0.0%	0.1%
	Yes	1.6%	-1.1%	-0.5%	0.0%	0.0%	-0.1%
Deprived ADI area	No	-0.1%	0.2%	0.0%	0.0%	0.0%	0.0%
	Yes	2.5%	-2.5%	-0.1%	0.1%	0.0%	-0.1%

CHAPTER 5. ASSOCIATIONS BETWEEN SOCIOECONOMIC STATUS, POST–ACUTE CARE LOCATION AND POST-DISCHARGE OUTCOMES: THE ROLE OF HOSPITAL SAFETY-NET STATUS

Introduction

High short-term (30-day) hospital readmissions may reflect poor quality care and are a major financial burden for the Medicare program, costing over $26 billion annually.[1] From 2007 to 2011, about 20% of Medicare patients were readmitted to the hospital within 30 days of discharge, among which about 20% to 50% were potentially avoidable, depending on type of disease.[1,2] On average, readmission stays were longer and more costly than the person's initial admission.[3,74] To reduce this burden, the Centers for Medicare & Medicaid Services (CMS) enacted the Hospital Readmission Reduction Program (HRRP) starting in October 2012 to improve hospital performance during inpatient care to improve post-discharge outcomes, reduce short-term readmissions, and reduce unnecessary medical costs.[28] The risk-adjusted 30-day hospital readmission rate was used to determine if hospitals had high readmission rates, which were adjusted by patient demographics, comorbidities, and patient frailty.[5] There were concerns raised by CMS and some experts because patient's socioeconomic status (SES) and hospital safety-net status were not included in the risk adjustment.

Previous studies found that SES is a powerful tool for predicting health-related outcomes as well as hospital discharge outcomes.[24,39,40] The results from Chapter 4 support that SES measures were associated with 30-day post-discharge outcomes. However, this association could be influenced by PAC location, which was associated with the post-discharge outcomes as well.[17,18] Hospital safety-net status may also be associated with post-discharge outcomes. Studies suggested that hospitals with high readmission rates get a higher percentage of low-SES patients and were expected to have higher readmission rates and accordingly face a higher likelihood and level of penalties.[1,3] The penalties can significantly increase financial burden, harm quality improvement efforts, and even incentivize hospitals to reduce care for low-SES patients. These concerns may be particularly pressing for safety-net hospitals located in underserved areas that may have very limited resources to improve quality.[13–15] Other studies suggested that safety-net hospitals that treat more low-SES patients may obtain better outcomes for these patients given their greater experience with low-SES patients.[16]

Therefore, this study examined the relationship between SES and 30-day post-discharge outcomes while controlling for both hospital safety-net status and PAC location. The hypothesis was that the association between SES and post-discharge outcomes was bigger in non-safety-net hospitals compared to non-safety-net hospitals. This study provides information that may be helpful to future studies and development of policies regarding the appropriate reimbursement of costs of care as well as adequate resources for vulnerable patients.

Methods

The study identified MCBS participants who were Medicare Fee-for-Service (FFS) beneficiaries age 65.5 years or older. Individuals who used veterans' health facilities were excluded. Index hospitalizations were identified as live hospital discharges for FFS beneficiaries that met additional inclusion criteria, primarily: 1) discharge to one of three types of post-discharge care: home with self-care, home with home health agencies (HHA), and skilled nursing facilities (SNFs); and 2) continuous FFS enrollment and no hospitalization during a six-month period prior to and three months after the index stay. To allow patients have six continous months of enrollment, the study inclusion age was defined as 65.5 and older.

SES was measured at the individual level (using dichotomous measures of Medicare &

Medicaid dual eligibility, low income level, and low education level) and at the geographic level using the Area Deprivation Index (ADI) merged by the Federal Information Processing Standard (FIPS) State and County Code. Dual-eligible status included full Medicaid benefits, partial Medicaid benefits, or Qualified Medicare Beneficiaries–only (QMB) benefits; low income was defined as having annual income less than $25,000; low education was defined as less than a high school degree. Based on work by other researchers, we defined highly deprived areas (low SES) as having an ADI value of more than 113.48.[44] Because dual eligibility and ADI measures were easily obtained from Medicare administrative files, we examined the regression models with all four SES measures and with dual and ADI only.

PAC locations were based on the first Medicare PAC claims (i.e., HHA or SNF) during the 30-day post-discharge period. If no claims were identified during this period, PAC location was defined as home with self-care. We compared the results between the models (regression coefficients as well as predicted probabilities) with and without PAC location measures to assess how adjustment for PAC location affected the associations.

A continuous measure of the hospital-level percent of total Medicare patient days accounted for by supplemental security income (SSI) was dichotomized to identify safety-net hospitals as the top 20% of hospitals ranked by this ratio each year. The measure was available from annual hospital data files aggregated from MedPAR data by CMS for the purpose of calculating DSH adjustment; these files are publicly available on the CMS Web site.[50]

This analysis controlled for patient demographics, disease-related factors, hospital characteristics, and area characteristics using multiple datasets (Figure 2.1 in Chapter 2). Purposefully, these characteristics go beyond the set of variables controlled for in the CMS risk adjustment. Hospital characteristics were identified from Medicare Cost Reports and Provider of

Service files from the Centers for Medicare & Medicaid Services, linked by provider numbers. Area health resources were captured using the Area Health Resource File (AHRF) linked by FIPS Code. Three 30-day outcomes were defined: hospital readmission, hospice/death, or neither (no event).

Multinomial logistic regression models were used to estimate the associations. Multiple imputation accounted for missing values in the explanatory variables. The method of propensity score weighting was used to adjust patient case-mix severity from PAC selection. The weights were calculated from the inverse values of probabilities of using each type of PAC services predicted by a multinomial regression model using the same variables as the main regression models in this study. We included the interaction terms of SES measures and PAC locations with safety-net status to examine to what extent the effects were modified by safety-net status. We reported predicted probabilities with standard errors corrected for clustering at the person level. Because fully specified regression models were estimated, complex survey weights or design effect adjustments were not adjusted for the standard errors, though estimations using these results (not presented) were similar to the estimated results using multiple imputation. Analysis files were constructed using SAS 9.3 (SAS Institute Inc., Cary, NC), and analyses were performed using Stata/SE 14.1 (StataCorp LP, College Station, TX).

Results

This observational study identified 13,173 index hospitalizations for 6,825 patients. A total of 1,428 hospitalizations (11.8%) in this study sample occurred in safety-net hospitals. The descriptive statistics for key variables for index hospitalizations in non-safety-net hospitals versus safety-net hospitals are listed in Table 5.1. Statistical tests showed that patients treated in safety-net hospitals had lower SES on all four measures compared to patients in non-safety net hospitals. About 17.9% hospitalizations were for patients with dual eligibility in non-safety-net hospitals versus 43.2% for dual-eligible patients in safety-net hospitals. About 3.4% of the hospitalizations were for patients living in highly deprived areas for non-safety-net hospitals versus 14.3% in safety-net hospitals. About 58.2% of the index hospital stays were for patients with annual income of less than $25,000 in non-safety-net hospitals while 72.8% were for patients with low annual income in safety-net hospitals. About 30.4% of hospitalizations were for patients with less than a high school degree in non-safety-net hospitals while about 47.5% were for patients with low education level in safety-net hospitals. About 22.6% of the safety-net hospitalizations were followed by readmission within 30-day of post-discharge while 18.8% of hospitalizations in non-safety-net hospitals were followed by 30-day readmissions. About 2.9% of the patients from safety-net hospitals died or initiated hospice within 30-day of post-discharge while 3.0% patients from non-safety-net hospitals did.

Table 5.2 lists results from multinomial logistic regressions for selected variables from four models with the full set of variables with and without adjustment for PAC location. Regression results for all variables were provided in Appendix I, Table J. To enable interpretation of interacted variables from the model estimations, the predicted probabilities of post-discharge outcomes were graphed. Figure 5.1 shows that regardless of their SES levels, patients discharged from safety-net hospitals had higher probabilities of 30-day readmission compared to patients discharged from non-safety-net hospitals (0.217–0.222 vs. 0.184–0.189). Patients who were discharged from safety-net hospitals had lower probabilities for no event (0.750–0.763 vs 0.780–0.785); for models adjusted for PAC locations, safety-net patients had lower hospice/death (0.019–0.027 vs. 0.030–0.031) compared to non-safety-net patients.

The results suggested that compared to non-safety-net hospitals, patients who received care in safety-net hospitals had higher probabilities of 30-day hospital readmission and lower probabilities of no event during the 30-day post-discharge period. However, the magnitudes of these differences were very small. These overall outcomes did not vary by variable selection and PAC locations adjustment. Patients from safety-net hospitals had lower predicted probabilities of hospice/death compared to non–safety-net hospitals with PAC location adjusted. When PAC location was not adjusted, estimates didn’t vary by either safety-net status or using full set vs. claims-only variables. The predicted values by SES measures were listed in Appendix I, Table K.

Models estimated using the full set of variables achieved lower Akaike information criterion (AIC) and Bayesian information criterion (BIC) scores versus models using the claims-only variables (Table 5.2). Although models using the full set of variables provide estimates of the associations controlling for as many potentially relevant observed variables as possible, results were provided measuring SES with just dual status and area deprivation level and controlling only for variables available from the claims given ease of measurement and possible relevance for payment policy. The estimations from the full variable model and the claims-only model were different and therefore were listed in Table 5.2. Once again, because of the interactions with safety-net status, figures of predicted probabilities enable assessment of any differences. Thirty-day hospital readmission rates did not differ significantly for dual patients at safety-net versus non-safety-net hospitals (Figure 5.2a). However, dual patients at safety-net hospitals had lower probabilities of hospice/death (0.021 vs. 0.035, p=0.007) compared to dual patients at non–safety-net hospitals (Figure 5.2a). For non-dual patients, safety-net hospital discharges had higher probabilities of readmission (0.214 vs. 0.179, p=0.004) and lower probabilities for hospice/death (0.019 vs. 0.029, p=0.009) compared to non-duals at non–safety-net hospitals (Figure 5.2b). For patients living in deprived areas, those who were discharged from safety-net hospitals did not have significant different post-discharge outcomes compared to those who were discharged from non–safety-net hospitals (Figure 5.3a). For patients living in non-deprived areas, those who were discharged from safety-net hospitals had higher readmission rates (0.219 vs. 0.191, p=0.010), lower hospice/deaths rates (0.024 vs. 0.036, p<0.0001), and a lower rate of neither event (0.756 vs. 0.779, p=0.006) (Figure 5.3b). Although statistical significance was achieved for some of these comparisons, the magnitude of the estimated differences was quite small in absolute terms.

The predicted probabilities of post-discharge outcomes were also compared between safety-net hospitals and non–safety-net hospitals by first PAC location (Figure 5.4). No differences in 30-day outcomes were identified for patients who used home/self-care. HHA users who were discharged from safety-net hospitals had a much lower probability of hospice/death with 30 days post-discharge (0.003 vs. 0.022, p< 0.0001) compared to patients discharged from non–safety-net hospitals. SNF users discharged from safety-net hospitals had higher probabilities of readmission (0.246 vs. 0.200, p=0.035), lower probabilities of no event (0.730 vs. 0.763, p=0.036), and no significant differences in hospice/death (0.024 vs. 0.037, p=0.142) compared to non–safety-net hospitals.

Discussion

This study has three key findings. The first finding is that compared to patients treated at non–safety-net hospitals, patients with high SES level (non-dual eligible and/or living in non-deprived areas) discharged from safety-net hospitals had higher readmission probabilities but lower probabilities for hospice/death. Low-SES patients from safety-net hospitals were not significantly different in readmission rates but may have lower rates of hospice referral or death rate (for dual patients) compared to those from non–safety-net hospitals. These findings implied that low-SES patients treated in safety-net hospitals may receive better outcomes by having lower hospice/readmission rates and not having higher readmission rates compared to non–safety-net hospitals. High-SES patients from safety-net hospitals had higher probabilities of readmission than those from non–safety-net hospitals, but again this disadvantage was attenuated by having lower probabilities of hospice/death. These findings are consistent with prior study results that safety-net hospitals did not provide lower quality of care to patients, especially low-SES patients.[16,75,76]

The second finding is that when comparing safety-net hospitals vs. non–safety-net hospitals by PAC location, outcomes were very similar if the patients were discharged to home/self-care and HHAs. These patients received better lower probabilities of hospice/death if discharged to an HHA. The biggest differences in post-discharge outcomes occurred among patients discharged to SNFs, because safety-net hospitals were more likely to have higher readmission rates. This part of the results suggested that not only patient's dual status but also PAC locations, especially SNF, were associated with the post-discharge outcomes. This result is consistent with a situation in which safety-net hospitals could be disadvantaged by capturing the lower quality of care provided by SNFs who they worked with, and the lower quality of care lead to the worse post-discharge outcomes and was not fully under hospital's control. To the extent this is the case, safety-net hospitals could be penalized for the lower quality of care of SNFs. The best approach to further address this issue is to examine the relationship between hospital safety-net status and the quality or types of SNFs (e.g., star-rating system).

Third, safety-net hospital patients, regardless of SES status, may have disadvantage of worse outcomes by having higher probabilities of readmission and lower probabilities of no 30-day event (readmission, hospice initiation, or death), but this disadvantage may be decreased by probabilities of lower hospice/death. The current HRRP policy assesses hospitals by readmission rates, and safety-net hospitals are at a higher risk of penalty.[24–26] Readmissions, however, are only part of the total adverse events of post-discharge care; although high readmission rates may reflect poor quality of hospital care, a broader analysis might consider mortality both during the index hospital stay as well as post-dicharge.[77] Although there were policies examining hospitals by mortality rates, the level of penalty for death rate is much lower than readmission. Therefore, for safety-net hospitals, having lower hospice/death rates might not be able to help address the higher risk of penalty, if death was weighted much lower than readmission. Studies found that if the death and readmission were weighted equally, the penalties would substantially change for Medicare hospitals.[78] Therefore, a measure including post-discharge hospice and death rate, which reflected safety-net hospitals' performance in a more complex way, may reduce the risk of penalty for safety-net hospitals at the same time assure the incentives for quality improvement and resources for vulnerable patients.

These findings suggested that safety-net status, specifically the proportion of patients with dual eligibility and those who lived in more deprived areas, might be included in evaluating patients' post-discharge outcomes for a hospital. Studies suggested that individual-level characteristics explained 60% of observed differences in readmissions between high- and low-DSH hospitals.[25] Our study suggested that safety-net status, with all patient characteristics controlled, contributed significantly not only to readmissions but also to the rest of the post-discharge outcomes.

The study results also suggested that models with the full set of variables had only small differences compared to models using claims data only. The results suggested that with PAC location adjusted, using claims data may increase the differences in predicted probabilities of readmission by 0.9 percentage points (0.42 vs. 0.033) between safety-net hospital and non–

safety-net hospitals. Without PAC locations adjusted, the differences decreased by 0.1 percentage points (0.032 vs. 0.033) (Figure 5.1). Therefore, the model using claims data information without PAC locations adjusted seemed to provide adequate information to evaluate safety-net hospitals vs. non–safety-net hospitals.

The study has limitations. First of all, this study defined individual annual income equal to or more than $25,000 as high income and income less than $25,000 as low income. The median per capita income among Medicare beneficiaries was $26,200 in 2016 and this level was stable over years. Therefore, income below $25,000 could be considered as low income among all the Medicare beneficiaries. However, the associations between income and outcome may be different among the middle income and high income groups. Using a dichotomous measure could limit this study's ability to recognize the associations between income and post-discharge outcomes. Furthermore, random measurement error in income could bias the estimated coefficient toward zero.

The estimates may still be subject to bias from the selection of SES measures or PAC location based on unobserved variables. For example, the disease severity for some chronic diseases was unavailable (e.g., pulmonary function for COPD, Hb1Ac for diabetic patients, etc.). These factors may affect the PAC selection and the post-discharge outcomes, resulting in bias in the estimates. However, we used multiple case-mix variables (e.g., Charlson index, physician visits within six months prior to the index hospitalizations, self-reported health status, admitted from ER or not, etc.) and propensity score weighting method to estimate and control for disease severity indirectly.

The study time frame was from 2006 to 2011, which was entirely in the pre-HRRP period. The advantage of this strategy was to better reflect the associations and outcome predictions without the influence of HRRP. However, the disadvantage was that these associations could have changed since the implementation of HRRP.

Conclusion

This study found that safety-net hospital patients (compared to patients at non–safety-net hospitals) had higher probabilities of readmissions but may have lower probabilities of hospital/death. Readmission rates for low-SES patients (dual patients) did not appear to be different by safety-net status, but hospice/death rates varied by SES and safety-net status. Readmission rates varied by safety-net status for SNF patients and hospice/death rates varied by safety-net status for HHA users. Because of the concerns of safety-net hospitals patients not getting sufficient resources, the findings from this study suggested that studies are needed that can appropriately measure the quality of care provided by hospitals with higher proportion of vulnerable patients (i.e., safety-net hospitals) and different types of SNFs. To be more specific, including safety-net status in the post-discharge outcome measurement can appropriately reflect the quality of care provided by safety-net hospitals, help with lowering the risks of penalty, and address the financial disadvantage for these hospitals. Such considerations are pertinent to efforts to ensure health care access for the low-SES population.

Table 5.1. Descriptive Statistics of Variables by Safety-Net Status, n=13,173

VARIABLES		Non-Safety-Net Hospitals n=10,685 mean (sd), n (%)	Safety-Net Hospitals n=1,428 mean (sd), n (%)	p-value
Post-discharge Outcomes	**No event**	8,354 (78.2%)	1,064 (74.5%)	0.003
	Readmission	2,013 (18.8%)	323 (22.6%)	
	Hospice/death	318 (3.0%)	41 (2.9%)	
Dual eligibility		1,914 (17.9%)	617 (43.2%)	<0.0001
Area deprived		365 (3.4%)	204 (14.3%)	<0.0001
Person's income level < $25,000		6,216 (58.2%)	1,040 (72.8%)	<0.0001
Person's education under high school		3,248 (30.4%)	678 (47.5%)	<0.0001
PAC Locations	**Home/Self-care**	6,061 (56.7%)	859 (60.2%)	0.02
	HHA	1,846 (17.3%)	244 (17.1%)	
	SNF	2,778 (26.0%)	325 (22.8%)	
Race	**White**	9,554 (91.8%)	861 (68.8%)	<0.0001
	Black	854 (8.2%)	390 (31.2%)	
	Other	261 (2.5%)	175 (14.0%)	
Age at index hospital stay		80.07 (7.770)	79.73 (8.291)	0.120
Gender, male		4,451 (41.7%)	524 (36.7%)	<0.0001
Currently married		4,529 (42.4%)	420 (29.4%)	<0.0001
living with helper		3,497 (32.7%)	474 (33.2%)	0.725
Number of children	**No child**	935 (13.0%)	156 (16.8%)	0.003
	1- 3 children	6,277 (87.0%)	772 (83.2%)	
	> 3 children	3,338 (46.3%)	463 (49.9%)	
Person living in metro area		7,933 (74.2%)	987 (69.1%)	<0.0001
Claim Year	**2006**	2,158 (20.2%)	366 (25.6%)	<0.0001
	2007	2,169 (20.3%)	293 (20.5%)	
	2008	1,871 (17.5%)	218 (15.3%)	
	2009	1,721 (16.1%)	225 (15.8%)	
	2010	1,692 (15.8%)	212 (14.8%)	
	2011	1,074 (10.1%)	114 (8.0%)	
Admitted from ER		5,373 (50.3%)	790 (55.3%)	<0.0001
Hospital stay length		2.95 (1.865)	3.063 (1.850)	0.682
Weekends discharge		1,998 (18.7%)	256 (17.9%)	0.481
DRG weights		1.45 (1.103)	1.39 (1.185)	<0.0001
General health status	**Excellent**	577 (7.7%)	33 (3.6%)	<0.0001
	Very good	1,669 (22.4%)	149 (16.3%)	
	Good	2,902 (38.9%)	397 (43.4%)	
	Fair	2,314 (31.0%)	336 (36.7%)	
	Poor	1,380 (18.5%)	259 (28.3%)	
With family helper or not before index hospital stay		4,846 (45.4%)	648 (45.4%)	0.986
With health professional helper or not before index hospital stay		420 (3.9%)	62 (4.3%)	0.456
Smoking status		770 (7.2%)	112 (7.8%)	0.360
Unmet needs of function impairment		2.39 (2.137)	2.938 (2.200)	0.003
Two or more physician visit with 6 months previously to index hospital stay		3,886 (36.4%)	506 (35.4%)	0.490

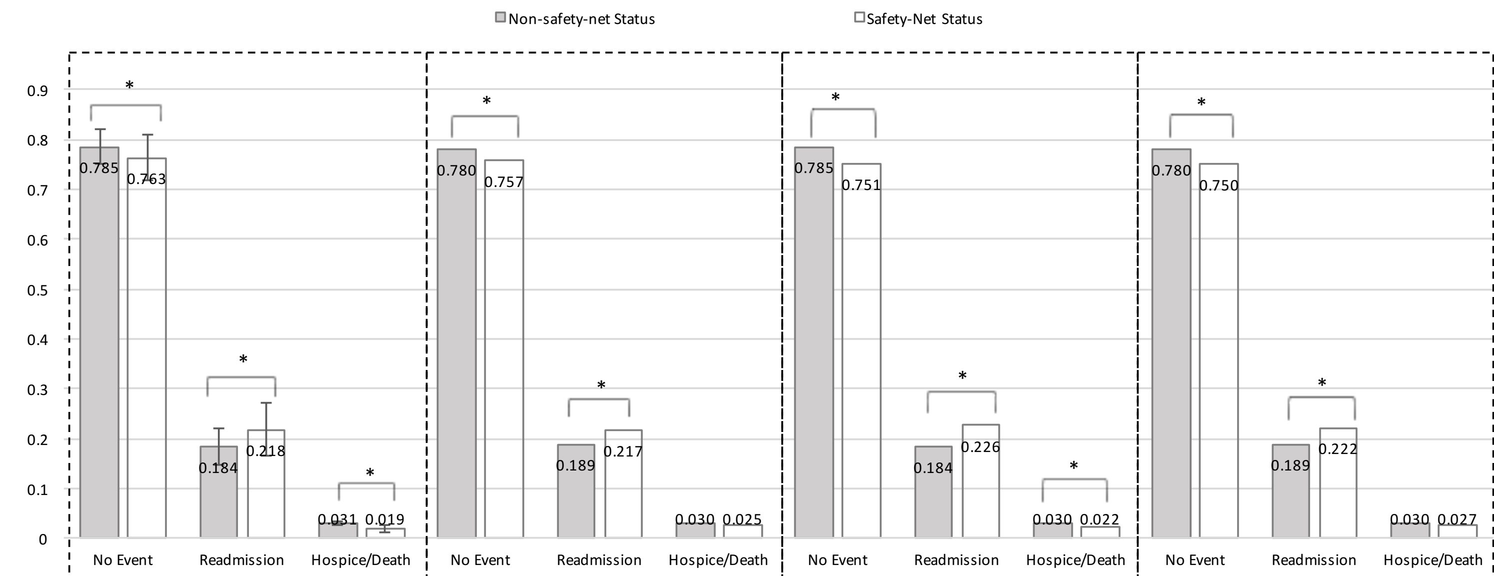
ADL index	1.27 (1.585)	1.681 (1.859)	<0.0001
iADL index	0.83 (1.350)	1.681 (1.859)	<0.0001
Charlson index	1.90 (1.857)	1.927 (1.769)	0.017
Total number of visits within 6 months previously to index hospital stay	5.98 (12.620)	5.42 (11.410)	<0.0001
Hospital type of control — **Non-profit**	7,626 (71.4%)	818 (57.3%)	<0.0001
For-profit	1,656 (15.5%)	350 (24.5%)	
Government	1,396 (13.1%)	260 (18.2%)	
DSH hospital	8,322 (77.9%)	1,426 (99.9%)	<0.0001
Hospital's teaching status	5,045 (47.2%)	716 (50.1%)	0.04
Total inpatient bed size (size in 100)	3.14 (2.248)	3.262 (2.248)	<0.0001
Physicians*	0.73 (0.285)	0.668 (0.296)	0.079
Nurse Practitioner*	0.37 (0.241)	0.332 (0.299)	<0.0001
Beds in nursing facilities*	0.26 (1.090)	0.1605 (0.729)	<0.0001
Home health agencies /10,000 persons	0.33 (0.347)	0.4034 (0.573)	<0.0001
Beds in skilled nursing facilities*	5.88 (3.080)	5.565 (3.640)	<0.0001
Beds in long-term care hospital*	0.26 (0.801)	0.2265 (1.290)	<0.0001
Beds in short-term community hospital*	2.62 (1.493)	2.912 (1.581)	0.004
Census divisions — **New England**	446 (4.5%)	39 (3.4%)	<0.0001
Middle Atlantic	1,615 (16.2%)	219 (18.9%)	
East North Central	2,187 (21.9%)	79 (6.8%)	
West North Central	758 (7.6%)	68 (5.9%)	
South Atlantic/Puerto Rico	2,233 (22.3%)	472 (40.7%)	
East South Central	1,104 (11.0%)	131 (11.3%)	
West South Central	1,049 (10.5%)	131 (11.3%)	
Mountain	600 (6.0%)	22 (1.9%)	
Pacific	693 (6.9%)	267 (23.0%)	

* Number of providers/beds in 1,000 populations at county level.

Table 5.2. Association Between SES and Post-Discharge Outcome Adjusted for Hospitals' Safety-Net Status, N=13,512

		Full variable set + PAC		**Full variable set**		**Claims-only + PAC**		**Claims-only**	
		Readmission	**Hospice/Death**	**Readmission**	**Hospice/Death**	**Readmission**	**Hospice/Death**	**Readmission**	**Hospice/Death**
		Odds Ratio	Odds Ratio	Odds Ratio	Odds Ratio	Odds Ratio	Odds Ratio	Odds Ratio	Odds Ratio
Dual eligibility		1.188 (0.936 - 1.507)	1.307 (0.999 - 1.711)	1.138 (0.936 - 1.384)	1.207 (0.989 - 1.472)	1.411* (1.064 - 1.871)	1.714** (1.368 - 2.148)	1.402** (1.121 - 1.753)	1.678** (1.462 - 1.926)
Deprived ADI area		0.977 (0.802 - 1.191)	1.971 (0.756 - 5.137)	0.832* (0.710 - 0.975)	1.254 (0.479 - 3.285)	1.325 (0.893 - 1.965)	2.116** (1.217 - 3.677)	1.060 (0.811 - 1.387)	1.374 (0.874 - 2.160)
Person's income level < $25,000		0.878 (0.742 - 1.038)	0.955 (0.619 - 1.471)	0.955 (0.827 - 1.103)	1.131 (0.796 - 1.605)	-	-	-	-
Person's Education < high school		1.179** (1.075 - 1.292)	0.969 (0.745 - 1.260)	1.077 (0.962 - 1.205)	1.003 (0.794 - 1.266)	-	-	-	-
PAC Locations	**Home**	Reference		-	-	Reference		-	-
	HHA	0.952 (0.817 - 1.110)	0.584 (0.325 - 1.049)	-	-	0.928 (0.819 - 1.052)	0.600 (0.345 - 1.045)	-	-
	SNF	1.171 (0.953 - 1.439)	1.151 (0.919 - 1.442)	-	-	1.157 (0.969 - 1.381)	1.282 (0.964 - 1.704)	-	-
Safety-Net hospital		1.782** (1.398 - 2.270)	0.502** (0.324 - 0.780)	1.324** (1.157 - 1.515)	0.456** (0.286 - 0.726)	1.477** (1.132 - 1.927)	1.174 (0.770 - 1.791)	1.337** (1.179 - 1.516)	0.977 (0.729 - 1.310)
Interaction Terms									
Safety-Net × Dual eligibility		0.952 (0.701 - 1.294)	0.903 (0.455 - 1.794)	0.845 (0.661 - 1.081)	0.620 (0.350 - 1.098)	0.662** (0.523 - 0.837)	1.057 (0.570 - 1.962)	0.726** (0.591 - 0.893)	0.905 (0.594 - 1.378)
Safety-Net × ADI		0.704 (0.393 - 1.261)	0.500 (0.0386 - 6.477)	0.968 (0.561 - 1.671)	1.297 (0.170 - 9.892)	0.449** (0.273 - 0.740)	0.331 (0.0483 - 2.275)	0.770 (0.434 - 1.367)	0.878 (0.170 - 4.528)
Safety-Net × Low Income		0.872 (0.686 - 1.109)	2.090 (0.911 - 4.797)	1.091 (0.910 - 1.307)	1.925* (1.026 - 3.614)	-	-	-	-
Safety-Net × Low Education		0.586* (0.387 - 0.888)	1.151 (0.532 - 2.489)	0.743 (0.512 - 1.079)	1.654 (0.883 - 3.097)	-	-	-	-
Safety-Net × PAC Locations	**× HHA**	0.826 (0.553 - 1.235)	0.114** (0.0656 - 0.199)	-	-	0.862 (0.578 - 1.285)	0.108** (0.0666 - 0.175)	-	-
	× SNF	1.013 (0.817 - 1.255)	0.729 (0.375 - 1.416)	-	-	1.139 (0.893 - 1.451)	0.648 (0.291 - 1.445)	-	-
	AIC	40389.6		13716.0		44787.2		15144.5	
	BIC	40546.8		13873.2		44951.9		15301.7	

Control variables including patient characteristics, hospital characteristics, area health resource, et al.
** p<0.01, * p<0.05



	Full set of variables + PAC Locations			Full set of variables			Claims-only variables + PAC Locations			Claims-only variables		
	No Event	Readmission	Hospice/Death	No Event	Readmission	Hospice/Death	No Event	Readmission	Hospice/Death	No Event	Readmission	Hospice/Death
Contrast	-.0222042 **	.0334886 **	-.0112845 **	-.0226994 **	.0278914 **	-.0051919	-.0337123 **	.0417799 **	-.0080676 **	-.029872 **	.0322835 **	-.0024115
p-value	0.035	0.002	0.000	0.040	0.032	0.059	0.034	0.011	0.011	0.012	0.025	0.491

Figure 5.1. Predicted probabilities of post-discharge outcomes by hospital safety-net status. (*p<0.05, from full set of variables model and claims-only model with and without PAC location adjusted)

Figure 5.2a. Predicted post-discharge outcomes for Dual patients
(* p<0.05, full set of variables + PAC location adjusted)

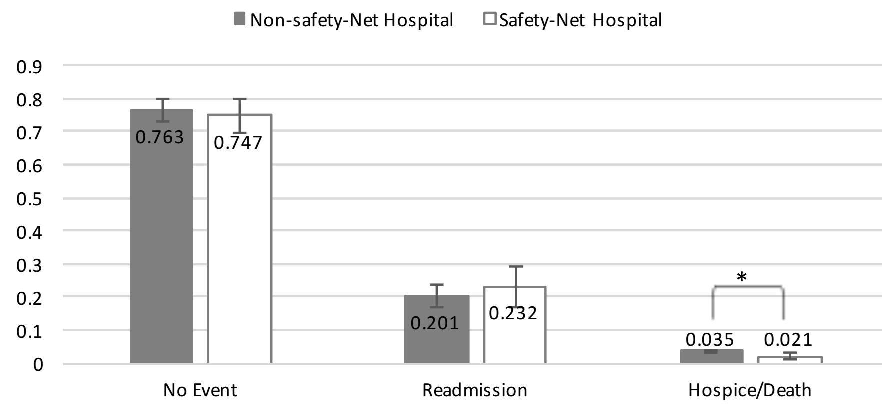


Figure 5.2b. Predicted post-discharge outcomes for Non-dual patients
(* p<0.05, full set of variables + PAC location adjusted)

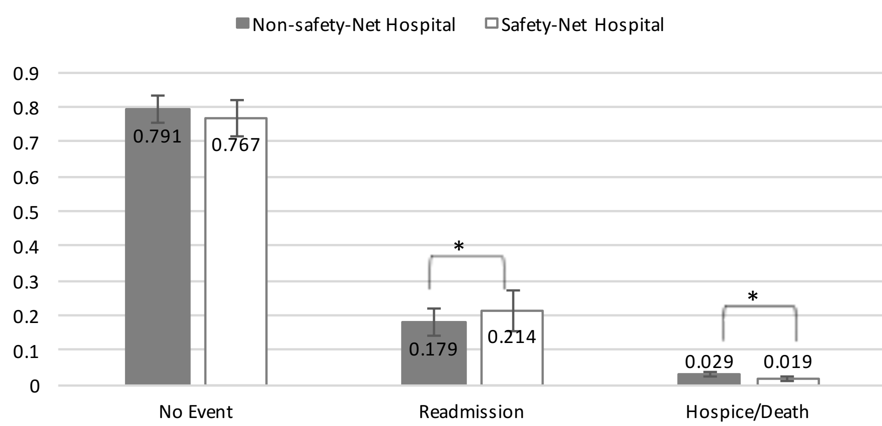
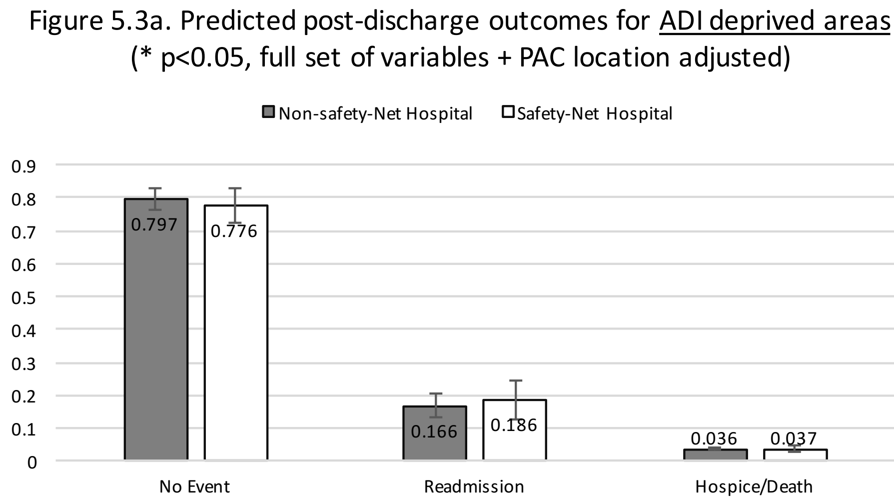


Figure 5.2. Predicted post-discharge outcomes for dual vs. non-dual patients.



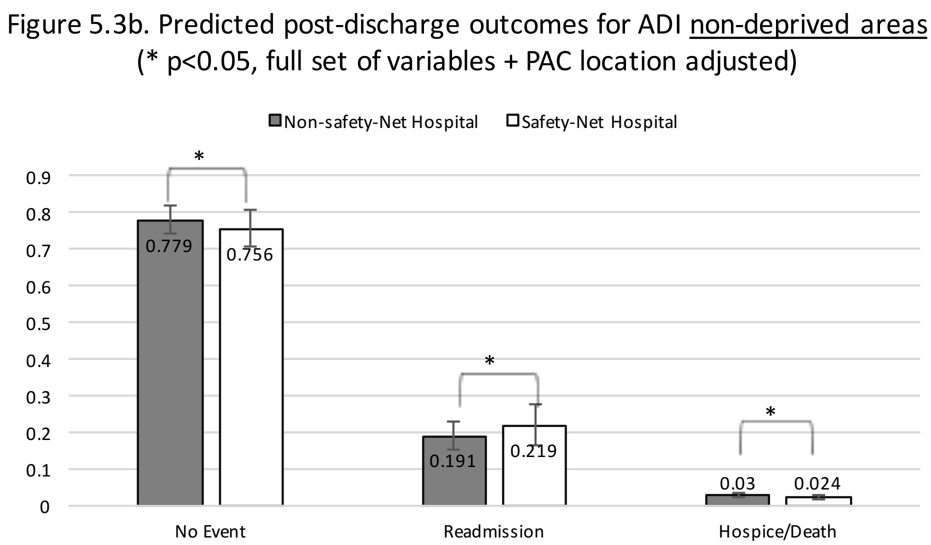


Figure 5.3. Predicted post-discharge outcomes for deprived vs. non-deprived ADI areas.

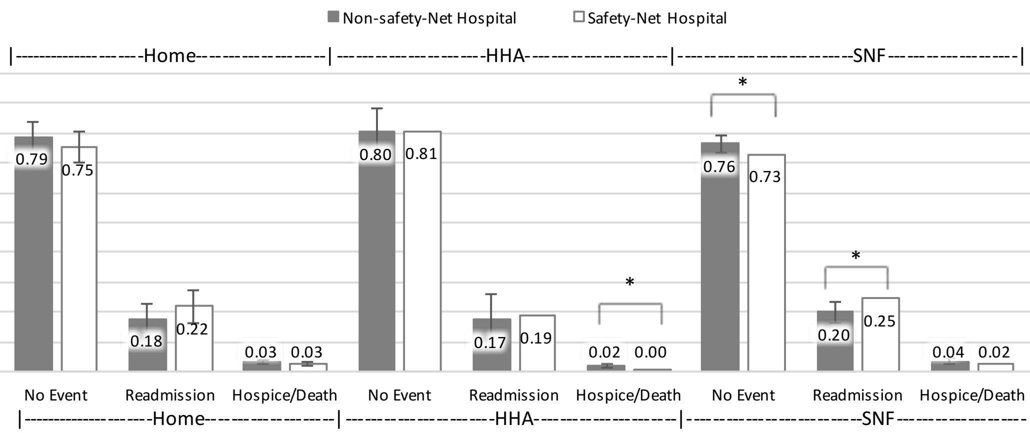


Figure 5.4. Post-discharge outcomes by PAC location.
(*p<0.05, full set of variables + PAC location adjusted)

CHAPTER 6. DISCUSSION AND CONCLUSION

Outcomes and Contribution

This dissertation examined the association of SES at the individual level and area level with outcomes following hospital discharge. Data came from hospitalizations and 30-day outcomes (including post–acute care use) for participants in a nationally representative survey of Medicare beneficiaries (the MCBS) from 2006 to 2011. The approach considered the influence of PAC locations and other options for variable selection (i.e., using full set of variables or using claims-only variables). The study has the following major findings:

1) The role of SES measures

Low SES levels (especially dual status) were associated with worse post-discharge outcomes (i.e., higher 30-day readmission rates), and the associations were modestly influenced by PAC location and variable source selection. Generally, the estimated effects for dual eligibility were bigger in the claims model compared to the full model. The study showed that the SES measures of dual status and living in a highly deprived county were likely sufficient to capture effects of SES and that additional measures such as education and income may not be needed. This finding is helpful because SES measures of education and income are not available in existing data sources and could be expensive to collect for the full Medicare population.

One conceivable implication of the study may be additional support for developing payment policies to enable hospitals to improve post-discharge outcomes by SES information, using dual eligibility and ADI levels. Given the inherent problem of different quality standards if HRRP adjusts for SES as stated by Dr. Krumholz, a better approach could be to consider the SES level in interventions to prevent readmissions. The goal is to promote high quality of care for all providers but address the obstacles that caused by low patient SES levels.

2) The role of discharging hospital safety-net status

Safety-net status was associated with post-discharge outcomes regardless of patients' SES level and model variable selection. Although under the current policy safety-net hospitals were at a higher risk of being penalized because of their high proportion of low-SES patients, results from this study suggested that outcomes for patients treated at safety-net hospital differ according to the patients' SES level. To evaluate safety-net hospital performance for low-SES patients, this study also estimated the probabilities of post-discharge outcomes by dual eligible and safety-net status. The results suggested that safety-net hospitals did not have worse outcomes for dual patients compared to non-safety-net hospitals; readmission rates were similar and hospice/death rates were lower. However, high-SES patients at safety-net hospitals had worse outcomes. These finding suggested that the overall poorer performance of safety-net hospitals may be mainly caused by worse outcomes for high-SES patients. This finding implies that hospitals' performance might be limited by deprived individual-level resources, so that patients with low individual SES had the same poor outcomes regardless of hospital safety-net status. When the individual resources were better, patients from non–safety-net hospitals had better outcomes. This finding indicated that policy research should focus on measuring the limitation of individual resources and on preventing readmissions for patients with low SES. Information is needed for policy alternatives to ensure that low-SES patients receive appropriate resources throughout hospital care and post-discharge care so as to achieve same outcome with high-SES patients.

However, the area-level SES seemed to affect the outcome in another direction. With area resources limited, patients had the same outcome regardless of hospital's safety-net status. When the area resources were better, patients from non–safety-net hospitals had higher readmission rates. This could be due to the fact that readmission is a measurement of use. Higher readmission rates in higher SES areas could result from better access to care and lower mortality rate of this area. This finding indicated that a better measurement of readmissions (e.g., avoidable readmissions) that can accurately reflect the poor quality of care should be developed for the payment policy.

3) The role of PAC location

SES levels along with other individual- and healthcare-related case-mix factors were also associated with PAC location choice. These case-mix factors were associated with post-discharge outcomes too. Therefore, weighting methods to address the case-mix severity among PAC locations were important for studies evaluating the associations between PAC locations and post-discharge outcomes. Area-level and individual-level SES were important to be included in such studies because they had opposite direction in their effects. For example, dual eligible patients were more likely to use SNFs while patients living in deprived areas were less likely to use SNFs. This finding implied that low individual SES was associated with higher SNF use, but area resource deprivation might cause low access to care and result in lower SNF use. This result indicated that policy research examining disparities in care use by SES levels needs to be addressed. To be more specific, studies should examine the extent to which the higher usage among patients with low individual SES is caused by poorer health outcomes and the extent to which the low use among patients with low area SES is due to access to care.

Besides the association of SES with type of PAC used, this study found that the effect of PAC locations on the association of SES and post-discharge outcomes were modest. However, PAC locations were associated with post-discharge outcomes. Specifically, patients discharged to SNFs had higher readmission rates and higher hospice/death rates compared to HHAs. These findings suggested that the effect of PAC type, specifically SNFs, was independent of patient's SES level, because adding PAC location didn't affect the association of SES with outcomes. However, studies reported that patient's SES level was associated with the quality and type of SNF.[38,65,66] Further study is needed to examine outcomes by subgroups of SNFs by quality and type indicators (e.g., star-rating system) to see if the associations vary by quality of SNF.

PAC location had an effect on the post-discharge outcomes that varied by safety-net status, especially for SNFs and HHAs: For patients discharged to HHAs, those who received care from safety-net hospitals had similar readmission rate but a lower hospice/death rate; for patients discharged to SNFs, those who received care from safety-net hospitals had higher readmission rates. Overall, patients from safety-net hospitals had a higher readmission rate, and SNFs were the only PAC location that contributed to the higher readmission rate for safety-net patients. It can be hypothesized that if post-discharge outcomes were evaluated without including PAC locations, the poor evaluation results could indicate the low quality of care provided by the hospitals and/or SNFs. This approach creates problems because penalties based on this evaluation will make hospitals (especially safety-net hospitals) absorb the consequences of low quality of care provided by SNFs. In this case, policies examining integrated systems including both of hospitals and PAC (e.g., bundle payment) could be a better approach to consider. However, further studies are needed on the associations between safety-net hospitals and the quality and type of SNF.

<u>4) Model variable selection</u>

Overall, the estimations of post-discharge outcomes considered three components: 1) using claims data only versus additional variables from surveys or other sources, 2) using dual eligibility and area deprivation levels as the SES measure rather than also controlling for income and education, and 3) adjusting for hospital safety-net status. Models using claims data only variables had better performance in predicting the post-discharge outcomes (with lower AIC/BIC scores) so that efforts to collect survey information could be avoided. Hospital and area resource variables had very modest effects on the association, which were not considered to be critical in the evaluation. Measures from survey data had greater effects on associations, but they may not explain sufficient additional variation for consideration in payment policy, especially given the time and effort involved in the survey data collection. The regression results suggested that adding the additional measures to the claims-only measures decreases the associations between SES and the PAC location as well as 30-day post-discharge outcomes. The study results should be useful to policy makers who may want to consider whether currently available data are sufficient for post-discharge outcome evaluation.

Models using claims data only (versus additional survey, hospital, or area measures) seemed to provide estimates greater in magnitude for both PAC use and post-discharge outcomes. Adding survey information into the models attenuated the estimated effects of SES measures, but the differences did not lead to difference in predicted post-acute outcomes. Therefore, the results suggested that using claims data is sufficient for post-discharge outcome evaluation rather than identifying a need to undertake the time and efforts in survey information collection.

5) Post-discharge outcome evaluation

This study included outcome categories based on claims data (i.e., readmission, hospice, death, and no event) to evaluate the quality of care patients received during index hospitalizations. The Institute of Medicine (IOM) defined quality of care as: “the degree to which health service for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge.”[79] Therefore, high quality of care should be defined as low likelihood of adverse events during the post-discharge period, especially unplanned readmission. Higher readmission rates were not necessarily related to poor quality of care but could result from good access of care and low mortality rates. Therefore, readmission can only reflect the outcome partially. Mortality can reflect the quality of care in cases where death is avoidable. Although referral to hospice may represent very appropriate care for terminally ill patients with poor prognosis, hospice referrals within 30 days were grouped with mortality because referrals to hospice usually lowers the likelihood of hospital readmissions and indicate limited life expectancy. Penalties based on readmission rates without examining mortality rates could potentially put hospitals in inappropriate punishment category that would not necessarily link to low quality of care.[21,77] Payment systems, if built on this mechanism, could harm the hospitals’ ability in managing severe and vulnerable patients and put the healthcare system into the direction of low readmission rates and higher mortality rates. With all these concerns, a better measure is needed that can reflect the actual quality of care provided by hospitals or the integrated system that includes all the players in the post–acute care pathways. One approach is to distinguish the “bad” readmissions (e.g., avoidable readmissions, malpractice cases) from “good” readmissions (e.g., unavoidable readmissions). These study results strongly support future policy research focus on this direction, which is especially important in evaluation of safety-net hospitals vs. non–safety-net hospitals, given that safety-net hospitals were penalized for their lower performance under the current payment system.

Significance

This study was significant because it addressed the important issue of how SES is associated with post–acute care use and post-discharge outcomes. First, patients with different SES might have different trajectories (care pathways) in disease progression, but the role of SES is understudied. Second, it is important to know the extent to which area-based versus individual SES plays a role. Some individual-level SES such as income and education are not available in claims data. From the policy-making perspective, if area-based SES measures are associated with outcomes, then claims data may be used to identify such measures based on patient residence. Depending on the relative empirical contribution of these measures, an area-level measure would arguably provide better incentives by accounting for the areas served by hospitals without targeting specific individuals. However, this study found that in addition to area-based measures, individual-level SES has significant separate effect on readmissions as well. Dual eligibility is also easily available from Medicare claims.

This study was significant because it addressed the issues of disparities in both care use and outcomes among patients with low SES. Specifically, the study responded to CMS's initiatives that hospitals should focus on improving quality of care, reducing unnecessary costs, and reducing the care disparities.[48] By far, it has been found that low SES contributes to worse health outcomes and higher likelihood of early readmissions, but the reasons why this impact exists are still unknown.[40,43] Through this study, we better understand the role of SES and what influential factors were in the post-discharge process. The results may help construct policies to better address the role of patient SES and achieve better outcomes for those vulnerable patients.

Furthermore, this study also helped assess the role of safety-net hospital status in associations of SES with post-discharge outcomes. The study results compared the outcomes of patients discharged from safety-net vs. non–safety-net hospitals, taking SES levels and PAC locations into consideration. To be more specific, this study is significant for providing evidence for policy alternatives pertaining to safety-net status.

Limitations

The estimates may still be subject to bias from the selection of SES measures or PAC location based on unobserved variables. For example, the disease severity for some chronic diseases was unavailable (e.g., pulmonary function for COPD, Hb1Ac for diabetic patients, et al.). These factors may affect the PAC selection and the post-discharge outcomes, resulting in bias in the estimates. However, multiple case-mix variables were used (e.g., Charlson index, physician visits within six months prior to the index hospitalizations, self-reported health status, admitted from ER or not, etc.) and propensity score weighting method to estimate and control for disease severity indirectly.

This study did not include all the variables used by the HRRP adjustment for the excess readmission rates. The penalty was not only based on the excess readmission rates but also the excess payment amount. This study only looked at the readmission rates while controlling for case-mix variables, which were similar to the variables used for HRRP adjustment (age, sex). This study adjusted for DRG weights, Charlson index, and other achievable variables from claims data and other resources to control for case-mix severity. Although the analyses in this study did not replicate the HRRP adjustment, they did show the strong associations between SES measures such as dual eligibility and the choice of PAC location and probability of readmission.

This study used claims-based post-discharge outcomes therefore was limited to looking at readmission and hospice use or death. However, post-discharge outcomes were not limited to these categories. Other studies evaluated post-discharge outcomes using a broader spectrum of measures including functional measures, quality of life, patients' perception of care, and others.[80,81]

The study analysis was from 2006 to 2011, which was entirely prior to the start of the HRRP. The contribution of this strategy was to reveal the associations and outcome predictions without the influence of HRRP. However, some of the associations might have changed since the HRRP started and it is very important to examine them under HRRP.

This study used a dichotomous measure of dual status because the sample size was not sufficient to estimate the effect of full status vs. partial status. Full dual status reflects lower income than partial status, and full and partial status could have different effects for post–acute care use and post-discharge outcomes.

This study defined individual annual income equal to or more than $25,000 as high income and income less than $25,000 as low income. This method was used to maximize the sample size from MCBS survey results because a continuous measure of income was missing for many respondents. The median per capita income among Medicare beneficiaries was $26,200 in 2016 and this level was stable over years. Therefore, income below $25,000 could be considered as low income among all the Medicare beneficiaries. However, the associations between income and outcome may be different among the middle income and high income groups.

The quality of PAC services was not measurable in this study. The star-rating of SNFs or HHAs was considered, but this measure was not available for a number of SNFs or HHAs during the study period. Previous studies suggested that low-SES patients were more likely to receive care from SNFs with lower star-ratings[65] and that the quality of SNF was associated with the post-discharge outcomes.[73] Controlling for PAC quality could be helpful in future research but was unobservable in this study.

Innovation

Several elements contributed to the innovative nature of this study. First, the post-discharge outcomes in this study included no event, readmission, and hospice/death while many of other studies only addressed readmissions with some addressed mortality rates. This measure better reflected the post-discharge outcomes, especially given readmission has the feature of usage. Second, the likelihood of various PAC locations based on SES levels was examined. In this way, the associations of SES with PAC location choice were assessed to enable a better understanding of the care needs and situation for low-SES patients after discharge. The predicted probabilities were used in the propensity score weighting for the outcome analysis to address possible selection of different PAC locations. Third, in measuring SES, both individual- and area-based SES measures were explored. Many studies used area-based SES measures because claims data lack individual-level SES information such as education or income. The advantage of using the MCBS is that it includes individual SES information on income and education and therefore allows such analysis to be accomplished. Furthermore, this study compared the full variable set model with the claims-only model to address the question of whether the current information (i.e., claims data) is sufficient for the evaluation purpose.

Future Directions

The type of PAC used following hospital discharge is very important. We found that patients had multiple PAC locations after discharge from hospitals. This study examined the first PAC locations within 30 days of post-discharge. However, the effects of sequences of various types of PACs and the composition of multi-type care need to be further examined.

CMS uses a quality star-rating system to measure SNF quality. Although some evidence indicates that the star-rating isn't necessarily associated with 30-day hospital readmission and mortality,[82] it would have been beneficial to explore whether safety-net status is associated with discharge to higher quality SNFs. Unfortunately, the star-rating was missing for too many SNF discharges in the sample to allow analysis, but the issue should be examined in future studies.

Besides readmission rate, other outcome measures for patients who were readmitted into hospital need to be examined further. These outcomes include measures available from claims (e.g., the length of hospital stay for the early readmissions, hospital mortality rate, and post-discharge experience) as well as other measures of health status and function. These outcomes can be an indicator for policy target or disease monitoring. Examining the impact of SES on these variables will be helpful to address the disparity issue of health use and outcomes among low-SES patients. Patient-centered perspective studies on the hospital care, transitional care, and post-discharge care are needed for low-SES patients. To better address the SES-related health disparities, patient-centered outcomes (e.g., quality of life, physical function, and cognitive ability) need to be examined.

SES impact on cost of readmission needs to be examined as well. The readmission rate and costs of readmission are not necessary related but to reduce the financial burden of readmission, these need to be examined. The role of SES needs to be examined as well, to provide information for hospitals with high share of low-SES patients and help them use already limited financial resources more efficiently. The excessive payment rate was examined under HRRP, therefore studies on costs during hospitalization and the post-discharge period will be of most policy relevance.

Because this study analysis was from 2006 to 2011, which was entirely prior to 2012 when HRRP was started, the estimated associations do not reflect the effect of HRRP. Changes could happen under the influence of HRRP, and it is very important to analyze the changes under HRRP to better understand current associations.

Conclusion

SES levels were associated with the type of PAC used and post-discharge outcomes. Including both an individual SES measure (i.e., dual eligibility) and an area-level SES measure (i.e., ADI) may be important in assessing both PAC use and outcomes. These SES measures from claims data may be sufficient for consideration for possible incorporation into payment policy. Hospital and area health resource measures only had very modest effects on the association of SES measures with PAC type.

PAC locations modestly influenced the associations between SES measures and 30-day post-discharge outcomes. However, inclusion of any choice variable such as PAC location in reimbursement formulas may lead to unintended consequences (i.e., patients may be diverted to a particular PAC location to ensure a higher reimbursement). Although the concern of unintended consequences of including dual status or ADI in a payment formula exists, these measures may reflect underlying patient needs that are not easily manipulated by providers and therefore some modification could be required to increase fairness in compensation.

Safety-net status was associated with post-discharge outcomes, and the association varies between PAC locations and SES levels. Because of the concern that safety-net hospital patients might not get sufficient resources,[5] the findings from this study suggested that policy alternatives are needed that can appropriately measure the quality of care provided by hospitals with higher proportions of vulnerable patients (i.e., safety-net hospitals). Although SES was not adjusted in the HRRP, alternative approaches such as modifications to the reimbursement strategy or health system structure may be worth considering to provide incentives to provide care commensurate with patient’s needs. For example, CMS could consider whether additional payments for case management services to dual patients or patients living in deprived areas could be beneficial. Other resources at the hospital level should be addressed as well. This will help address the issue that these high-need patients who may require more case management resources will be appropriately managed in hospitals, even in safety-net hospitals with a higher share of these high-need patients.

In summary, this study found that evaluating the high readmission rates using the relatively immutable patient characteristics of dual status and ADI (at least relatively immutable to an individual hospital) might enable appropriate support to patients with low SES levels as well as to hospitals caring for a large proportion of low-SES patients while aiming for the same high quality regardless of patient's SES status.

APPENDIX I. TABLES AND FIGURES

Table A: Formulas to Calculate the Readmission Adjustment Factor

Excess readmission ratio = risk-adjusted predicted readmissions/risk-adjusted expected readmissions
Aggregate payments for excess readmissions = [sum of base operating DRG payments for AMI x (excess readmission ratio for AMI-1)] + [sum of base operating DRG payments for HF x (excess readmission ratio for HF-1)] + [sum of base operating DRG payments for PN x (excess readmission ratio for PN-1)] + [sum of base operating DRG payments for COPD x (excess readmission ratio for COPD-1)] + [sum of base operating payments for THA/TKA x (excess readmission ratio for THA/TKA -1)] *Note, if a hospital's excess readmission ratio for a condition is less than/equal to 1, then there are no aggregate payments for excess readmissions for that condition included in this calculation. "The proposed readmission measures are risk- standardized readmission measures that adjust for case-mix differences based on the clinical status of the patient at the time of admission to the hospital. That is, they are risk-adjusted for certain key variables (for example, age, sex, co- morbid diseases and indicators of patient frailty) that are clinically relevant and/or have been found to have strong relationships with the outcome." (42 CFR Parts 412, 413, and 476, 51670)
Aggregate payments for all discharges = sum of base operating DRG payments for all discharges
Ratio = 1 - (Aggregate payments for excess readmissions/ Aggregate payments for all discharges)
Readmissions Adjustment Factor = the higher of the Ratio or 0.97 (3% reduction). (For FY 2013, the higher of the Ratio or 0.99% (1% reduction), and for FY 2014, the higher of the Ratio or 0.98% (2% reduction).)

Centers for Medicare & Medicaid Services. **Readmissions reduction program**. https://www.cms.gov/medicare/medicare-fee-for-service-payment/acuteinpatientpps/readmissions-reduction-program.html. Updated 2014. Accessed 08/20, 2015.

Table B: Selected medical/public health-related studies with SES indicators

Type of SES measure	SES Components	Data Set Used to Measure SES	Study Topic	Authors, year
Area-based (zip code)	- Income - Education - Wealth - Housing - Employment status	Census	Race-ethnicity codes and SES indicators for Medicare beneficiaries	Bonito, *et al.*, 2008 [57]
Area-based (county + zip code)	- Educational attainment (individual) - Area-based SES indicators: median household income, poverty*, college or higher education*, unemployment* - Neighborhood Deprivation Index (NDI) - SES index by AHRQ	Electronic Health Record, Census	Health care quality, delivery and disparity	Bonito, *et al.*, 2015[21] Berkowitz, *et al.*, 2015 [57,65]
Mixed-level (household + individual)	- Government poverty line (household) - Education (individual)	Survey	Child development	Betancourt, *et al.*, 2015 [66] Hackman, *et al.*, 2015[24]
Area-based (county)	- Area deprivation index (ADI) score using Singh method[24]	Medicare, Census	30-day rehospitalization	Kind, *et al.*, 2015 [53,67] Singh, *et al.*, 2015[24]
Area-based (zipcode)	- Education - Job type - Government poverty line - Rent - Income	Survey	Breast Cancer	Shariff-Marc, *et al.*, 2015[25]
Individual level	- Education (individual) - Employment (individual)	Primary clinical data	Acute coronary syndrome prevention	Abbasi, *et al.*, 2015[26]
Mixed-levels (area + individual)	Model 1: - Age, sex, comorbidities, hospital (all individual level) Model 2: - Age, sex, comorbidities, hospital (all individual level) - AHRQ SES index	Census, Medicare fee-for-service	Hospital profiling	Blum, *et al.*, 2015[27]
Area-based (county)	- Median household income - Median home value - Education	Guidelines®-Heart Failure™ (GWTG-HF) Registry,	Heart Failure	Eapen, *et al.*, 2015[28]

	- Career (white collar)	county-level census data		
Area-based (address)	- Poverty - Education - Median household income	CMS	Hospital readmission	Hu, *et al.*, 2015[29]

EHR, electronic health record
Census, U.S. Bureau of the Census
* Percentage of persons

Table C. Descriptive statistics by PAC locations.

VARIABLES		Home n=7,363 mean (sd), n(%)		HHA n=2,430 mean (sd), n(%)		SNF n=3,380 mean (sd), n(%)		IRF n=451 mean (sd), n(%)		Between groups p-value
SES Measures										
Dual eligibility		1,345	(18.3%)	453	(18.6%)	959	(28.4%)	72	(16.0%)	<0.0001
Area Deprivation Index		407	(0.055)	106	(0.044)	138	(0.041)	19	(0.042)	0.005
Person's income level < $25,000		4,122	(56.0%)	1,486	(61.2%)	2,329	(68.9%)	263	(58.3%)	<0.0001
Person's Education under high school		2,318	(31.5%)	816	(33.6%)	1,160	(34.3%)	109	(24.2%)	<0.0001
Individual Characteristics										
Race	**White**	6,356	(86.4%)	2,071	(85.4%)	2,954	(87.6%)	403	(89.6%)	0.025
	Black	738	(10.0%)	252	(10.4%)	325	(9.6%)	37	(8.2%)	
	Other	261	(3.5%)	103	(4.2%)	94	(2.8%)	10	(2.2%)	
Age at Index Hospital Stay		78.59	(7.547)	80.24	(7.631)	83.1	(7.586)	80.35	(7.155)	<0.0001
Gender, male		3,371	(45.8%)	879	(36.2%)	1,141	(33.8%)	180	(39.9%)	<0.0001
Currently Married		3,405	(46.2%)	931	(38.3%)	987	(29.2%)	179	(39.7%)	<0.0001
living with helper		2,722	(37.0%)	982	(40.4%)	620	(18.3%)	184	(40.8%)	<0.0001

Number of Children	**No child**	511	(7.0%)	199	(8.2%)	453	(13.9%)	34	(7.6%)	
	<= 3 chilren	4,229	(57.9%)	1,427	(59.1%)	2,006	(61.4%)	275	(61.4%)	<0.0001
	> 3 children	2,559	(35.1%)	787	(32.6%)	809	(24.8%)	139	(31.0%)	
Person living in metro area		5,194	(70.5%)	1,806	(74.3%)	2,524	(74.7%)	338	(74.9%)	<0.0001
Claim Years	**2006**	1,546	(21.0%)	489	(20.1%)	721	(21.3%)	102	(22.6%)	
	2007	1,530	(20.8%)	433	(17.8%)	678	(20.1%)	79	(17.5%)	
	2008	1,311	(17.8%)	450	(18.5%)	511	(15.1%)	77	(17.1%)	0.001
	2009	1,143	(15.5%)	408	(16.8%)	565	(16.7%)	67	(14.9%)	
	2010	1,131	(15.4%)	398	(16.4%)	540	(16.0%)	64	(14.2%)	
	2011	702	(9.5%)	252	(10.4%)	365	(10.8%)	62	(13.7%)	
Hospital stay Factors										
Admitted from ER		3,546	(48.2%)	1,032	(42.5%)	1,763	(52.2%)	191	(42.4%)	<0.0001
hospital stay length		2.974	(1.843)	2.995	(1.803)	2.987	(1.916)	2.929	(1.830)	0.8912
weekends discharge		1,595	(21.7%)	446	(18.4%)	379	(11.2%)	51	(11.3%)	<0.0001
DRG weights		1.311	(1.843)	1.539	(1.143)	1.571	(1.148)	2.169	(2.133)	<0.0001
Charlson index		1.85	(1.842)	1.906	(1.843)	1.912	(1.778)	1.844	(1.917)	0.3945
Health Related Factors										
General health status	**Excellent**	440	(6.6%)	109	(4.9%)	99	(5.1%)	20	(5.0%)	
	Very good	1,284	(19.3%)	362	(16.2%)	320	(16.4%)	79	(19.8%)	
	Good	2,229	(33.5%)	716	(32.0%)	610	(31.3%)	116	(29.1%)	<0.0001
	Fair	1,680	(25.2%)	616	(27.5%)	579	(29.7%)	111	(27.8%)	
	Poor	1,021	(15.3%)	433	(19.4%)	343	(17.6%)	73	(18.3%)	
With family helper or not		3,577	(48.6%)	1,390	(57.2%)	997	(29.5%)	212	(47.0%)	<0.0001
With health professional helper or not		237	(3.2%)	148	(6.1%)	141	(4.2%)	20	(4.4%)	<0.0001
Smoking status		646	(8.8%)	166	(6.8%)	148	(4.4%)	28	(6.2%)	<0.0001
unmet needs of function inpairment		2.13	(2.100)	2.95	(2.192)	3.15	(2.120)	3.05	(2.092)	<0.0001
ADL index		1.088	(1.485)	1.594	(1.744)	1.907	(1.806)	1.723	(1.793)	<0.0001
iADL index		0.7051	(1.246)	1.054	(1.470)	1.268	(1.584)	1.157	(1.520)	<0.0001
total number of visits (6 mo within)		5.488	(12.120)	1.054	(1.470)	7.72	(15.220)	1.148	(6.741)	<0.0001

Hospital Characteristics										
Hospital Types of Control	**Non-profit**	4,905	(66.6%)	1,522	(62.6%)	2,263	(67.0%)	298	(66.1%)	
	For-profit	1,207	(16.4%)	451	(18.6%)	565	(16.7%)	87	(19.3%)	0.003
	Government	1,096	(14.9%)	293	(12.1%)	446	(13.2%)	66	(14.6%)	
DSH hospital		5,604	(76.1%)	1,660	(68.3%)	2,486	(73.6%)	363	(80.5%)	<0.0001
Hospital's teaching status		3,295	(44.8%)	1,031	(42.4%)	1,466	(43.4%)	251	(55.7%)	<0.0001
Total inpatient bed size(size in 100)		3.06	(2.402)	3.1	(2.540)	2.886	(2.201)	3.553	(2.441)	<0.0001
Arear Health Resources										
# Phys,Primary Care, Patient Care/1,000 persons		0.709	(0.288)	0.7163	(0.290)	0.7322	(0.281)	0.7295	(0.271)	0.0011
# NP,Primary Care, Patient Care/1,000 persons		0.3533	(0.237)	0.3669	(0.254)	0.3778	(0.261)	0.3533	(0.222)	<0.0001
# Beds Nursing Facilities/1,000 pop		0.2843	(1.100)	0.2318	(0.989)	0.1929	(0.833)	0.2282	(0.551)	0.0002
# Home Health Agencies /1,000 pop		0.3416	(0.387)	0.3419	(0.382)	0.336	(0.393)	0.356	(0.371)	0.7387
# Beds Skilled Nursing Facilities/1,000 pop		5.842	(3.189)	5.761	(3.186)	6.149	(3.243)	5.924	(3.525)	<0.0001
# Beds Long Term Care hospital/ 1,000 pop		0.2347	(0.894)	2.657	(0.783)	0.2957	(0.815)	0.2833	(0.855)	0.0035
# Beds Short-term community hospital/1,000 pop		2.672	(1.503)	2.657	(1.527)	2.61	(1.500)	2.65	(1.358)	0.259
Area Control										
Census Divisions	**New England**	213	(2.9%)	87	(13.7%)	215	(6.4%)	7	(1.6%)	
	Middle Atlantic	989	(13.4%)	89	(14.0%)	562	(16.6%)	62	(13.7%)	
	East North Central	1,396	(19.0%)	96	(15.1%)	612	(18.1%)	99	(22.0%)	
	West North Central	585	(7.9%)	85	(13.3%)	238	(7.0%)	42	(9.3%)	
	South Atlantic/Puerto Rico	1,637	(22.2%)	37	(5.8%)	646	(19.1%)	71	(15.7%)	<0.0001
	East South Central	821	(11.2%)	21	(3.3%)	343	(10.1%)	32	(7.1%)	
	West South Central	748	(10.2%)	48	(7.5%)	321	(9.5%)	91	(20.2%)	
	Mountain	378	(5.1%)	78	(12.2%)	145	(4.3%)	30	(6.7%)	
	Pacific	596	(8.1%)	96	(15.1%)	298	(8.8%)	17	(3.8%)	

*Status were evaluated up to 1 year before index hospital stay.

Table D. Regression models with or without multiple imputation or survey cross-sectional weights

	Claims Data Variables only (w/o Multiple Imputation)						Claims Data Variables only (w/ Survey cross-sectional weights)						Claims Data Variables only (w/ Multiple Imputation)					
	HHA (n=2,430)		SNF (n=3,380)		IRF (n=451)		HHA (n=2,430)		SNF (n=3,380)		IRF (n=451)		HHA (n=2,430)		SNF (n=3,380)		IRF (n=451)	
VARI-ABLES	Odds Ratio	(se)	Odds Ratio	(se)	Odds Ratio	(se)	Odds Ratio	(se)	Odds Ratio	(se)	Odds Ratio	(se)	Odds Ratio	(se)	Odds Ratio	(se)	Odds Ratio	(se)
SES Measures																		
Deprived Area	0.688**	(0.021)	0.645**	(0.005)	0.696**	(0.009)	0.726	(0.035)	0.710*	(0.042)	0.733	(0.120)	0.744**	(0.019)	0.662**	(0.007)	0.704**	(0.050)
Dual eligibility	1.004	(0.002)	2.005**	(0.003)	0.961	(0.074)	1.051	(0.012)	1.935**	(0.028)	1.005	(0.051)	1.004	(0.003)	1.992**	(0.002)	0.950	(0.970)
Individual Characteristics																		
Race: White	Reference						Reference						Reference					
Black	1.091	(0.016)	0.803**	(0.006)	0.789	(0.047)	1.093	(0.019)	0.823	(0.028)	0.913	(0.108)	1.081	(0.017)	0.806**	(0.006)	0.782	(0.022)
Other	1.202	(0.029)	0.520**	(0.004)	0.630	(0.147)	1.220	(0.065)	0.542**	(0.039)	0.665	(0.190)	1.197	(0.035)	0.520**	(0.004)	0.613	(0.248)
Age at Index Hospital Stay	1.032**	(0.000)	1.086**	(0.000)	1.040**	(0.000)	1.032**	-(0.001)	1.086**	(0.000)	1.046**	(0.000)	1.032**	(0.000)	1.086**	(0.000)	1.041**	-(0.045)
Gender, male	0.658**	(0.000)	0.691**	(0.003)	0.701**	(0.023)	0.637**	(0.004)	0.666**	(0.005)	0.658**	(0.021)	0.661**	(0.001)	0.690**	(0.003)	0.713*	(0.050)
Claim Years: 2006	Reference						Reference						Reference					
2007	0.888	(0.014)	0.929*	(0.002)	0.844	(0.086)	0.903	(0.012)	0.968	(0.013)	0.942	(0.062)	0.901	(0.014)	0.950	(0.002)	0.801	-(0.065)
2008	1.094	(0.013)	0.867	(0.017)	0.894	(0.029)	1.141	(0.016)	0.896	(0.015)	0.876	(0.051)	1.086	(0.011)	0.859	(0.015)	0.892	(0.064)
2009	1.140*	(0.008)	1.074*	(0.002)	0.934	(0.066)	1.132	(0.016)	1.111	(0.018)	0.967	(0.062)	1.134*	(0.006)	1.063	(0.003)	0.920	-(0.083)
2010	1.015	(0.003)	1.048	(0.004)	0.991	(0.131)	1.028	(0.015)	1.097	(0.019)	1.005	(0.070)	1.012	(0.004)	1.033	(0.004)	0.959	(0.037)
2011	1.022	(0.002)	1.264**	(0.004)	1.551	(0.230)	1.010	(0.021)	1.333**	(0.032)	1.483	(0.118)	0.981	(0.002)	1.206**	(0.004)	1.437	(0.409)
Hospital stay Factors#																		
Admitted from ER	0.799**	(0.005)	1.165**	(0.002)	0.870	(0.068)	0.761*	(0.005)	1.173**	(0.007)	0.831	(0.024)	0.796**	(0.005)	1.192**	(0.003)	0.889	-(0.230)
hospital stay length	1.009	(0.000)	1.017	(0.000)	1.009	(0.001)	1.013	(0.001)	1.016	(0.000)	1.014	(0.001)	1.012	(0.000)	1.018	(0.000)	1.007	-(0.010)
weekends discharge	0.819**	(0.008)	0.474**	(0.004)	0.488**	(0.015)	0.835*	(0.007)	0.469**	(0.004)	0.516**	(0.026)	0.822**	(0.007)	0.479**	(0.004)	0.486**	(0.021)
DRG weights	1.293**	(0.003)	1.415**	(0.001)	1.623**	(0.004)	1.316*	(0.002)	1.422**	(0.003)	1.618**	(0.005)	1.280**	(0.003)	1.401**	(0.000)	1.605**	(0.208)

Charlson index	1.028**	(0.000)	1.024*	(0.000)	0.999	(0.001)	1.042*	(0.001)	1.026	(0.000)	1.006	(0.002)	1.028**	-(0.001)	1.026**	(0.001)	1.001	-(0.025)
Health Related Factors																		
total number of visits prior 6 months	1.001	(0.000)	1.012**	(0.000)	0.864**	(0.003)	1.001	(0.000)	1.012**	(0.000)	0.844**	(0.004)	1.000	(0.000)	1.012**	(0.000)	0.882**	-(0.130)

Table E. Predicted probabilities of PAC locations

	Claims + Hospital + AHRF + Survey				**Claims Data Variables only**			
VARIABLES	**Home (n=7,363)** Predicted Pr (95%CI)	**HHA (n=2,430)** Predicted Pr (95%CI)	**SNF (n=3,380)** Predicted Pr (95%CI)	**IRF (n=451)** Predicted Pr (95%CI)	**Home (n=7,363)** Predicted Pr (95%CI)	**HHA (n=2,430)** Predicted Pr (95%CI)	**SNF (n=3,380)** Predicted Pr (95%CI)	**IRF (n=451)** Predicted Pr (95%CI)
High income	0.560 (0.536 - 0.583)	0.179 (0.173 - 0.184)	0.230 (0.222 - 0.238)	0.032 (0.0203 - 0.0437)				
Low Income	0.529 (0.508 - 0.549)	0.179 (0.171 - 0.187)	0.258 (0.252 - 0.265)	0.034 (0.0232 - 0.0449)				
Not Deprived Area	0.537 (0.517 - 0.557)	0.179 (0.173 - 0.185)	0.251 (0.245 - 0.257)	0.033 (0.0221 - 0.0441)	0.537 (0.509 - 0.564)	0.179 (0.172 - 0.187)	0.251 (0.242 - 0.260)	0.033 (0.0211 - 0.0456)
Deprived Area	0.605 (0.560 - 0.651)	0.167 (0.140 - 0.193)	0.195 (0.178 - 0.213)	0.032 (0.0177 - 0.0478)	0.616 (0.567 - 0.666)	0.156 (0.128 - 0.184)	0.199 (0.182 - 0.217)	0.027 (0.0186 - 0.0373)
Not Dual Eligible	0.547 (0.526 - 0.569)	0.187 (0.179 - 0.194)	0.232 (0.227 - 0.238)	0.033 (0.0213 - 0.0458)	0.558 (0.528 - 0.588)	0.185 (0.175 - 0.195)	0.223 (0.215 - 0.230)	0.034 (0.0203 - 0.0489)
Dual Eligible	0.515 (0.490 - 0.540)	0.150 (0.141 - 0.160)	0.304 (0.289 - 0.318)	0.031 (0.0240 - 0.0384)	0.471 (0.449 - 0.494)	0.153 (0.146 - 0.160)	0.349 (0.332 - 0.365)	0.026 (0.0218 - 0.0318)
High Education	0.537 (0.516 - 0.559)	0.176 (0.166 - 0.186)	0.250 (0.246 - 0.253)	0.036 (0.0249 - 0.0488)				

Low Education	0.547 (0.527 - 0.567)	0.183 (0.171 - 0.194)	0.245 (0.230 - 0.261)	0.025 (0.0157 - 0.0349)
Non-Safety-net Hospital	0.534 (0.510 - 0.559)	0.179 (0.174 - 0.185)	0.253 (0.245 - 0.261)	0.033 (0.0218 - 0.0455)
Safety-Net Hospital	0.591 (0.574 - 0.607)	0.172 (0.157 - 0.188)	0.209 (0.189 - 0.230)	0.027 (0.0172 - 0.0384)

Table F. Propensity Scores by Post-Acute Care Locations

	ALL Patients		
Mean (sd)	0.445 (0.165)		
Group Size	3,380		
Discharge Places	**Home-Self Care**	**HHA**	**SNF**
Mean (sd)	0.618 (0.161)	0.220 (0.084)	0.377 (0.182)
Group Size	7,363	2,430	3,380

Table G. Inverse Probability Weights by Post-Acute Care Locations

	All Patients		
Mean (sd)	3.044 (5.6)		
Group Size	13,173		
Discharge Places	**Home-Self Care**	**HHA**	**SNF**
Mean (sd)	1.975 (6.86)	5.295 (2.216)	3.753 (3.102)
Group Size	7,363	2,430	3,380

Table H. Regression results on associations between SES measures with post-discharge outcomes (i.e. no event, Readmissions, hospice/death) with PAC location adjusted or not, multinomial logit regression, n=13,173

		Full Set of Variables + PAC (AIPW)		Full Set of Variables		Claims + PAC (AIPW)		Claims	
		(Reference group: no events during the 30-day post-discharge period)							
		Readmission	Hospice/Death	Readmission	Hospice/Death	Readmission	Hospice/Death	Readmission	Hospice/Death
		(2) Odds Ratio	(3) Odds Ratio	(5) Odds Ratio	(6) Odds Ratio	(8) Odds Ratio	(9) Odds Ratio	(11) Odds Ratio	(12) Odds Ratio
Person's annual income level < $25,000		0.864	0.943	0.961	1.160	-	-	-	-
		(0.740 - 1.009)	(0.668 - 1.330)	(0.846 - 1.091)	(0.883 - 1.524)				
Area deprivation level		0.887	1.485	0.814**	1.244	1.073	1.556**	1.072	1.550**
		(0.745 - 1.056)	(0.780 - 2.829)	(0.725 - 0.915)	(0.731 - 2.115)	(0.801 - 1.436)	(1.123 - 2.157)	(0.797 - 1.441)	(1.123 - 2.137)
Dual eligibility		1.209	1.322	1.135	1.157	1.324*	1.639**	1.323*	1.672**
		(0.953 - 1.533)	(0.994 - 1.759)	(0.943 - 1.366)	(0.961 - 1.393)	(1.025 - 1.709)	(1.366 - 1.966)	(1.027 - 1.703)	(1.380 - 2.025)
Person's education under high school		1.096	0.973	1.042	1.029	-	-	-	-
		(0.999 - 1.202)	(0.767 - 1.235)	(0.908 - 1.197)	(0.836 - 1.266)				
PAC locations	Home	Reference		-	-	Reference		-	-
	HHA discharge	0.908	0.541*	-	-	0.912	0.525*	-	-
		(0.757 - 1.088)	(0.320 - 0.916)			(0.770 - 1.080)	(0.309 - 0.892)		
	SNF discharge	1.156	1.183	-	-	1.176	1.223	-	-
		(0.953 - 1.403)	(0.885 - 1.582)			(0.974 - 1.421)	(0.901 - 1.659)		
Race	White	Reference		-	-	Reference		-	-
	Black	1.083	1.237*	1.155*	1.196	1.027	1.022	1.030	1.029
		(0.947 - 1.239)	(1.034 - 1.480)	(1.020 - 1.307)	(0.957 - 1.495)	(0.916 - 1.151)	(0.866 - 1.206)	(0.919 - 1.154)	(0.870 - 1.218)
	Other	0.912	0.765	0.969	0.831	0.942	0.559	0.944	0.554
		(0.724 - 1.148)	(0.380 - 1.539)	(0.794 - 1.182)	(0.499 - 1.383)	(0.748 - 1.187)	(0.279 - 1.120)	(0.751 - 1.187)	(0.279 - 1.097)
Age at index hospital stay		1.008*	1.075**	1.009*	1.086**	1.005	1.076**	1.005	1.078**
		(1.000 - 1.016)	(1.064 - 1.086)	(1.001 - 1.017)	(1.071 - 1.101)	(0.996 - 1.013)	(1.066 - 1.087)	(0.996 - 1.014)	(1.068 - 1.089)
Gender, male		0.986	1.546**	1.022	1.366**	1.058	1.463**	1.055	1.466**
		(0.883 - 1.102)	(1.275 - 1.875)	(0.933 - 1.119)	(1.224 - 1.524)	(0.956 - 1.172)	(1.282 - 1.670)	(0.954 - 1.167)	(1.280 - 1.680)
Currently married		1.278**	1.137	1.129**	1.231**	-	-	-	-
		(1.190 - 1.371)	(0.863 - 1.498)	(1.056 - 1.207)	(1.070 - 1.415)				
Person living with helper(s)		0.788**	0.606	0.919	0.807	-	-	-	-
		(0.660 - 0.940)	(0.266 - 1.382)	(0.837 - 1.009)	(0.517 - 1.259)				

Number of living children level	No child	Reference		Reference		-	-	-	-
	≤ 3 children	1.097	1.239	1.040	1.203	-	-	-	-
		(0.905 - 1.330)	(0.795 - 1.931)	(0.918 - 1.178)	(0.998 - 1.450)				
	> 3 children	1.151	1.125	1.047	1.027	-	-	-	-
		(0.862 - 1.536)	(0.699 - 1.811)	(0.898 - 1.222)	(0.875 - 1.205)				
Person living in metro area		0.875	0.689**	0.954	0.771**	-	-	-	-
		(0.734 - 1.042)	(0.532 - 0.892)	(0.832 - 1.093)	(0.667 - 0.890)				
Claim years	Year 2006	Reference		Reference		Reference		Reference	
	Year 2007	0.957	0.878	0.924	0.834**	0.985	0.913	0.990	0.920
		(0.854 - 1.071)	(0.713 - 1.080)	(0.819 - 1.043)	(0.765 - 0.910)	(0.874 - 1.109)	(0.740 - 1.127)	(0.878 - 1.116)	(0.769 - 1.100)
	Year 2008	0.990	0.750*	0.981	0.699*	1.021	0.756	1.022	0.759
		(0.843 - 1.163)	(0.591 - 0.951)	(0.886 - 1.088)	(0.514 - 0.950)	(0.889 - 1.173)	(0.567 - 1.009)	(0.884 - 1.182)	(0.573 - 1.006)
	Year 2009	0.896	0.516**	0.882	0.573**	0.914	0.513**	0.919	0.520**
		(0.767 - 1.047)	(0.416 - 0.639)	(0.763 - 1.020)	(0.448 - 0.733)	(0.777 - 1.075)	(0.413 - 0.638)	(0.779 - 1.083)	(0.417 - 0.649)
	Year 2010	0.908	0.652	1.002	0.683	0.960	0.707	0.962	0.701
		(0.804 - 1.025)	(0.424 - 1.004)	(0.895 - 1.122)	(0.454 - 1.026)	(0.845 - 1.092)	(0.471 - 1.061)	(0.846 - 1.094)	(0.463 - 1.063)
	Year 2011	0.843	1.012	0.921	1.116	0.890	1.143	0.894	1.133
		(0.706 - 1.007)	(0.711 - 1.440)	(0.803 - 1.057)	(0.887 - 1.402)	(0.759 - 1.042)	(0.744 - 1.756)	(0.766 - 1.043)	(0.726 - 1.766)
Admitted from ER		1.040	1.267	1.115**	1.349	1.097	1.329	1.098	1.305
		(0.914 - 1.184)	(0.847 - 1.895)	(1.034 - 1.202)	(0.899 - 2.024)	(0.945 - 1.274)	(0.835 - 2.114)	(0.946 - 1.276)	(0.812 - 2.098)
Hospital stay length		0.991	0.981	0.997	1.003	0.994	0.984	0.993	0.984
		(0.968 - 1.014)	(0.944 - 1.018)	(0.983 - 1.011)	(0.975 - 1.033)	(0.970 - 1.017)	(0.946 - 1.023)	(0.970 - 1.017)	(0.951 - 1.019)
Weekends discharge		0.952	1.048	0.872**	0.940	0.940	1.007	0.936	0.980
		(0.773 - 1.174)	(0.855 - 1.286)	(0.796 - 0.954)	(0.821 - 1.077)	(0.754 - 1.173)	(0.842 - 1.203)	(0.750 - 1.169)	(0.792 - 1.214)
DRG weights		0.886**	0.931	1.043**	1.082	0.900**	0.939	0.899**	0.946
		(0.847 - 0.927)	(0.826 - 1.049)	(1.017 - 1.069)	(0.981 - 1.193)	(0.861 - 0.940)	(0.846 - 1.043)	(0.861 - 0.940)	(0.845 - 1.059)
Charlson index		1.175**	1.324**	1.155**	1.313**	1.195**	1.340**	1.194**	1.335**
		(1.108 - 1.246)	(1.277 - 1.373)	(1.111 - 1.201)	(1.276 - 1.352)	(1.126 - 1.269)	(1.299 - 1.382)	(1.125 - 1.268)	(1.292 - 1.379)
General health status compared to other same age persons	Excellent	Reference		Reference		-	-	-	-
	Very good	1.229	1.088	1.167	0.994	-	-	-	-
		(0.941 - 1.604)	(0.637 - 1.859)	(0.960 - 1.418)	(0.637 - 1.552)				
	Good	1.475**	0.852	1.466**	0.857	-	-	-	-
		(1.156 - 1.882)	(0.532 - 1.362)	(1.194 - 1.801)	(0.594 - 1.237)				
	Fair	1.450**	0.878	1.512**	0.910	-	-	-	-
		(1.106 - 1.901)	(0.499 - 1.545)	(1.211 - 1.887)	(0.551 - 1.503)				
	Poor	1.953**	1.049	1.899**	1.306	-	-	-	-
		(1.438 - 2.652)	(0.540 - 2.038)	(1.508 - 2.390)	(0.749 - 2.278)				
With family helper or not before index hospital stay		0.641**	0.215**	0.632**	0.163**	-	-	-	-
		(0.557 - 0.736)	(0.144 - 0.321)	(0.558 - 0.715)	(0.136 - 0.196)				

With health professional helper or not before index hospital stay		0.752**	1.032	0.704**	1.150	-	-	-	-
		(0.607 - 0.931)	(0.637 - 1.670)	(0.602 - 0.822)	(0.758 - 1.745)				
Smoking status during the year of index hospital stay		1.088	1.506**	1.145	1.594**	-	-	-	-
		(0.814 - 1.455)	(1.112 - 2.040)	(0.968 - 1.354)	(1.146 - 2.219)				
Unmet needs of function impairment		1.041	1.036	1.034	1.023	-	-	-	-
		(0.973 - 1.113)	(0.945 - 1.137)	(0.966 - 1.106)	(0.935 - 1.120)				
ADL index		1.063*	1.107*	1.071**	1.122**	-	-	-	-
		(1.013 - 1.116)	(1.010 - 1.212)	(1.039 - 1.103)	(1.034 - 1.217)				
iADL index		0.972	0.956	1.018	0.962	-	-	-	-
		(0.925 - 1.022)	(0.880 - 1.039)	(0.984 - 1.052)	(0.882 - 1.050)				
Total number of visits wihtin 6 mo previously to index hospital stay		0.950**	1.031**	0.949**	1.034**	0.950**	1.031**	0.950**	1.032**
		(0.939 - 0.960)	(1.015 - 1.047)	(0.941 - 0.957)	(1.028 - 1.040)	(0.940 - 0.961)	(1.015 - 1.048)	(0.940 - 0.961)	(1.016 - 1.048)
Hospital's type of control	Non-profit	Reference		Reference		-	-	-	-
	For profit	1.005	0.787	1.024	0.930	-	-	-	-
		(0.931 - 1.085)	(0.484 - 1.280)	(0.932 - 1.125)	(0.657 - 1.316)				
	Government	1.155	1.000	1.083	1.105*	-	-	-	-
		(0.835 - 1.599)	(0.871 - 1.150)	(0.916 - 1.280)	(1.011 - 1.207)				
DSH hospital		1.180*	1.223	1.198**	1.259	-	-	-	-
		(1.004 - 1.386)	(0.874 - 1.711)	(1.060 - 1.355)	(0.901 - 1.761)				
Hospital's teaching status		1.046	1.031	0.961	0.983	-	-	-	-
		(0.925 - 1.182)	(0.752 - 1.413)	(0.854 - 1.080)	(0.656 - 1.473)				
Total inpatient bed size(size in 100)		0.997	0.938	0.984*	0.906*	-	-	-	-
		(0.975 - 1.020)	(0.834 - 1.054)	(0.970 - 0.997)	(0.825 - 0.995)				
# Phys,Primary Care, Patient Care/1,000 persons		1.375**	0.863	1.215**	1.043	-	-	-	-
		(1.162 - 1.628)	(0.485 - 1.538)	(1.080 - 1.367)	(0.715 - 1.521)				
# NP,Primary Care, Patient Care/1,000 persons		1.072	1.426	1.114	1.165	-	-	-	-
		(0.814 - 1.413)	(0.909 - 2.237)	(0.920 - 1.348)	(0.586 - 2.315)				
# Beds in nursing facilities/1,000 pop		1.071*	1.012	1.051	0.975	-	-	-	-
		(1.008 - 1.138)	(0.826 - 1.240)	(0.998 - 1.106)	(0.780 - 1.220)				
# Home health agencies /1,000 pop		1.265**	0.890	1.188**	0.961	-	-	-	-
		(1.100 - 1.455)	(0.626 - 1.265)	(1.065 - 1.326)	(0.702 - 1.317)				
# Beds in skilled nursing facilities/1,000 pop		1.004	0.971*	1.018	0.997	-	-	-	-
		(0.982 - 1.028)	(0.945 - 0.999)	(0.999 - 1.037)	(0.967 - 1.027)				
# Beds LTC hospital/ 1,000 pop		0.968	0.827**	0.947	0.841	-	-	-	-
		(0.913 - 1.026)	(0.727 - 0.941)	(0.878 - 1.021)	(0.690 - 1.024)				
# Beds short-tem community hospital/1,000 pop		0.970	0.946	0.966*	0.944	-	-	-	-
		(0.919 - 1.023)	(0.859 - 1.043)	(0.940 - 0.992)	(0.865 - 1.030)				
Census division	1 New England	Reference		Reference		-	-	-	-

2 Middle Atlantic	0.941	1.275*	0.895	0.974	-	-	-	-
	(0.728 - 1.217)	(1.015 - 1.603)	(0.672 - 1.192)	(0.744 - 1.274)				
3 East North Central	0.759	1.303	0.762	1.083	-	-	-	-
	(0.546 - 1.056)	(0.900 - 1.887)	(0.563 - 1.031)	(0.842 - 1.394)				
4 West North Central	0.680**	1.172	0.646**	0.693**	-	-	-	-
	(0.514 - 0.898)	(0.691 - 1.987)	(0.513 - 0.813)	(0.557 - 0.864)				
5 South Atlantic/Puerto Rico	0.773*	1.124	0.779*	0.977	-	-	-	-
	(0.600 - 0.996)	(0.879 - 1.438)	(0.615 - 0.986)	(0.715 - 1.335)				
6 East South Central	0.709**	1.170	0.789*	0.749	-	-	-	-
	(0.565 - 0.889)	(0.683 - 2.003)	(0.636 - 0.980)	(0.491 - 1.142)				
7 West South Central	0.750	1.222	0.739**	0.881	-	-	-	-
	(0.536 - 1.049)	(0.864 - 1.729)	(0.593 - 0.921)	(0.741 - 1.048)				
8 Mountain	0.764	1.090	0.757	1.066	-	-	-	-
	(0.472 - 1.237)	(0.804 - 1.479)	(0.540 - 1.061)	(0.735 - 1.546)				
9 Pacific	0.808	1.296	0.809	1.159	-	-	-	-
	(0.555 - 1.177)	(0.851 - 1.973)	(0.588 - 1.113)	(0.930 - 1.445)				
AIC#	43384.79		43519.42		43659.93		45078.43	
BIC#	43541.99		43676.63		43816.58		45235.63	

* p<0.05, ** p<0.01

AIC and BIC were calculated from 1st imputations.

Table I. Predicted probabilities of post-discharge outcomes by SES measures, n=13,173

		Full Set of Variables with PAC Locations			Full Set of Variables			Claims-Only Variables with PAC Locations			Claims only Variables		
		No Events Predicted Pr (95% CI)	**Readmission** Predicted Pr (95% CI)	**Hospice /Death** Predicted Pr (95% CI)	**No Events** Predicted Pr (95% CI)	**Readmission** Predicted Pr (95% CI)	**Hospice /Death** Predicted Pr (95% CI)	**No Events** Predicted Pr (95% CI)	**Readmission** Predicted Pr (95% CI)	**Hospice /Death** Predicted Pr (95% CI)	**No Events** Predicted Pr (95% CI)	**Readmission** Predicted Pr (95% CI)	**Hospice /Death** Predicted Pr (95% CI)
Low Income	**No**	0.771 (0.713 - 0.829)	0.199 (0.126 - 0.271)	0.030 (0.0153 - 0.0451)	0.777 (0.710 - 0.845)	0.196 (0.116 - 0.275)	0.027 (0.0152 - 0.0396)	-	-	-	-	-	-
	Yes	0.792 (0.741 - 0.844)	0.178 (0.120 - 0.236)	0.029 (0.0212 - 0.0379)	0.780 (0.721 - 0.838)	0.189 (0.124 - 0.254)	0.031 (0.0240 - 0.0386)	-	-	-	-	-	-
	Contrast	.0210846	-.0204012	-.0006835	.0026999	-.0065963	.0038964	-	-	-	-	-	-
	p-value	0.085	0.098	0.88	0.775	0.518	0.195	-	-	-	-	-	-
Deprived Area	**No**	0.784 (0.731 - 0.837)	0.187 (0.124 - 0.249)	0.029 (0.0194 - 0.0391)	0.777 (0.716 - 0.839)	0.193 (0.123 - 0.263)	0.029 (0.0212 - 0.0382)	0.785 (0.728 - 0.843)	0.185 (0.118 - 0.252)	0.029 (0.0196 - 0.0389)	0.777 (0.716 - 0.839)	0.193 (0.123 - 0.263)	0.029 (0.0212 - 0.0382)
	Yes	0.790 (0.735 - 0.846)	0.168 (0.0953 - 0.241)	0.041 (0.0144 - 0.0688)	0.800 (0.745 - 0.854)	0.164 (0.0902 - 0.237)	0.036 (0.0137 - 0.0600)	0.765 (0.708 - 0.822)	0.193 (0.122 - 0.264)	0.042 (0.0214 - 0.0634)	0.799 (0.745 - 0.854)	0.164 (0.0904 - 0.237)	0.037 (0.0141 - 0.0600)
	Contrast	.0063886	-.0186813	.0122927	.0223202 **	-.0295373 **	.007217	-.020651	.0075374	.0131136	-.02059	.0075216	.0130684
	p-value	0.657	0.081	0.294	0.01	0	0.419	0.365	0.723	0.055	0.372	0.729	0.057
Dual Eligible	**No**	0.792 (0.735 - 0.849)	0.180 (0.114 - 0.246)	0.028 (0.0177 - 0.0388)	0.783 (0.721 - 0.846)	0.187 (0.117 - 0.258)	0.029 (0.0207 - 0.0377)	0.795 (0.734 - 0.857)	0.177 (0.106 - 0.249)	0.027 (0.0167 - 0.0374)	0.784 (0.722 - 0.846)	0.187 (0.117 - 0.258)	0.028 (0.0198 - 0.0379)
	Yes	0.760 (0.711 - 0.808)	0.206 (0.148 - 0.264)	0.034 (0.0235 - 0.0455)	0.762 (0.698 - 0.827)	0.205 (0.131 - 0.280)	0.032 (0.0217 - 0.0429)	0.744 (0.698 - 0.789)	0.217 (0.163 - 0.270)	0.039 (0.0306 - 0.0487)	0.762 (0.698 - 0.825)	0.205 (0.134 - 0.276)	0.033 (0.0249 - 0.0419)
	Contrast	-.0320462	.0257743	.0062718	-.0210664	.0179757	.0030907	-.0517694**	.0392146**	.0125547**	-.0524058**	.0390834**	.0133224**
	p-value	0.072	0.094	0.076	0.161	0.188	0.182	0.001	0.014	0	0.001	0.014	0
Low Education	**No**	0.789 (0.738 - 0.840)	0.181 (0.119 - 0.243)	0.030 (0.0187 - 0.0418)	0.781 (0.723 - 0.839)	0.189 (0.121 - 0.258)	0.029 (0.0197 - 0.0399)	- -	- -	- -	-	-	-
	Yes	0.777 (0.718 - 0.835)	0.194 (0.129 - 0.260)	0.029 (0.0203 - 0.0378)	0.775 (0.705 - 0.844)	0.195 (0.120 - 0.271)	0.030 (0.0229 - 0.0377)	- -	- -	- -	-	-	-
	Contrast	-.0118951	.0130582	-.0011631	-.0064149	.0059196	.0004952	-	-	-	-	-	-
	p-value	0.103	0.06	0.712	0.58	0.567	0.84	-	-	-	-	-	-
PAC Locations	**Home**	0.785*** (0.716 - 0.854)	0.183*** (0.106 - 0.259)	0.0324*** (0.0222 - 0.0426)	-	-	-	0.786*** (0.713 - 0.858)	0.182*** (0.102 - 0.261)	0.0324*** (0.0223 - 0.0425)	-	-	-
	HHA	0.808*** (0.764 - 0.852)	0.172*** (0.117 - 0.228)	0.0194*** (0.00778 - 0.0310)	-	-	-	0.810*** (0.762 - 0.858)	0.172*** (0.113 - 0.230)	0.0186*** (0.00727 - 0.0298)	-	-	-
	SNF	0.761*** (0.713 - 0.809)	0.203*** (0.144 - 0.262)	0.0363*** (0.0250 - 0.0477)	-	-	-	0.758*** (0.706 - 0.810)	0.205*** (0.141 - 0.268)	0.0376*** (0.0258 - 0.0493)	-	-	-

Table J. Association between SES and post-acute care outcome adjusted for safety-net status, N=13,512.

		Full variable set + PAC		Full variable set		Claims-only + PAC		Claims-only	
		Readmission	Hospice/Death	Readmission	Hospice/Death	Readmission	Hospice/Death	Readmission	Hospice/Death
		(1) Odds Ratio	(2) Odds Ratio	(3) Odds Ratio	(4) Odds Ratio	(5) Odds Ratio	(6) Odds Ratio	(7) Odds Ratio	(8) Odds Ratio
<u>SES Measures</u>									
Dual eligibility		1.188	1.307*	1.138	1.207*	1.411**	1.714***	1.402***	1.678***
		(0.936 - 1.507)	(0.999 - 1.711)	(0.936 - 1.384)	(0.989 - 1.472)	(1.064 - 1.871)	(1.368 - 2.148)	(1.121 - 1.753)	(1.462 - 1.926)
Deprived area level		0.977	1.971	0.832**	1.254	1.325	2.116***	1.060	1.374
		(0.802 - 1.191)	(0.756 - 5.137)	(0.710 - 0.975)	(0.479 - 3.285)	(0.893 - 1.965)	(1.217 - 3.677)	(0.811 - 1.387)	(0.874 - 2.160)
Person's income level < $25,000		0.878	0.955	0.955	1.131	-	-	-	-
		(0.742 - 1.038)	(0.619 - 1.471)	(0.827 - 1.103)	(0.796 - 1.605)				
Person's Education under high school		1.179***	0.969	1.077	1.003	-	-	-	-
		(1.075 - 1.292)	(0.745 - 1.260)	(0.962 - 1.205)	(0.794 - 1.266)				
PAC Locations	**Home**	Reference		-	-	Reference		-	-
	HHA discharge	0.952	0.584*	-	-	0.928	0.600*	-	-
		(0.817 - 1.110)	(0.325 - 1.049)			(0.819 - 1.052)	(0.345 - 1.045)		
	SNF discharge	1.171	1.151	-	-	1.157	1.282*	-	-
		(0.953 - 1.439)	(0.919 - 1.442)			(0.969 - 1.381)	(0.964 - 1.704)		
Safety-Net hospital		1.782***	0.502***	1.324***	0.456***	1.477***	1.174	1.337***	0.977
		(1.398 - 2.270)	(0.324 - 0.780)	(1.157 - 1.515)	(0.286 - 0.726)	(1.132 - 1.927)	(0.770 - 1.791)	(1.179 - 1.516)	(0.729 - 1.310)
<u>Interaction Terms</u>									
Safety-Net * Income < $25,000		0.872	2.090*	1.091	1.925**	-	-	-	-
		(0.686 - 1.109)	(0.911 - 4.797)	(0.910 - 1.307)	(1.026 - 3.614)				
Safety-Net * ADI		0.704	0.500	0.968	1.297	0.449***	0.331	0.770	0.878
		(0.393 - 1.261)	(0.0386 - 6.477)	(0.561 - 1.671)	(0.170 - 9.892)	(0.273 - 0.740)	(0.0483 - 2.275)	(0.434 - 1.367)	(0.170 - 4.528)
Safety-Net * Dual eligibility		0.952	0.903	0.845	0.620	0.662***	1.057	0.726***	0.905
		(0.701 - 1.294)	(0.455 - 1.794)	(0.661 - 1.081)	(0.350 - 1.098)	(0.523 - 0.837)	(0.570 - 1.962)	(0.591 - 0.893)	(0.594 - 1.378)
Safety-Net * Education < high school		0.586**	1.151	0.743	1.654	-	-	-	-
		(0.387 - 0.888)	(0.532 - 2.489)	(0.512 - 1.079)	(0.883 - 3.097)				
Safety-Net * PAC Locations (reference group: Home Discharge)	**Safety-Net *HHA discharge**	0.826	0.114***	-	-	0.862	0.108***	-	-
		(0.553 - 1.235)	(0.0656 - 0.199)			(0.578 - 1.285)	(0.0666 - 0.175)		
	Safety-Net * SNF discharge	1.013	0.729	-	-	1.139	0.648	-	-
		(0.817 - 1.255)	(0.375 - 1.416)			(0.893 - 1.451)	(0.291 - 1.445)		

Control Variables									
Race	**White**	Reference		Reference		Reference		Reference	
	Black	1.074 (0.948 - 1.217)	1.340** (1.065 - 1.685)	1.107* (0.982 - 1.247)	1.275*** (1.078 - 1.507)	1.012 (0.891 - 1.149)	1.105 (0.911 - 1.340)	1.093 (0.965 - 1.238)	1.023 (0.879 - 1.191)
	Other	0.958 (0.736 - 1.248)	0.852 (0.395 - 1.839)	0.985 (0.798 - 1.217)	0.922 (0.529 - 1.605)	0.918 (0.751 - 1.122)	0.597 (0.262 - 1.357)	0.930 (0.765 - 1.132)	0.653 (0.326 - 1.311)
Age at index hospital stay		1.009** (1.001 - 1.018)	1.070*** (1.058 - 1.082)	1.010** (1.002 - 1.018)	1.080*** (1.066 - 1.093)	1.006 (0.998 - 1.014)	1.077*** (1.067 - 1.086)	1.009** (1.001 - 1.017)	1.088*** (1.075 - 1.102)
Gender, male		0.945 (0.835 - 1.069)	1.668*** (1.455 - 1.912)	0.978 (0.889 - 1.076)	1.479*** (1.286 - 1.701)	1.051 (0.953 - 1.159)	1.455*** (1.278 - 1.657)	1.041 (0.956 - 1.133)	1.327*** (1.167 - 1.509)
Currently Married		1.287*** (1.201 - 1.379)	1.126 (0.856 - 1.481)	1.148*** (1.083 - 1.216)	1.216** (1.045 - 1.414)				
Living with helper(s)		0.804** (0.675 - 0.958)	0.586 (0.277 - 1.237)	0.909** (0.832 - 0.994)	0.776 (0.516 - 1.167)				
Number of living children level	**0 child**	Reference		Reference					
	1-3 children	1.100 (0.884 - 1.369)	1.273 (0.827 - 1.960)	1.043 (0.906 - 1.202)	1.168* (0.977 - 1.397)				
	> 3 children	1.166 (0.844 - 1.611)	1.189 (0.767 - 1.844)	1.060 (0.887 - 1.266)	1.007 (0.875 - 1.158)				
Person living in metro area		0.857 (0.707 - 1.038)	0.741** (0.563 - 0.975)	0.947 (0.815 - 1.102)	0.798*** (0.676 - 0.941)				
Claim years	**Year 2006**	Reference		Reference					
	Year 2007	0.942 (0.873 - 1.016)	0.897 (0.673 - 1.196)	0.917* (0.832 - 1.010)	0.884* (0.779 - 1.002)	0.981 (0.872 - 1.104)	0.887 (0.746 - 1.054)	0.941 (0.844 - 1.049)	0.849*** (0.787 - 0.915)
	Year 2008	1.002 (0.884 - 1.136)	0.743** (0.587 - 0.941)	0.989 (0.898 - 1.088)	0.716** (0.532 - 0.964)	1.030 (0.900 - 1.178)	0.731** (0.534 - 1.000)	1.000 (0.902 - 1.109)	0.707* (0.482 - 1.037)
	Year 2009	0.882** (0.799 - 0.975)	0.517*** (0.448 - 0.596)	0.884** (0.795 - 0.982)	0.605*** (0.520 - 0.704)	0.912 (0.784 - 1.060)	0.494*** (0.386 - 0.632)	0.898 (0.768 - 1.051)	0.560*** (0.423 - 0.743)
	Year 2010	0.926 (0.822 - 1.043)	0.633* (0.376 - 1.066)	1.044 (0.940 - 1.160)	0.674* (0.434 - 1.046)	0.970 (0.854 - 1.103)	0.692* (0.470 - 1.020)	1.037 (0.909 - 1.183)	0.705* (0.470 - 1.057)
	Year 2011	1.000 (0.813 - 1.230)	0.926 (0.529 - 1.618)	1.103 (0.959 - 1.269)	0.986 (0.679 - 1.433)	0.902 (0.770 - 1.056)	1.123 (0.741 - 1.703)	0.962 (0.851 - 1.087)	1.234 (0.935 - 1.627)
Admitted from ER		1.015 (0.899 - 1.147)	1.308 (0.806 - 2.125)	1.096** (1.020 - 1.177)	1.319 (0.827 - 2.104)	1.096 (0.945 - 1.271)	1.371 (0.864 - 2.175)	1.163*** (1.070 - 1.264)	1.465 (0.896 - 2.395)

Hospital stay length		0.987 (0.963 - 1.013)	0.985 (0.949 - 1.022)	0.997 (0.984 - 1.010)	1.003 (0.967 - 1.040)	0.992 (0.969 - 1.016)	0.982 (0.945 - 1.021)	0.998 (0.984 - 1.013)	1.004 (0.984 - 1.025)
Weekends discharge		0.948 (0.761 - 1.181)	1.042 (0.805 - 1.348)	0.877*** (0.802 - 0.959)	0.957 (0.813 - 1.128)	0.946 (0.761 - 1.177)	1.017 (0.844 - 1.226)	0.849*** (0.773 - 0.933)	0.912 (0.787 - 1.057)
DRG weight		0.888*** (0.844 - 0.934)	0.920 (0.820 - 1.031)	1.055*** (1.029 - 1.080)	1.058 (0.968 - 1.157)	0.901*** (0.863 - 0.940)	0.938 (0.845 - 1.042)	1.037*** (1.010 - 1.064)	1.073* (0.991 - 1.162)
Charlson index		1.149*** (1.087 - 1.215)	1.324*** (1.276 - 1.375)	1.132*** (1.091 - 1.175)	1.313*** (1.279 - 1.349)	1.195*** (1.125 - 1.268)	1.340*** (1.299 - 1.382)	1.177*** (1.123 - 1.233)	1.334*** (1.295 - 1.374)
General health status compared to other same age persons	**Excellent**	Reference		Reference					
	Very good	1.205 (0.904 - 1.604)	1.065 (0.611 - 1.855)	1.148 (0.941 - 1.400)	0.981 (0.628 - 1.532)				
	Good	1.408*** (1.094 - 1.813)	0.841 (0.516 - 1.370)	1.409*** (1.128 - 1.760)	0.843 (0.583 - 1.219)				
	Fair	1.359** (1.029 - 1.796)	0.856 (0.479 - 1.529)	1.405*** (1.105 - 1.787)	0.899 (0.538 - 1.502)				
	Poor	1.779*** (1.296 - 2.441)	1.176 (0.605 - 2.283)	1.733*** (1.339 - 2.243)	1.440 (0.809 - 2.561)				
with family helper or not before index hospital stay		0.646*** (0.561 - 0.742)	0.226*** (0.161 - 0.317)	0.639*** (0.559 - 0.730)	0.174*** (0.152 - 0.198)				
with health professional helper or not before index hospital stay		0.791** (0.645 - 0.970)	0.942 (0.530 - 1.674)	0.738*** (0.630 - 0.865)	0.998 (0.579 - 1.722)				
patient smoke or during the year of index hospital stay		1.097 (0.839 - 1.435)	1.371* (0.971 - 1.936)	1.174* (0.987 - 1.397)	1.483** (1.058 - 2.079)				
patients' unmet needs of function impairment		1.032 (0.965 - 1.105)	1.050 (0.965 - 1.144)	1.024 (0.956 - 1.096)	1.035 (0.950 - 1.128)				
patient had two or more physician visit with 6 months previously to index hospital stay		0.0918*** (0.0742 - 0.114)	5.699*** (2.279 - 14.25)	0.0930*** (0.0754 - 0.115)	5.536*** (2.682 - 11.43)	0.950*** (0.940 - 0.961)	1.031*** (1.015 - 1.047)	0.950*** (0.942 - 0.957)	1.035*** (1.029 - 1.041)
ADL index		1.055** (1.003 - 1.110)	1.111** (1.020 - 1.211)	1.068*** (1.037 - 1.100)	1.125*** (1.032 - 1.227)				
iADL index		0.960 (0.913 - 1.010)	0.980 (0.902 - 1.066)	1.003 (0.970 - 1.037)	0.979 (0.897 - 1.069)				
total number of visits within 6 months previously to index hospital stay		1.021*** (1.007 - 1.035)	1.019** (1.003 - 1.035)	1.023*** (1.017 - 1.028)	1.021*** (1.017 - 1.026)				

Hospital's type of control	Non-profit	Reference		Reference	
	For-profit	1.015 (0.945 - 1.091)	0.848 (0.568 - 1.265)	1.020 (0.926 - 1.122)	0.952 (0.683 - 1.328)
	Government	1.188 (0.825 - 1.712)	0.974 (0.789 - 1.203)	1.083 (0.900 - 1.303)	1.110 (0.969 - 1.272)
Hospital's DSH Status		1.178* (0.976 - 1.420)	1.278 (0.907 - 1.799)	1.187** (1.020 - 1.381)	1.277 (0.914 - 1.785)
Hospital's teaching status		1.012 (0.881 - 1.163)	1.156 (0.829 - 1.612)	0.945 (0.837 - 1.066)	1.041 (0.722 - 1.502)
Total inpatient bed size(size in 100)		1.000 (0.973 - 1.028)	0.929 (0.827 - 1.044)	0.983** (0.968 - 0.998)	0.903** (0.823 - 0.990)
# Phys,Primary Care, Patient Care/1,000 persons		1.348*** (1.155 - 1.572)	0.875 (0.484 - 1.582)	1.190*** (1.064 - 1.330)	1.142 (0.789 - 1.653)
# NP,Primary Care, Patient Care/1,000 persons		1.074 (0.829 - 1.392)	1.323 (0.888 - 1.972)	1.139 (0.914 - 1.421)	1.128 (0.568 - 2.240)
# Beds Nursing Facilities/1,000 pop		1.057* (0.990 - 1.128)	1.004 (0.818 - 1.232)	1.046 (0.981 - 1.115)	0.980 (0.778 - 1.234)
# Home Health Agencies /1,000 pop		1.261*** (1.098 - 1.447)	0.882 (0.615 - 1.265)	1.190*** (1.058 - 1.338)	0.956 (0.648 - 1.410)
# Beds Skilled Nursing Facilities/1,000 pop		1.008 (0.987 - 1.030)	0.971* (0.938 - 1.005)	1.022** (1.004 - 1.041)	0.995 (0.965 - 1.026)
# Beds Rehab hospital/ 1,000 pop		0.982 (0.913 - 1.055)	0.832*** (0.727 - 0.953)	0.956 (0.875 - 1.044)	0.834* (0.688 - 1.012)
# Beds Short-term community hospital/1,000 pop		0.973 (0.924 - 1.023)	0.940 (0.854 - 1.035)	0.967* (0.933 - 1.002)	0.928* (0.855 - 1.008)
Census Division	New England	Reference		Reference	
	Middle Atlantic	0.972 (0.732 - 1.290)	1.216** (1.010 - 1.463)	0.938 (0.695 - 1.264)	0.948 (0.687 - 1.307)
	East North Central	0.785 (0.566 - 1.090)	1.286 (0.928 - 1.782)	0.810 (0.608 - 1.078)	1.066 (0.868 - 1.310)
	West North Central	0.765** (0.589 - 0.993)	1.088 (0.536 - 2.211)	0.693*** (0.566 - 0.850)	0.635*** (0.461 - 0.874)
	South Atlantic/Puerto Rico	0.828 (0.628 - 1.091)	1.070 (0.803 - 1.427)	0.843 (0.666 - 1.068)	0.922 (0.639 - 1.329)

6 East South Central	0.738**	1.207	0.834	0.730		
	(0.566 - 0.964)	(0.721 - 2.022)	(0.669 - 1.040)	(0.494 - 1.080)		
7 West South Central	0.762	1.241	0.761***	0.910		
	(0.537 - 1.083)	(0.861 - 1.790)	(0.619 - 0.936)	(0.740 - 1.121)		
8 Mountain	0.840	0.895	0.850	0.881		
	(0.536 - 1.317)	(0.686 - 1.169)	(0.633 - 1.140)	(0.666 - 1.166)		
9 Pacific	0.868	1.268	0.901	1.027		
	(0.579 - 1.301)	(0.812 - 1.982)	(0.651 - 1.247)	(0.809 - 1.305)		
Observations		13,173		13,173	13,173	13,173
Log Pseudoliklihood		20173.794		6836.9976	22371.611	7551.2234
AIC		40389.59		13716	44787.22	15144.45
BIC		40546.79		13873.2	44951.91	15301.65

*** p<0.01, ** p<0.05, * p<0.1

Table K. Predicted probabilities of post-discharge outcomes by safety-net status and SES measures, n=13,173

	Full set variable + PAC location			Full SET variables, no PAC			Claims only + PAC location			Claims only		
	No Event	Readmission	Hospice/ Death	No Event	Readmission	Hospice/ Death	No Event	Readmission	Hospice/ Death	No Event	Readmission	Hospice/ Death
Variables	(1) Predicted Pr (95%CI)	(2) Predicted Pr (95%CI)	(3) Predicted Pr (95%CI)	(4) Predicted Pr (95%CI)	(5) Predicted Pr (95%CI)	(6) Predicted Pr (95%CI)	(7) Predicted Pr (95%CI)	(8) Predicted Pr (95%CI)	(9) Predicted Pr (95%CI)	(10) Predicted Pr (95%CI)	(11) Predicted Pr (95%CI)	(12) Predicted Pr (95%CI)
Non-safety-net Status	0.785 (0.750 - 0.819)	0.184 (0.147 - 0.221)	0.031 (0.0269 - 0.0353)	0.78 (0.739 - 0.821)	0.189 (0.146 - 0.232)	0.03 (0.0280 - 0.0328)	0.785 (0.731 - 0.839)	0.184 (0.120 - 0.248)	0.03 (0.0208 - 0.0410)	0.78 (0.717 - 0.844)	0.189 (0.118 - 0.261)	0.03 (0.0219 - 0.0387)
Safety-Net Status	0.763 (0.716 - 0.809)	0.218 (0.164 - 0.271)	0.019 (0.0117 - 0.0278)	0.757 (0.697 - 0.818)	0.217 (0.151 - 0.284)	0.025 (0.0186 - 0.0319)	0.751 (0.671 - 0.832)	0.226 (0.133 - 0.318)	0.022 (0.0100 - 0.0357)	0.75 (0.666 - 0.835)	0.222 (0.124 - 0.319)	0.027 (0.0142 - 0.0416)
Contrast	-.0222042 **	.0334886 **	-.0112845 **	-.0226994 **	.0278914 **	.0051919	-.0337123 **	.0417799 **	-.0080676 **	-.029872 **	.0322835 **	.0024115
p-value	0.035	0.002	0.000	0.040	0.032	0.059	0.034	0.011	0.011	0.012	0.025	0.491
High income	0.772 (0.731 - 0.814)	0.198 (0.149 - 0.248)	0.029 (0.0201 - 0.0381)	0.778 (0.729 - 0.828)	0.195 (0.139 - 0.251)	0.026 (0.0203 - 0.0334)	-	-	-	-	-	-
Low Income	0.791 (0.756 - 0.827)	0.179 (0.143 - 0.214)	0.029 (0.0261 - 0.0335)	0.779 (0.738 - 0.821)	0.189 (0.148 - 0.230)	0.031 (0.0292 - 0.0334)	-	-	-	-	-	-
Contrast	.0189985	-.0196492	.0006507	.0010012	-.005459	.0044578	-	-	-	-	-	-
p-value	0.133	0.130	0.888	0.910	0.580	0.212	-	-	-	-	-	-
Not Deprived area	0.784 (0.748 - 0.820)	0.187 (0.148 - 0.225)	0.029 (0.0250 - 0.0334)	0.778 (0.734 - 0.821)	0.193 (0.147 - 0.239)	0.029 (0.0271 - 0.0321)	0.785 (0.728 - 0.843)	0.186 (0.119 - 0.253)	0.029 (0.0193 - 0.0392)	0.779 (0.712 - 0.845)	0.192 (0.116 - 0.267)	0.029 (0.0208 - 0.0385)
Deprived area	0.776 (0.744 - 0.808)	0.176 (0.131 - 0.221)	0.048 (0.0159 - 0.0805)	0.796 (0.772 - 0.819)	0.167 (0.128 - 0.207)	0.037 (0.0131 - 0.0611)	0.74 (0.685 - 0.794)	0.21 (0.141 - 0.280)	0.05 (0.0191 - 0.0811)	0.767 (0.726 - 0.809)	0.194 (0.139 - 0.249)	0.038 (0.0203 - 0.0566)
Contrast	-.00825 **	-.0107442 **	.0189942	.0181324 **	-.0256257 **	.0074933 **	-.0456888 **	.0248176	.0208712 **	-.0112683 **	.0024525 **	.0088158 **
p-value	0.028	0.011	0.050	0.049	0.010	0.030	0.015	0.074	0.043	0.026	0.032	0.020
Not Dual Eligible	0.79 (0.751 - 0.830)	0.181 (0.139 - 0.224)	0.028 (0.0239 - 0.0328)	0.782 (0.737 - 0.827)	0.189 (0.142 - 0.235)	0.029 (0.0271 - 0.0320)	0.795 (0.732 - 0.857)	0.179 (0.107 - 0.250)	0.026 (0.0167 - 0.0369)	0.79 (0.721 - 0.859)	0.183 (0.106 - 0.260)	0.027 (0.0189 - 0.0356)
Dual Eligible	0.763 (0.728 - 0.798)	0.203 (0.165 - 0.240)	0.034 (0.0293 - 0.0394)	0.764 (0.715 - 0.813)	0.203 (0.152 - 0.255)	0.032 (0.0286 - 0.0368)	0.739 (0.695 - 0.783)	0.22 (0.168 - 0.273)	0.04 (0.0310 - 0.0503)	0.733 (0.670 - 0.796)	0.227 (0.155 - 0.299)	0.04 (0.0311 - 0.0495)
Contrast	-.027588	.0215856	.0060025**	-.017993	.0148211	.0031719	-.0554829**	.0415966**	.0138863**	-.05689**	.0438415**	.0130484**
p-value	0.107	0.159	0.031	0.215	0.260	0.136	0.002	0.015	0.000	0.000	0.002	0.000

High Education	0.788 (0.753 - 0.822)	0.182 (0.143 - 0.222)	0.03 (0.0244 - 0.0356)	0.78 (0.740 - 0.821)	0.19 (0.146 - 0.235)	0.029 (0.0255 - 0.0332)	-	-	-	-	-	-
Low Education	0.775 (0.735 - 0.815)	0.196 (0.155 - 0.236)	0.029 (0.0247 - 0.0336)	0.774 (0.722 - 0.826)	0.195 (0.144 - 0.247)	0.03 (0.0276 - 0.0334)	-	-	-	-	-	-
Contrast	-.012757**	.0136113**	-.0008543	-.0062505	.0050737	.0011768	-	-	-	-	-	-
p-value	0.036	0.027	0.776	0.584	0.612	0.622	-	-	-	-	-	-

APPENDIX II. RESEARCH MEMOS

Memo 1. Disease Subgroup Analysis

To: Sally Stearns

From: Ye Zhu

Date: October 16, 2017

Re: Disease subgroups analysis

As mentioned in the PAC memo, different PAC locations have different disease profiles. One important issue in this study is that different disease categories might lead to different case-mix severity of patients, hence would impact the post-discharge outcomes. This memo provided information for major diseases included in this study to support the weighting strategy in the analysis.

After examining for the major disease categories, the following conclusions were drawn:

1) There are no big differences in disease profiles by hospital's safety-net status, or PAC locations
2) Safety-net hospitals had different number of cases for certain diseases (e.g. cerebrovascular disease, orthopedic disease), but the average number of multiple chronic disease varies little (between 1.4 to 1.5).
3) Subgroup regression results suggested that with the same disease groups, the role of SES and PAC location were very similar with the full sample analysis.

This memo supported that the basic model in Aim 2 and Aim 3 were sufficient in controlling for case mix severity for PAC locations.

1. **Disease diagnoses by ICD-9 code**

The hospital stays were grouped into disease categories using ICD-9 definition was listed in the table.

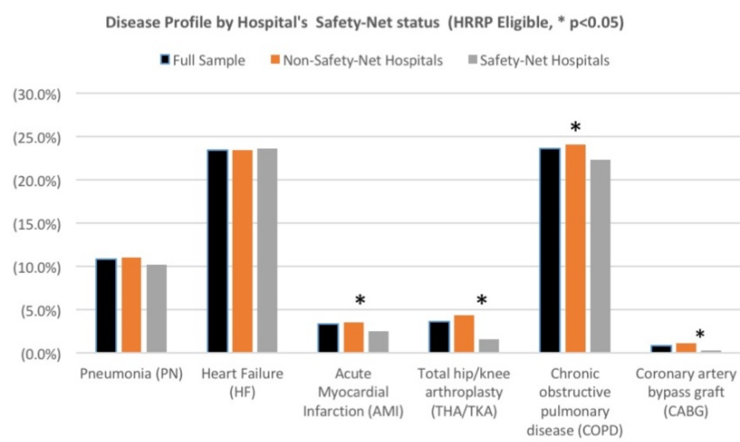
The ICD–9–CM codes for the AMI, HF, PN, THA/TKA, COPD, and CABG applicable conditions in HRRP can be found on the QualityNet Web site (http://www.QualityNet.org > Hospital-Inpatient > Claims-Based Measures > Readmission Measures > Measure Methodology>Archived Resources) from (76 FR 51673 through 51676). Note that CMS claims have different format for ICD-9. Here is the link to the document explaining how ICD-9 was documented:

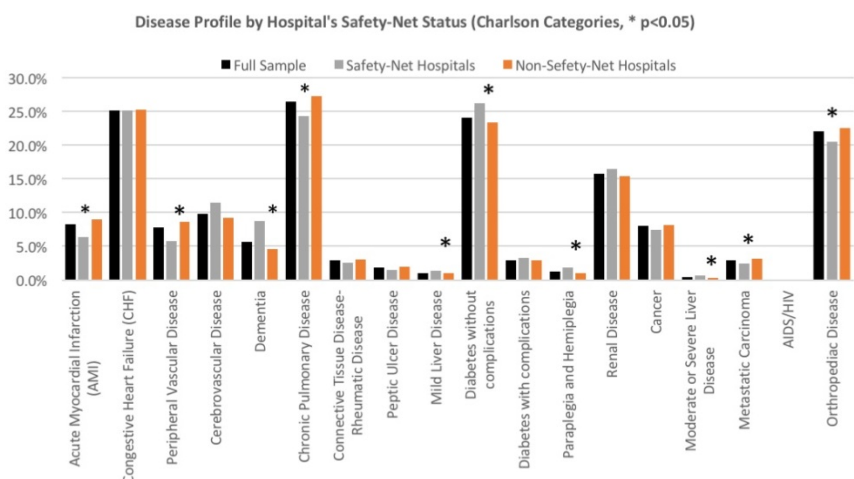
https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/HospitalQualityInits/Downloads/HospitalAppendix_F.pdf

The codes for each disease categories were listed in the appendix.

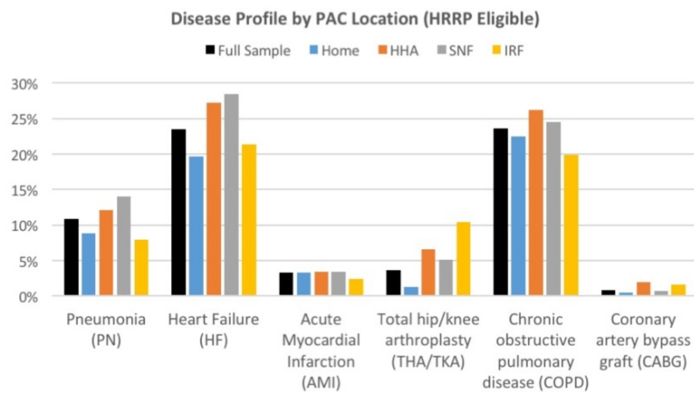
2. **Disease profile by safe-net vs non-safety-net hospitals**

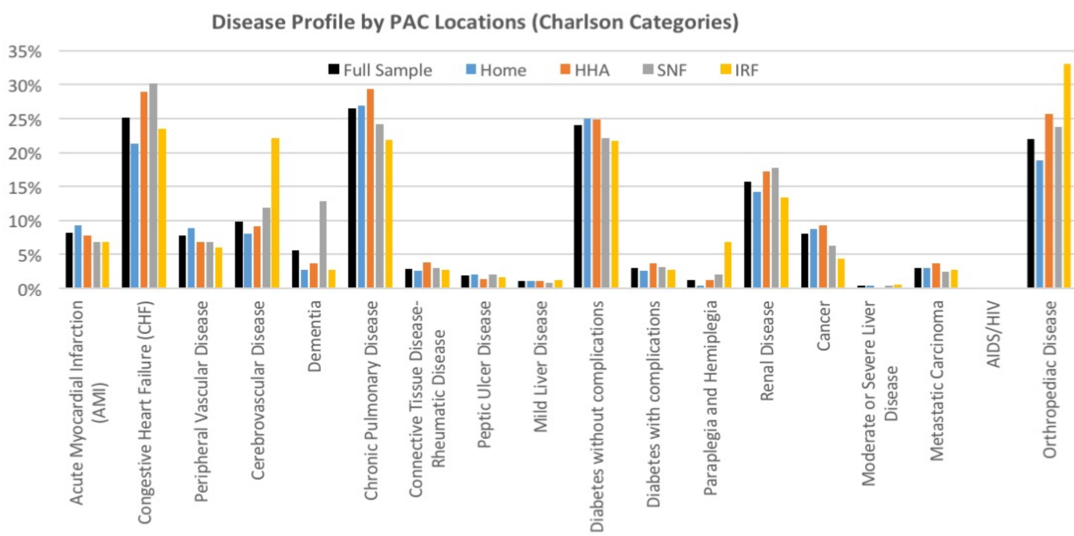
Distribution (Basic unit was disease diagnosis. One patient could have multiple diagnoses)





3. Disease profile by PAC locations
Distribution (Basic unit was one disease diagnosis. One patient could have multiple diagnoses)





4. These diseases have very low degree correlations with each other (correlation coefficients < 0.2), except for mild liver disease and moderate to severe liver disease, and cancer and metastatic carcinoma. (Correlation table was in spreadsheet "Disease_profile" - "Summary" – Column Y-AQ, line 5-30.)

6. Patients with Diseases included in HRRP vs. Patients with Disease not included
Distribution (Basic unit was one patient. Patient with at least one diagnosis included in the HRRP was coded as "1".)

	Full Sample N=13,534	Non-Safety-Net N=10,011	Safety-Net N=3,523	p-value	Home N=6,854	HHA N=2,556	SNF N=3,622	IRF N=502
	n(%)	n(%)	n(%)		n(%)	n(%)	n(%)	n(%)
Patients with HRRP Disease	6,462 (47.7%)	4,896 (48.9%)	1,566 (44.5%)	<0.0001	2,880 (42.0%)	1,409 (55.1%)	1,933 (53.4%)	240 (47.8%)

7. Largest chronic disease patients group
Distribution

	Full Sample N=13,534	Non-Safety-Net N=10,011	Safety-Net N= 3,523	Home N=6,854	HHA N=2,556	SNF N=3,622	IRF N=502
Variable	Mean(sd)	Mean(sd)	Mean(sd)	Mean(sd)	Mean(sd)	Mean(sd)	Mean(sd)
Number of Chronic diseases	1.44(1.14)	1.44(1.15)	1.45(1.12)	1.37(1.12)	1.52(1.15)	1.53(1.14)	1.41(1.21)
Variable	**n(%)**	**n(%)**	**n(%)**	**n(%)**	**n(%)**	**n(%)**	**n(%)**
Congestive Heart Failure (CHF)	**3,409 (25.2%)**	2,525 (25.2%)	884 (25.1%)	1,457 (21.3%)	740 (29.0%)	1,094 (30.2%)	118 (23.5%)
Chronic Pulmonary Disease	**3,583 (26.5%)**	2,728 (27.3%)	855 (24.3%)	1,846 (26.9%)	752 (29.4%)	875 (24.2%)	110 (21.9%)
Diabetes without complications	**3,257 (24.1%)**	2,336 (23.3%)	921 (26.1%)	1,713 (25.0%)	635 (24.8%)	800 (22.1%)	109 (21.7%)
Orthopedic Disease	**2,982 (22.0%)**	2,260 (22.6%)	722 (20.5%)	1,297 (18.9%)	656 (25.7%)	863 (23.8%)	166 (33.1%)
Heart Failure (HF)	**3,179 (23.5%)**	2,346 (23.4%)	833 (23.6%)	1,345 (19.6%)	696 (27.2%)	1,031 (28.5%)	107 (21.3%)
Chronic obstructive pulmonary disease (COPD)	**3,201 (23.7%)**	2,413 (24.1%)	788 (22.4%)	1,542 (22.5%)	671 (26.3%)	888 (24.5%)	100 (19.9%)

8. Orthopedic groups vs. complex chronic disease groups
   Distribution

Variable	Full Sample N=13,534 n(%)	Non-Safety-Net N=10,011 n(%)	Safety-Net N= 3,523 n(%)	Home N=6,854 n(%)	HHA N=2,556 n(%)	SNF N=3,622 n(%)	IRF N=502 n(%)
Orthopedic Diseases	2,982(22.0%)	2,260(22.6)	722(20.5)	1,297(18.9)	656(25.7)	863(23.8)	166(33.1)

	Disease Category	HRRP	ICD-9 Codes (CMS claims format)
HRRP Groups			
	Pneumonia (PN)	Yes	4800x, 4801x, 4802x, 4803x, 4808x, 4809x, 481xx, 4820x, 4821x, 4822x, 48230, 48231, 48232, 48239, 48240, 48241, 48242, 48249, 48281, 48282, 48283, 48284, 48289, 4829x, 4830x, 4831x, 4838x, 485xx, 486xx, 4870x, 48811
	Heart Failure (HF)	Yes	40201, 40211, 40291, 40401, 40403, 40411, 40413, 40491, 40493, 428xx
	Acute Myocardial Infarction (AMI)	Yes	41000, 41001, 41010, 41011, 41020, 41021, 41030, 41031, 41040, 41041, 41050, 41051, 41060, 41061, 41070, 41071, 41080, 41081, 41090, 41091
	Total hip/knee arthroplasty (THA/TKA)	Yes	8151, 8154 (Procedure codes)
	Chronic obstructive pulmonary disease (COPD)	Yes	49121, 49122, 4918x, 4919x, 4928x, 49320, 49321, 49322, 496xx, 51881, 51882, 51884, 7991x
	Coronary artery bypass graft (CABG)	Yes	3610xx, 3611xx, 3612xx, 3613xx, 3614xx, 3615xx, 3616xx, 3617xx, 3619xx (procedure codes)
Charlson Groups			
	Acute Myocardial Infarction (AMI)	Yes	410xx, 412xx
	Congestive Heart Failure (CHF)	Yes	39891, 40201, 40211, 40291, 40401, 40403, 40411, 40413, 40491, 40493, 4254x, 4255x, 4257x, 4258x, 4259x, 428xx
	Peripheral Vascular Disease	No	0930x, 4373x, 4431x, 4432x, 4438x, 4439x, 4471x, 5571x, 5579x, 440xx, 441xx, V434x
	Cerebrovascular Disease	No	36234, 430xx, 431xx, 432xx, 433xx, 434xx, 435xx, 436xx, 437xx, 438xx
	Dementia	No	290xx, 2941x, 3312x
	Chronic Pulmonary Disease	Partially	4168x, 4169x, 5064x, 5081x, 5088x, 490xx, 491xx, 492xx, 493xx, 494xx, 495xx, 496xx, 500xx, 501xx, 502xx, 503xx, 504xx, 505xx
	Connective Tissue Disease-Rheumatic Disease	No	4465x, 7100x, 7101x, 7102x, 7103x, 7104x, 7140x, 7141x, 7142x, 7148x, 725xx
	Peptic Ulcer Disease	No	531xx, 532xx, 533xx, 534xx
	Mild Liver Disease	No	07022, 07023, 07032, 07033, 07044, 07054, 0706x, 0709x, 5733x, 570xx, 571xx, V427x
	Diabetes without complications	No	2500x, 2501x, 2502x, 2503x, 2508x, 2509x
	Diabetes with complications	No	2504x, 2505x, 2506x, 2507x

	Paraplegia and Hemiplegia	No	342xx, 343xx, 3341x, 3440x, 3441x, 3442x, 3443x, 3444x, 3445x, 3446x, 3449x
	Renal Disease	No	40301, 40311, 40391, 40402, 40403, 40412, 40413, 40492, 40493, 582xx, 585xx, 586xx, 5830x, 5831x, 5832x, 5834x, 5836x, 5837x, 5880x, V420x, V451x, V56xx
	Cancer	No	140xx, 141xx, 142xx, 143xx, 144xx, 145xx, 146xx, 147xx, 148xx, 149xx, 150xx, 151xx, 152xx, 153xx, 154xx, 155xx, 156xx, 157xx, 158xx, 159xx, 160xx, 161xx, 162xx, 163xx, 164xx, 165xx, 170xx, 171xx, 172xx, 174xx, 175xx, 176xx, 179xx, 180xx, 181xx, 182xx, 183xx, 184xx, 185xx, 186xx, 187xx, 188xx, 189xx, 190xx, 191xx, 192xx, 193xx, 194xx, 195xx, 200xx, 201xx, 202xx, 203xx, 204xx, 205xx, 206xx, 207xx, 208xx, 2386x
	Moderate or Severe Liver Disease	No	4560x, 4561x, 4562x, 5722x, 5723x, 5724x, 5728x
	Metastatic Carcinoma	No	196xx, 197xx, 198xx, 199xx
	AIDS/HIV	No	042xx, 043xx, 044xx
	Orthopedic Diseases	Partially	715xx, 716xx, 717xx, 718xx, 719xx, 721xx, 722xx, 7330x

Note:
- In the MCBS claims data file, the "DGNSCD 1-25" documented the disease diagnosis at admissions using ICD-9 codes, and "PRCDRCD 1-25" was documented using ICD-9 procedure codes. While calculating Charlson index, 17 disease categories were created using the ICD-9 codes diagnosis codes.
- The last (18th) group of Charlson category was created for the purpose of examining orthopedic diseases, which was not included in Charlson index.
- For the purpose of analysis, diseases diagnosis related to HRRP (42 CFR 405,412,413, et al.) were added too.
- Multiple diagnoses occurred to some hospital stays.

Diagnosis Codes	Submission File	Procedure Codes	Submission File
EXXX.	EXXX~~bb~~	XX.	XX~~bb~~
EXXX.X	EXXXX~~b~~	XX.XX	XXXX
XXX.	~~b~~XXX~~bb~~	03.8	038~~b~~
XXX.X	~~b~~XXXX~~b~~	07.80	0780
XXX.XX	~~b~~XXXXX	21.0	210~~b~~
E845.	E845~~bb~~		
E852.0	E8520~~b~~		
V51.	~~b~~V51b~~b~~		
V52.0	~~b~~V520~~b~~		
650	~~b~~650~~bb~~		
788.39	~~b~~78839		

Note: b denotes a space or blank.

Memo 2. Star-rating system for SNF

To: Sally Stearns

From: Ye Zhu

Date: October 31, 2017

Re: Star Rating for Nursing Home and Home Health Care

This memo is to explore the five-star rating for SNF, so as to address the quality issue.

Nursing Home Comparison

The overall star-rating system for nursing homes started in 2008, with the 2009 as the first year to have the overall five-star rating levels. This rating system includes three components: 1) health inspection, 2) staffing and 3) quality measures. Each individual component has its five-star rating value. Before 2009, hospitals were not rated overall, but were rated individually for quality measure.

Below was the link to the Nursing Home Five-Star Quality System files from CMS-Medicare.

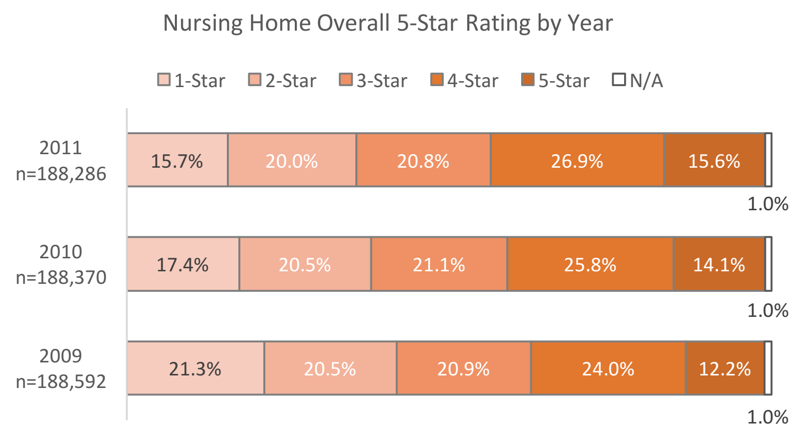
https://www.cms.gov/medicare/provider-enrollment-and-certification/certificationandcomplianc/fsqrs.html

This section discussion about the best method to estimate the quality of nursing homes in our study sample for the years of 2006, 2007 and 2008, since the overall star-rating was not started yet. We examined two ways to estimate the quality: 1) use the quality measure ratings to estimate the overall star rating in 2006-2008. The quality measure rating had strong correlation and significantly associated with the overall star rating. 2) The other method of using the overall star rating in 2009 as a proxy of 2006-2008 was examined as well. However, the performances for majority of the hospitals were not consistent between months over 2009-2011, therefore we could not assume that the same quality happened in 2006-2008 as in 2009. There were around 30% of the missing values for the overall star rating every year.

1. <u>Overall</u> Five-star Rating system for SNF was not consistent (from nationwide CMS data)

The overall five-star rating data was only available from year 2009. Therefore, if we want to use this rating system, the years of 2006-2008 has to be estimated using the year 2009.

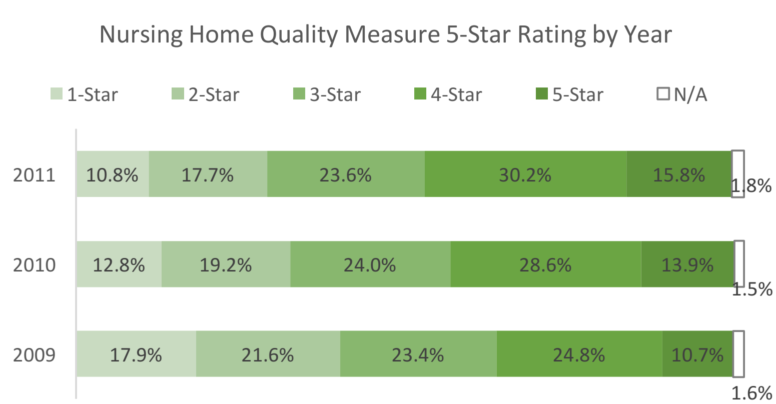
The distribution of the star rating level in the nursing home facilities for year 2009-2011 is listed below:



The consistency was checked for changes happened to one facility over months through out one year. It was found that the ratings were changing over time for 58.2% of the nursing homes, while about 41.8% facilities were consistent over year-months.

Standard Deviation of each facility over months	obs.	
0	235,109	41.85%
0-1	307,738	54.78%
>=1	18,932	3.37%

2. Star Rating for quality measure and staffing (from nationwide CMS data)



The correlation coefficient for quality rating and overall rating was 0.3278 (p<0.00001), and staffing rating and overall rating was 0.4796 (p<0.00001). The correlation between quality rating and staffing rating was very weak (coefficient -0.0131, p<0.00001).

When examined using linear regression model, the coefficient of quality rating on overall rating was 0.3450 (p<0.0001).

```
. reg ova r qual r

      Source |       SS           df       MS      Number of obs   =   556,205
-------------+----------------------------------   F(1, 556203)    =  66979.65
       Model |  105013.467         1  105013.467   Prob > F        =    0.0000
    Residual |  872038.102   556,203  1.56784142   R-squared       =    0.1075
-------------+----------------------------------   Adj R-squared   =    0.1075
       Total |  977051.569   556,204  1.75664247   Root MSE        =    1.2521

------------------------------------------------------------------------------
       ova r |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      qual r |   .3449723   .0013329   258.80   0.000     .3423598    .3475848
        cons |    1.90209   .0044321   429.17   0.000     1.893403    1.910777
------------------------------------------------------------------------------
```

3. Overall star rating in the study sample 2009-2011

The overall star rating in the study sample from 2009-2011 was listed below. Note that every year there were around 30% of the SNF didn't have star rating.

```
-> year = 2009

      ova r |      Freq.     Percent        Cum.
------------+-----------------------------------
          1 |        104       17.54       17.54
          2 |         70       11.80       29.34
          3 |         93       15.68       45.03
          4 |         97       16.36       61.38
          5 |         33        5.56       66.95
          . |        196       33.05      100.00
------------+-----------------------------------
      Total |        593      100.00

------------------------------------------------
-> year = 2010

      ova r |      Freq.     Percent        Cum.
------------+-----------------------------------
          1 |         70       12.37       12.37
          2 |         95       16.78       29.15
          3 |         76       13.43       42.58
          4 |         95       16.78       59.36
          5 |         38        6.71       66.08
          . |        192       33.92      100.00
------------+-----------------------------------
      Total |        566      100.00

------------------------------------------------
-> year = 2011

      ova r |      Freq.     Percent        Cum.
------------+-----------------------------------
          1 |         36        9.78        9.78
          2 |         69       18.75       28.53
          3 |         57       15.49       44.02
          4 |         72       19.57       63.59
```

```
          5 |         39       10.60       74.18
          . |         95       25.82      100.00
------------+-----------------------------------
      Total |        368      100.00
```

The overall rating and quality rating are coexisting:

```
. tab ova r qual r,m

           |                              qual r
     ova r |         1          2          3          4          5          . |     Total
-----------+------------------------------------------------------------------+----------
         1 |       128         89         75         94          0          0 |       386
         2 |        61         88        100        106         19          0 |       374
         3 |        80         90         74         98         19          0 |       361
         4 |        60        103        126        160         51          0 |       500
         5 |         0         15         34         45         98          6 |       198
         . |         0          0          0          0          0     11,715 |    11,715
-----------+------------------------------------------------------------------+----------
     Total |       329        385        409        503        187     11,721 |    13,534

. tab ova r qual r if year>2008,m

           |                              qual r
     ova r |         1          2          3          4          5          . |     Total
-----------+------------------------------------------------------------------+----------
         1 |       128         89         75         94          0          0 |       386
         2 |        61         88        100        106         19          0 |       374
         3 |        80         90         74         98         19          0 |       361
         4 |        60        103        126        160         51          0 |       500
         5 |         0         15         34         45         98          6 |       198
         . |         0          0          0          0          0      3,848 |     3,848
-----------+------------------------------------------------------------------+----------
     Total |       329        385        409        503        187      3,854 |     5,667
```

4. **Quality Measure Star Rating in the study sample 2006-2008**

The data files for quality measures were publicly available from CMS website:

https://www.cms.gov/medicare/provider-enrollment-and-certification/certificationandcomplianc/fsqrs.html

The data files only include scores for each evaluation domain and didn't include star rating values. Users have to add up all the domain scores and calculate the total score. Then, to assign a star rating for each facility using the users' guide provided the methods of 5-star rating cut-off points provided by CMS:

https://www.cms.gov/Medicare/Provider-Enrollment-and-Certification/CertificationandComplianc/Downloads/usersguide.pdf

However, the star rating calculated from the nationwide file was not sensible. The problem could be missing data. According to the guideline, the missing values were imputed. The guideline didn't provide the variables how the missing value were imputed. The task was stopped here because of lack of information.

```
. tab qual r,m

     qual r |      Freq.     Percent        Cum.
------------+-----------------------------------
          1 |  3,161,153       89.13       89.13
          2 |     95,296        2.69       91.82
          3 |     31,270        0.88       92.70
          4 |     35,678        1.01       93.71
          5 |    223,136        6.29      100.00
------------+-----------------------------------
      Total |  3,546,533      100.00
```

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