OUTCOMES AND COSTS OF POST-HOSPITALIZATION TRANSITIONS IN URBAN AND RURAL SETTINGS

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ABSTRACT

Matthew Robert Toth: Outcomes and Costs of Post-Hospitalization Transitions in Urban and Rural Settings
(Under the direction of Pam Silberman**)**

The Patient Protection and Affordable care Act introduced new incentives and reforms to improve hospital 30-day readmission rates and reduce unnecessary expenditures during a post-discharge period. Early follow-up care and home health utilization are key elements to improving these outcomes and costs. Little is known on how rural Medicare beneficiaries fare during a post-discharge period. This project will determine whether rural beneficiaries experience poorer quality of post-discharge care compared to urban beneficiaries (Aim 1), and assess whether the effect of early follow-up care and home health care on outcomes and costs are modified by rural residency (Aim 2 and Aim 3).

We use the Medicare Current Beneficiary Survey, Cost and Use files, 2000-2010. Key independent variables include rural residency, follow-up care (7-day/14-day), and use of home health care within 14 days. Key dependent variables included: Aim 1) time to first readmission, emergency department use (ED), and follow-up care; Aim 2) 30- and 60-day readmission, ED use, and mortality; and Aim 3) 30-, 60-, and 180-day Medicare expenditures. The analytical approach included a Cox Proportional Hazard model (Aim 1), a logistic regression with a two-stage residual inclusion (Aim 2), and a quantile regression with a two-stage residual inclusion (Aim 3).

Rural beneficiaries had fewer follow-up visits and a greater probability of ED use over 60-days post-discharge. There were no rural-urban differences in the effect of follow-up care and home health on readmission and mortality; however we found that rural beneficiaries experienced a greater benefit of 14-day follow-up care on reducing 30-day ED use. Early follow-up care increased expenditures for low-cost beneficiaries, and decreased expenditures for high-cost beneficiaries. High-cost rural beneficiaries who received a follow-up visit expended more Medicare expenditures compared to high-cost urban beneficiaries.

These findings support the role of early-follow-up care on reducing readmission, ED use, mortality, and expenditures. Efforts to improve access to early follow-up care for rural beneficiaries, and targeting high-cost beneficiaries for early follow-up care, may be advantageous for rural providers working within bundled payment models, ACOs, or other shared-risk arrangements.

I dedicate this work to my wife Jennie, my daughter Joanie, my parents, family and friends.
Thank you for your love and support.

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CHAPTER 1: INTRODUCTION

Introduction

Medicare spending on post-acute care has doubled from $26.6 Billion in 2000, to $58 billion in 2010, and is the largest contributor to geographic variation in Medicare expenditures.[1, 2] Beneficiaries receiving these services are often vulnerable with complex medical needs that complicate a post-hospital transition home. Complicated care transitions can lead to preventable readmissions and emergency department (ED) use, costing Medicare $12 Billion each year.[3, 4] Certain care elements lead to a successful care transition, specifically receiving follow up care within 7 or 14 days post-discharge and home visits.[5, 6] Rural beneficiaries may have poorer access to these care elements. The degree to which post hospital transition patterns and outcomes are associated with a patient's rural residency is poorly understood. Access to appropriate follow up care is key to a successful care transitions, but whether rural beneficiaries have adequate access to health services is unclear.[7-10] Few studies have identified whether rural beneficiaries receive timely follow up care post-discharge. Additionally, rural beneficiaries may receive fewer home health visits and a more limited range of home health services.[11] Whether rural beneficiaries are at greater risk for readmissions or ED use post-hospital discharge is unclear. However, it appears that rural beneficiaries may have greater 30-day mortality rates, and receive poorer quality of inpatient and, potentially, outpatient services.[12, 13] This project will fill a critical gap in understanding the association of rural setting and post-hospital transition outcomes by utilizing the Medicare Current Beneficiary Survey, 2000-2010, a nationally representative sample of the Medicare population**.**

My overall objective in this project is to identify whether rural Medicare beneficiaries experience less favorable outcomes post-hospital discharge than their urban counterparts. Further, this project will identify policy relevant factors that are associated with these outcomes. *My central hypothesis is that rural Medicare beneficiaries will experience more unplanned acute care, emergency care, and more Medicare expenditures post-discharge compared to their urban counterparts*. Further, due to fewer post-discharge resources in the outpatient and post-acute setting and potentially poorer access to specialty providers for patients with chronic conditions,[14, 15] the beneficial effect of a 7 day or 14 day follow up, and home health use, will be smaller among rural beneficiaries. This central hypothesis will be tested by pursuing these three *specific aims*:

AIM 1: **Determine whether rural beneficiaries have a greater probability of all-cause readmission, emergency department (ED) use, follow-up care within 7 to 14 day compared to urban beneficiaries.** *Hypothesis*: Rural Medicare beneficiaries will have a greater likelihood of a readmission, emergency department use, and a lower likelihood of follow up care compared to urban beneficiaries. A Cox proportional hazard model, controlling for individual and hospital level characteristics, will be used to test this hypothesis.

AIM 2: **Assess whether rural residency modifies the effect of 7 to 14 day follow up care and home health use on all-cause 30-day and 60-day readmission, ED use, and mortality.** *Hypothesis*: Follow-up visits within 7 to 14 days post-discharge (Early follow-up care), and home health use will have a smaller reduction in readmission, ED use, and mortality among rural beneficiaries compared to urban beneficiaries at 30- and 60-days. A logistic regression with a difference in difference estimation strategy will be used to conduct this analysis. An instrumental variable approach will be used to account for treatment selection bias. We will test a number of instruments captures from the Area Resource File and Dartmouth Atlas of Health Care.

AIM 3: Assess whether rural residency modifies the effect of 7 to 14 day follow up and home health use on 30-, 60-, and 180-day Medicare expenditures. *Hypothesis.* Early follow-up care and home health care will be associated with a smaller reduction in Medicare expenditures among rural beneficiaries compared to urban beneficiaries. Quantile regression with an instrumental variable approach will be used to account for treatment selection bias. We will test a number of instruments captured from the Area Resource File and Dartmouth Atlas of Health Care.

This research will identify policy modifiable factors associated with outcomes and costs of post-hospital care transitions among rural beneficiaries. This project will guide policymakers in improving the delivery of care among elderly rural Medicare beneficiaries, particularly in the context of bundled payments and Accountable Care Organizations. Project findings will help providers in developing interventions to better support the improvement of quality, efficiency, and effectiveness of care among the rural elderly population.

Background

Post-hospitalization transitions have become a major policy focus, but research lags behind in understanding transitions in rural settings. Hospital readmissions that result from poorly executed care transitions cost Medicare $17 Billion each year.[16] Under the Affordable

Care Act (ACA), hospitals now have financial incentives to invest in better post-discharge care to reduce readmissions. It is important to better understand what kind of post discharge interventions may be helpful. It is understood that there are certain components of a successful care transition, specifically whether a patient receives follow up care within 7 to 14 days post-hospital discharge and home visits.[6, 17] Studies suggest that early follow up care reduces the risk of a readmission and emergency care. [16, 18] However, a recent review of transitional care programs, of which early follow-up care is a component, found mixed results on reducing readmission among adults with chronic conditions.[19] Furthermore, certain conditions may require home health care services. Some research points to the role of home health on reducing the risk of readmission and improving health outcomes.[20, 21] Rural beneficiaries may have poorer access to needed home health services.[22] Indeed, rural beneficiaries may have fewer options of post-discharge care, adding to the concern that penalizing hospitals for post-discharge outcomes may disproportionately affect rural safety net hospitals. Whether rural beneficiaries have a similar mix of post-hospital transition care and outcomes to urban beneficiaries has not been fully examined. Additionally, home health agencies recently began reporting 30-day readmission and ED use as a quality metric to the Centers for Medicare and Medicaid Services (CMS). Moreover, 60-day care transition episodes are currently being considered by CMS in designing the post-acute care bundled payment.[25] Thus, this study has important implications for hospitals and policymakers seeking to improve post-discharge outcomes. In particular, this study can inform that policy agenda for care transitions in rural settings.

The literature on post-discharge care in rural settings does not provide a clear action agenda. Some studies point to better access to care among rural patients through having a usual source of care and greater use of urgent and elective surgical procedures. [7, 8] Other studies suggest poorer rural access to follow up and post – acute care as evidenced by greater hospitalizations for ambulatory care sensitive conditions and emergency room visits. [26, 27] The extent to which post-hospital transitions home have differential patterns and outcomes across urban and rural settings is unclear. Studies that look at 30-day readmissions, a commonly used care transition outcome for policymakers and researchers,[28] have illustrated mixed results. [29, 30] Other studies are often limited to one disease category,[31, 32] and have methodological limitations. Few studies have used a nationally representative sample to assess the degree to which 7 to 14 day follow up care, home health care, and post-hospitalization transition outcomes are associated with a Medicare patient's rural residency. Furthermore, no study to my knowledge has assessed whether there is a modification effect of rurality and follow up care/home health care on readmission, ED use, mortality, and expenditures. The contribution of this study is that it will be the first to establish factors associated with differences in post-hospital to home transition outcomes among urban and rural Medicare beneficiaries. This contribution is significant because it will point to modifiable factors, such as receipt of follow up care within 7 or within 14 days post-discharge, and home health care use, associated with patient level outcomes and costs of post-hospitalization transitions for rural Medicare beneficiaries. As such, findings from this study will be relevant to practitioners and policy makers in a number of ways.

First, findings from this study can point to ways to improve cost incentives and penalties for hospitals serving rural and disadvantaged beneficiaries. Should this research show poorer post-discharge outcome in rural settings, then it will 1) provider further evidence of potential disproportionate penalties under CMS's Hospital Readmission Reduction Program,[28] and 2) perhaps suggest alternative models of de-incentivizing readmissions. For example, Medicare could establish a single episode price for an admission that covers reduced payments for readmission between 15 and 30 days.[33] Second, evidence could inform CMS on reimbursement policy and allocation of resources to providers serving rural beneficiaries. Greater reimbursement for discharge planning services, case management, or other post-discharge interventions that improve access to early follow-up care may be called for, particularly within post-acute bundled payments to rural providers.[34] Third, findings could have implications for future care transition interventions. Interventions that include 7/14 day follow up care or home health care would receive increased attention from policy makers if Medicare expenditures are negatively impacted. Finally, findings from this study can also highlight areas for intervention to support efforts to reduce all cause 30-day readmission and ED use, and lower Medicare costs among rural beneficiaries. For example, patients from rural settings may require further post-discharge support, such as tele-health case management, to improve follow up care and reduce the risk of readmission.[35]

This study will advance the literature on post-discharge quality of care in rural settings in at least two important ways. First, this study will use a nationally representative sample of the Medicare population. Most studies that examine readmissions post-hospital discharge use hospital databases or statewide data.[36] More representative studies often use only administrative claims, and cannot account for key environmental and personal level control variables, such as personal socio-economic status, number of functional limitations, and discharging hospital-level characteristics.[37, 38] Indeed, the use of claims data to assess transitions of care outcomes may suffer from omitted variable bias. Additionally, few studies have explored the variation in post-discharge follow up care, by rural and urban settings, and use of home health services. Two recent studies suggest a relationship between rural residence and follow up care[39] and the subsequent effect on Medicare expenditures and readmissions.[40] However, small sample sizes and methodological limitations constrain the generalizability of these studies. Other studies of have identified differences in home health utilization and outcomes rural and urban beneficiaries entering care from the community,[22, 41] but no study to my knowledge has identified the role home health services plays during a post-hospitalization transition among rural Medicare beneficiaries.

Second, this study will use econometric analyses not previously applied in this setting. Because patients who receive follow up care post-hospital discharge, or who receive home health care, may be different than their counterparts who do not receive these services, the treatment effects examined for both Aims 2 and Aims 3 may be biased. Indeed, there may be observed and unobserved selection bias in the use of follow up care, and the use home health services.[21, 42] For example, sicker patients may be more likely to receive a follow up appointment and more likely to be readmitted, making it appear that follow up care increases the probability of a readmission. Most studies that examine the effect of follow up care on an outcome use either propensity score matching, or do not address the inherent selection bias. While propensity scores are frequently used in health services research to account for selection bias,[43] it cannot account for other unobserved characteristics that effect treatment selection. Similarly, sicker individuals with greater functional limitations are more likely to utilize home health services, and are also at greater risk for ED use and readmission. Instrumental variables (IV) have been used to account for unobserved endogeneity in treatment selection in health service utilization.[44] To my knowledge, no study has used an IV approach to assess the effect of follow-up care on readmission, ED use, mortality, and expenditures by rural and urban setting (AIM 2 and AIM 3). For both AIM 2 and AIM 3, I intend to use self-reported, **area level physician supply and area level home health agency (HHA) supply,** through the Area Resource File, and a number of county-level service utilization variables from the Dartmouth Atlas of Healthcare, and **distance from residence to the nearest HHA** and **discharging hospita**l from CMS's Provider of Service files as instruments for the main explanatory variable.[42, 44] Thus, this study will be the first to utilize an IV approach to account for selection bias in receipt of follow up care, and home health services, among Medicare beneficiaries during a post-hospitalization transition.

Conceptual Model

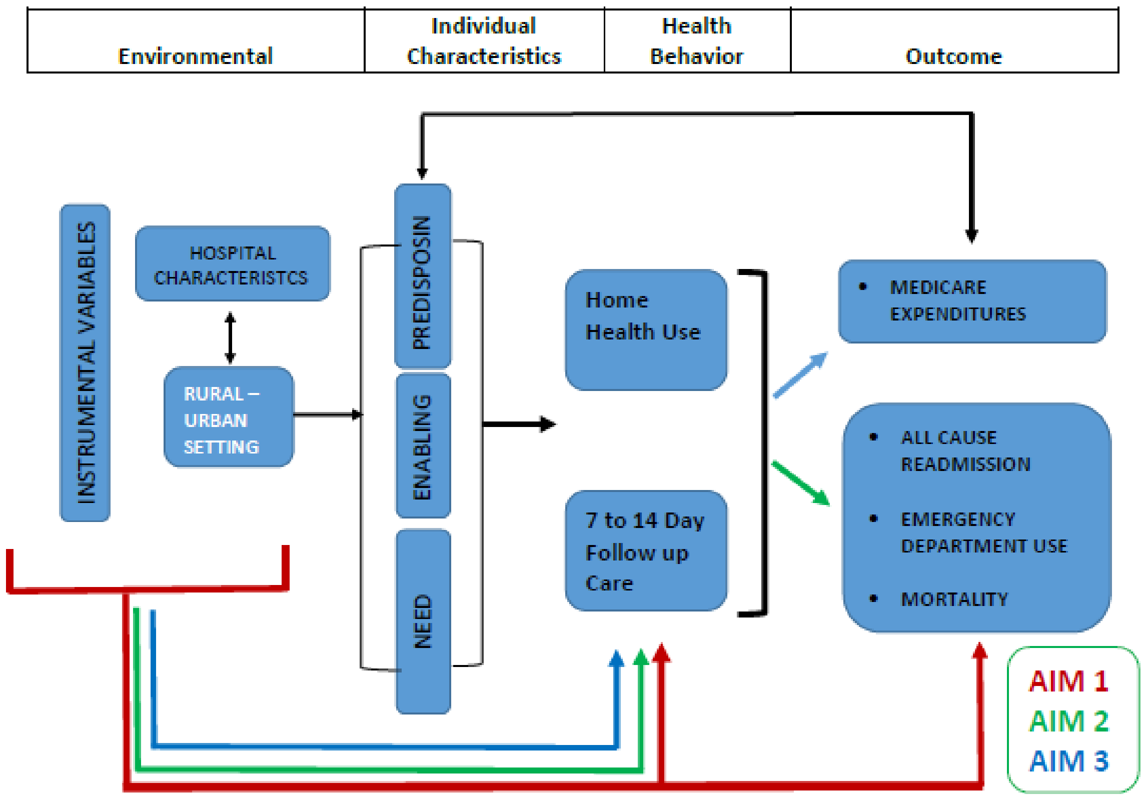
Similar to other studies on rural-urban differences in health service utilization, this study will use a conceptual model grounded in Anderson's Behavioral Model of health care utilization. [45] This model is comprised of four components: Environment, Individual Characteristics, Health Behavior, and Outcome. Individual characteristics are sub-grouped in to predisposing (i.e. age, race, education, etc.), enabling (i.e. income, Medicaid status, etc.), and need (i.e. health status, functional limitations, etc.) factors associated with health service use. Figure 1.1 illustrates how Individual factors contribute to both the propensity for health service use and outcomes. Environmental factors, such as "rural/urban" relate with predisposing and enabling individual characteristics to determine services utilization and outcomes. [45] The main explanatory variable in AIM 1, rural/urban status, is considered an environmental variable that has direct effects on follow-up care and home health utilization, and outcomes, as well as indirect effects on the main outcome variables through receiving 7 to 14 day follow up care and home health care. In ordered to adapt this model to account for a care transition episode, facility level characteristics of the discharging hospital are included. In this case, hospital characteristics are associated with whether the hospital is rural or urban. Simultaneously, whether a beneficiary is rural or urban is associated with the type of hospital they are admitted too.

This model also helps explain the instruments of choice for Aim 2 and Aim 3. In order for an instrumental variable to appropriately be used, it must not have a direct effect on the outcome of interest, and only an indirect effect principally through the endogenous explanatory variable. [42] For *Specific Aim 2* and *Specific Aim 3*, I intend to use both **physician supply** and **HHA supply** through the Area Resource File. In addition, **% 14-day follow-up care at the county level**, **average physician reimbursement** per enrollee, and average **HHA episodes** per enrollee at the county level from the Dartmouth Atlas of Health Care will be tested. Finally, residence **distance to discharging hospital** and **closest HHA** will also be tested. These potential instrumental variables are considered environmental characteristics in a model of post-hospitalization use. They have should have a direct effect on use of follow-up and home health services, but only an indirect effect the outcomes through the propensity to use these services.

Summary

Post – hospital care transitions have become a major policy focus because of its high cost to Medicare and the potentially enormous consequence to the health of the patient. There is reason to think the quality of post-hospital care transitions may be poorer in rural settings. Yet, research lags behind in understanding transitions in rural settings, particularly whether rural beneficiaries are more likely to receive timely follow up care, and whether the quality of follow up and home health care vary by rural residency. This research will use a nationally representative sample of the Medicare population to determine the whether rural Medicare beneficiaries have a higher probability of all – cause 30 to 60 day readmissions, ED use, and mortality during a care transition. It will further determine whether this association is modified by receiving timely follow up care, and by home health care use. Additionally, the effect of these interventions on 30-day to 180-day Medicare expenditures will also be explored. To my knowledge, no study has sought to determine post-hospital transition differences in outcomes and costs between rural and urban beneficiaries. Findings from this study can guide policy makers and providers in the development of reimbursement strategies for hospitals serving rural residents, and interventions to improve transitional care quality.

Figure 1.1: Adapted Anderson Healthcare Utilization Model For Post-Hospital Transition



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CHAPTER 2: METHODS

Data Source

The Medicare Current Beneficiary Survey (MCBS), 2000-2010, will be the main data source used to conduct this study. The MCBS is longitudinal panel survey of a nationally representative sample of the Medicare population. Survey data is collected three times a year over a four year period. These data include information on the beneficiary's health status, access to care, household composition, health service use and expenditures, as well socio-demographic characteristics. Survey data is linked with Medicare claims which are collected continuously for the duration of the beneficiary's participation in the survey. Claims data include the beneficiary's utilization of inpatient care, outpatient care, skilled nursing facilities, home health, hospice, medical equipment, and physician carrier services. The Area Resource File will be linked to the beneficiary's zip code to capture provider supply characteristics of the beneficiary's environment. I will link facility identification variables from the MCBS to the Provider of Service File to collect hospital level variables. The Provider of Service File is administered by the Centers for Medicare and Medicaid Services, and contains detailed information on Medicare authorized providers, including hospitals. This data is collected on a quarterly basis.

Study sample

All beneficiaries with an inpatient admission from the MCBS, 2000 to 2010, will be identified for all Aims. To ensure that the admission is the beginning of an acute care episode, or an index admission, I will restrict the sample to admissions without a previous admission 60 days before. Of beneficiaries with an index admission, I will keep those 65 years and older, enrolled in Fee for Service, have a discharge date, and alive for 60 days post discharge. We also excluded index admissions for cancer management and a primary diagnosis of a psychiatric or rehabilitation condition (not usually in acute stay hospitals).[1] The sample will be further restricted by including only beneficiaries discharged to a non-institutional setting. Figure 1 illustrates the sample selection for this study population for Aim 1. For Aims 2 and 3, the sample will come from the Aim 1 sample, but with further specification in that I will exclude observations that were readmission/ ED visits (Aim 2) and have any acute or post-acute spending (Aim 3) prior to 3 days post-discharge, to ensure the potential to receive follow up care and home health services. The reason for this exclusion is 1) there should be enough time post-discharge for the beneficiary to receive the treatment [2] and 2) acute and post-acute outcomes that occur closer to the discharge date reflect inpatient quality rather than outpatient quality.[3]

Key Independent variables

Follow up care was defined as any Evaluation and Management visit in an outpatient or office based setting (HCPCS codes >=99241 & <=99245, >=99201 & <=99205, and >=99210 & <=99215) during the 7 and 14-day period that takes place before any acute events and expenditures (Aim 2 and Aim 3) or post-acute expenditures (Aim 3). [4] Home health use was defined as having any home health claim within 14-days of the discharge date, and occurring prior to an acute or non-home health post-acute expenditures or events (Aim 2 and Aim 3). A variable for rural residency was created from the Rural-Urban-Commuting Codes (RUCA) and coded as a dichotomous variable (Rural vs. Urban). RUCA codes combine standard Census definitions with area commuting behaviors to capture functional and work relationships between regions.

Dependent Variables

Readmission. For the purposes of this study, the Yale/CMS all cause 30 day readmission measure will be used as the primary outcome. As described by Horwitz et al.,[5] any readmission is undesirable and exposes the patient to greater risk. The Yale/CMS all-cause 30 day readmission measure includes all condition categories. Readmissions under this measure included all unplanned admissions. Because it is difficult to assess what a "planned" admission might be using administrative claims data, this measure excludes admissions for maintenance chemotherapy or rehabilitation, and where at least one of 35 typically planned procedures occur but were not coded as being 1 of 27 acute primary diagnosis.[6] Readmission will be measured as "time to readmission" in Aim 1, and the probability of 30- and 60-day readmission in Aim 2.

Emergency Department Use. ED use as a 30-day care transition outcome has received increased attention.[7] Studies that identify 30-day ED use generally do not distinguish between using the ED as a result of the underlying health condition or because of some other event or accident.[8] While there is some literature on distinguishing between emergent and non-emergent ED use,[9] any ED use within 30 days and 60 days of discharge is an appropriate outcome for this study. Recent studies that include an ED as a 30-day care transition outcome include ED visits that do not result in a hospitalization.[10] As such, this study will identify any emergency department visit that does not result in a hospitalization within 30 and 60 days post-discharge for all Aims.

Mortality. Aim 2 will include as a dependent variable the probability of death within 30- and 60-days post-discharge. Mortality will be captured retrospectively from responses by proxies of the participant in the MCBS.

Medicare Expenditures. Aim 3 will assess Medicare expenditures within 30-, 60-, and 180-days post-discharge. Expenditures will be obtained from Medicare inpatient, outpatient, carrier, hospice, skilled nursing facility, home health, and medical equipment claims. Total 30-, 60-, and 180-day expenditures will be calculated by summing all claims within specified post-discharge period.

Instrumental Variables

Provider distance. I will calculate a straight line distance between the geographic center of the beneficiaries' residency zip code to the: (1) center of the admitting hospital zip code and (2) nearest home health agency (HHA). Distance to provider has been used as instrument for health outcomes in other studies. [11] The closer a resident is to the discharging hospital, the more likely that person would receive a follow-up visit as they are more likely to live within that hospital's network of providers and outpatient facilities, simplifying care coordination. Once patient level demographic, health, and hospital characteristics are controlled for, distance to the hospital should have no relationship with the outcome, except through follow-up care. [12]

Physician Supply (Aim 2 only). Total general practitioners, family practitioners and specialists per 10,000 elderly (*physician supply*) will be obtained from the Area Resource File. Physician supply should be strongly associated with follow-up care. [13] Some research suggests supply of primary care physicians reduces the number of preventable hospitalization in a county [14], yet I argue here that the beneficial effect of physician supply on 30- and 60- day post-discharge outcomes is a result of better access to primary care and better continuity of care [15], which in this case would represent an early follow-up visit. Therefore, *physician supply* can be validly excluded from our outcome models because its principal relationship with 30- and 60-day outcomes will be captured by whether the beneficiary receives an early follow-up visit. Residents living in in communities with a higher density of primary care providers should be more likely to receive a follow-up visit within 7 and/or 14 days of discharge, compared to residents living in areas with lower primary care density.

County Follow-up Rate. County level rates of 14-day primary care follow-up (*percent follow up*) will be acquired from the Dartmouth Atlas of Health Care. Federal Information Processing Standard (FIPS) values from the Dartmouth files can be linked with beneficiary zip-codes. Geographic practice patterns are frequently used as instrumental variables in the literature and should be a good candidate for an IV in this analysis. [16, 17] County level 14-day follow-up care is an indicator of coordination of care within the county. [18] Any relationship between county level rates of 14-day follow-up care with patient level outcomes in readmission, ED use, or mortality post-discharge can be attributed to whether a patient receives a physician visit post-discharge. Any additional correlation can be accounted for through our demographic, health, and hospital characteristics controls. Higher county level rates of 14-day follow-up care should be positively associated with the probability that a beneficiary with a residency in the same county would receive a follow-up visit.

Physician Medicare Reimbursement (Aim 3 only). County level average of Medicare Part B reimbursement per enrollee will be obtained from the Dartmouth Atlas of Health Care, 2000 to 2010. Federal Information Processing Standard (FIPS) values from the Dartmouth files with will be linked with beneficiary zip-codes. Dartmouth uses prices adjusted averages, thus the variation across FIPS should reflect service intensity. Variation in Medicare expenditures within Hospital Referral Regions (HRR) are mostly associated with post-acute service utilization, such as SNF, Home Health care, rehabilitative care and inpatient care. [19] As such it may be the case the average physician reimbursement per enrollee at the county level may be validly excluded from models on 30-, 60-, and 180-day post-discharge expenditures because 89% of expenditure variation within HRR are a result of post-acute and acute service utilization. Thus, conditioning on a recent discharge and controlling for health status, hospital characteristics, and whether the beneficiary receives a follow up visit, physician reimbursement per enrollee should not have any explanatory power in an expenditure model.

HHA episodes. Dartmouth Atlas of Health Care files will be used to acquire home health episodes per 1000 beneficiaries at the county level from 2000 to 2010 (*episodes*). A higher number of episodes should predict better access to home health services. In turn, episodes should not be correlated with the propensity for a 30- or 60-day outcome except through its relationship with access to home health services. Similar to the rational above, after adjusting for patient-level demographic, health, and hospital-level characteristics there should be no remaining relationship between *episodes* and the outcomes.

Control variables

Table 2.1 describes the control variables used for this study. Predisposing variables will include age, race, gender, education, and living situation (lives alone, with kids, with spouse, etc…). Enabling variables will include income, Medicaid status, and hospital characteristics. Similar to other care transition outcome studies, hospital characteristics will include size, number of full-time registered nurses, profit status, and geographic location. [20-22] Hospital level variables will come from the Provider of Service File. Need variables will include the number of limitations of activities of daily living (ADLs) and instrumental activities of daily living (IADLs), length of stay, and the Charlson Comorbidity Index (CCI). The CCI is a calculated score to predict risk of mortality, based off primary and secondary diagnosis.[23] It is frequentally used to control for confounding of disease severity on outcomes.[21, 24]

Analytic Approach

For Aims 1 and 2, I will adjust for MCBS's complex survey design by using survey weighted regression with replicate cross-sectional weights and bootstrapped standard errors For Aim 3, I will adjust for the complex survey design using non-replicate weights.

Specific Aim 1. Hypothesis: *Rural Medicare beneficiaries will have a higher risk of all-cause readmission, ED use, mortality, and lower risk of 7 to 14 day follow up at 30 and 60 days post-discharge, compared to urban beneficiaries.* A multivariate Cox Proportional Hazard Model will be used to test this hypothesis. Each of these models will include control variables listed in Table 1.1. Appropriate specification tests and tests of proportionality will be used to construct the model.

$$Pr(t = T|X) = \frac{\exp(X_t \beta)}{\sum \exp(X_t \beta)} where\ X\beta$$

$$= \alpha + \beta_1(Personal\ Characteristics) + \beta_2(Hospital\ Characteristics)$$

$$+ \beta_3(Environmental\ Characteristics) + \delta\ Rural\ Residency + \gamma\ Time$$

$$+ \varepsilon \quad (Equation\ 1)$$

The probability of an outcome at time *T* will be calculated as the exponentiated values of the X betas at time *t* given the outcome, over the summation of the exponentiated values of the X betas at time *t* without the outcome. The β's represent the predisposing, enabling, and need characteristics described in Table 1.1. The outcome variables will be time to event for all-cause readmission, follow up within 7 days to 14 days, ED use, and mortality. Rural residency will be a dichotomous (1= Rural, 0 = Urban) indicator, represented by δ. Year fixed effects will be included to control for the trend in readmission, ED use, follow up care, and mortality over time.

Sample Size for Aim 1. There are approximately 11,000 hospital admissions in the MCBS from 2000 to 2009 where the beneficiary was discharged home. Recent estimates of un-adjusted readmissions among Medicare patients by rural settings suggest a 0.1% to 4% difference,[25, 26] while other studies show similar rates across urban and rural hospitals.[28] To detect a 3% point change in the probability of having a readmission, at α = .05 and β = .80 I would need approximately 2,600 observation is each group (Urban vs. Rural). A similar number will be needed to assess the relationship between rural setting and emergency room utilization, and timely follow up care. Assuming a 3% point difference in the probability of receiving a follow up visit[29] at α = .05, β = .80, I would need approximately 2,600 observations in category. I expect to have close to this many observations [30] in the rural category, and perhaps twice as much in the urban category.

<u>*Specific Aim 2*</u>. Hypothesis: Receipt of a *follow up visit within 7 to 14 days post-discharge and home health services will have a smaller reduction in readmission, ED use, and mortality among rural beneficiaries compared to urban beneficiaries.* I will employ an instrumental variable using a two-stage residual inclusion strategy to control for treatment selection bias.[31] Two first-stage equations will be run for follow-up care and for home health care. The coefficients β_1- β_5 represent the instruments and δ represents a vector of pre-disposing, enabling, and need covariates listed in Table 1.1. The calculated residuals of the probability of having a follow up visit and the probability of having home health use will be interacted with a rural dichotomous variable, amounting to 4 residuals included in the 2nd stage model.

$$
\begin{aligned}
1st\ Stage&: Prob(Treatment|Z_1 - Z_5, X)\ \alpha + \beta_1(Physician\ Supply) \\
&+ \beta_2(County\ Level\ \%\ Follow-up\ Rates) + \beta_3\ (Distance\ to\ hospital) + \beta_4 \\
&+ \beta_4\ (Distance\ to\ HHA) \\
&+\ \ \beta_5\ (County\ Level\ HHA\ Episodes\ per\ beneficiary) +\ \delta X +\ \varepsilon \\
&\ (Equation\ 2)
\end{aligned}
$$

The second stage equation will employ a difference in difference analysis with logistic regression for 30 day and 60 day readmission, ED use, and mortality. The calculated residuals from the first stage equation will be included to control for the unobserved endogeneity of the treatment variables. The treatment group will be rural residents who receive a follow up visit and rural residents who receive home health. The control group will be urban residents who receive a follow up visit and urban residents who receive home health:

$$2nd\ Stage: Prob(Y\ |X) = \beta_o + \beta_1(X) + \beta_2(Follow\ \ up) + \ \beta_3(Home\ Health) + \ \beta_4(Rural) + \beta_5\ (Rural * Follow\ Up) + \ \beta_6\ (Home\ Health * Rural) + \hat{\gamma}1\ + \ \hat{\gamma}2 + \hat{\gamma}3 + \ \hat{\gamma}4 (Equation\ 3)$$

In this model β_1 are the predisposing, enabling, and need characteristics, plus years. The effect of follow up care among rural beneficiaries is represented by the linear summation of $\beta_2 + \ \beta_4 + \beta_{5.}$ The effect of home health among rural beneficiaries is represented by $\beta_3 + \beta_4 + \beta_6$. The difference in difference effect of rural residency on the effect of follow-up care on the on the outcome will be β_5. The difference in difference effect of rural residency on the effect of home health care on the outcome is represented by β_7. Finally, $\hat{\gamma}1 - \hat{\gamma}4$ are the residuals from the first stage equation and account for the unobserved endogeneity associated with the treatment variables in the second stage equation. The marginal effects of the treatment variables will calculated using the method of recycled predictions, and the standard errors will be bootstrapped.

Sample size for Aim 2. Estimates on the effect of follow up care on readmission and ED use vary by widely by study, and by certain disease categories. These estimates range from a 3% to 23% reduction of risk, to about 90% decrease in the odds of a 30-day readmission. [8, 32, 33] To detect a 5 percentage point difference in the probability of a 30-day ER visit at α = .05 and β = .80, I will need approximately 1,231 observations in each group. I have approximately 12,000 index admissions, and I expect at least 20% are rural admissions.[28] Assuming 37% receive a timely follow up (7 days or less),[29] I should have the observations I need to detect at least a 5 percentage point difference.

Studies that have included home health services as part of a broader care-transition intervention show relative risk reductions of 22% to 45% of hospitalizations at 6 months.[34-36] Other studies suggest odds reductions of 12 month hospitalization of 0.65 [37] or a 4% point effect size when the sample re-hospitalization average was 34%. Only one study evaluated rural-urban differences in hospitalization from home-care services and found rural patients were 5% points more likely to be hospitalized at 120 days, compared to urban patients.[38] As no study directly tests the modification effect of home health services on 30 and 60 day outcomes among rural beneficiaries, I assume an effect size of 0.05 to be conservative. Using Stata's powerlog command, and an R^2 of 0.02 among the included covariates, I will need approximately 640 observations to detect a change 0.05 in the predicted probability of a readmission, at $\alpha = .05$ and $\beta \geq 0.80$, assuming a readmission average of 29%. Assuming at least 20% of discharges receive home health services, I should have an appropriate sample size to detect this change.

Specific Aim 3. Hypothesis*: Receipt* of a *follow up visit within 7 to 14 days post-discharge and home health care will have a smaller reduction in Medicare expenditures among rural beneficiaries compared to urban beneficiaries.* Similar to Aim 2, a two-stage residual inclusion will be used to address endogeneity concerns within the treatment variable. There may be unobserved characteristics that effect both the use of home health services, follow up care, and Medicare expenditures, biasing the observed effect. The first stage equation will be similar to Aim 2, which includes a probit for the same instruments with exception to *physician supply*. This instrument was substituted *for physician reimbursement* per enrollee at the county level. The predicted residuals from the first stage will be included in a second stage difference in difference model using quantile regression. Quantile regression will be used to assess the treatment effects on the conditional distribution of the 30-, 60-, and 180-day expenditure variables.[39] Conditional quantile regressions will be run for the 10th, 25th, 50th, 75, and 90th percentiles of 30-day, 60-day, and 180-day Medicare expenditures. The right hand side variables for this model will be equivalent to *Equation 3*. The marginal effects of interest will the same as in Aim 2. For example, β_4 represents the baseline association between rural residency and the conditional expenditure outcome. The marginal effect of home health service use among rural beneficiaries is represented by $\beta_3 + \beta_4 + \beta_6$. The marginal effect of follow up services on Medicare expenditures among rural beneficiaries is represented by $\beta_2 + \beta_4 + \beta_5$.

Most likely the expenditure dependent variables will be logged, [40] thus the marginal effects will be re-transformed and calculated using the method of recycled predictions:

$$Marginal\ Effect\ (\$) = Q_\tau exp(logged\ y \mid \widehat{Treatment} = 1) - Q_\tau exp(logged\ y \mid \widehat{Treatment} = 0)$$

Sample size for Aim 3. It is expected that receipt of follow up services and/or home health services can reduce Medicare expenditure during a post-acute period. Care transition interventions have demonstrated expenditure differences between the intervention and control groups at 180-days and one year.[41, 42] These differences range from approximately $500 to $7,000. An observational study determined estimated around $10,000 difference between those who received follow up care within 90-days post-discharge and those who did not over a year period.[2] Using the sampsi command in Stata, to detect a $1000 difference in Medicare expenditures between rural and urban beneficiaries at 80% power and alpha = 0.05, with a standard deviation of $5,000, I will need approximately 393 in each treatment arm. I expect to have adequate sample size to detect this difference.

Table 2.1: Key explanatory variables		
Predisposing	**Variable**	**Type**
	Age	Categorical
	Race	Categorical
	Gender	Categorical
	Education	Categorical
	Living situation	Categorical
Enabling		
	Income	Continuous
	Medicaid	Categorical
	Hospital Characteristics (Size, Profit status, # nurses, rural location)	Categorical (Profit status, rural location) Continuous (# of beds, # of nurses)
	Rural Residency (RUCA codes)	Categorical
Need		
	Functional Limitations	Continuous
	Charlson Comorbidity Score	Continuous
	Length of stay	Continuous

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CHAPTER 3: RURAL MEDICARE BENEFICIARIES HAVE POORER FOLLOW-UP CARE AND GREATER EMERGENCY DEPARTMENT USE POST-DISCHARGE

Introduction

Medicare spending on post-acute care has more than doubled from $26.6 billion in 2000 to $62 billion in 2012, and is the largest contributor to geographic variation in Medicare expenditures.[1-3] Beneficiaries receiving these services have complex medical needs that complicate care transitions from hospitals to home. Complicated care transitions, defined as care transitions from lower to higher levels of medical care (e.g., from home back to hospitals), frequently lead to unplanned hospital readmissions and emergency department (ED) use, costing Medicare $12 billion each year.[4-6] Studies demonstrate that timely receipt of follow-up post-discharge care can reduce the risk of hospital readmissions and Medicare costs.[7]

Studies of access to post-discharge care and patient outcomes for rural vs. urban Medicare beneficiaries suggest that rural beneficiaries experience unique challenges as they seek post-acute care after hospitalization; however findings in available research are incomplete and suggest the need for further research. For example, a recent MedPac report found no major unadjusted differences in post-acute care utilization and outcomes at the provider level in rural and urban settings.[8] However, 30-day and 60-day readmission rates among rural hospitals was higher than urban hospitals for some conditions.[9] Moreover, ED use also has been used as a measure of the quality of post-acute care. [10] [6] Among Medicare beneficiaries, 17% [11] to 24% [12] had an ED visit within 30 days of hospital discharge. ED visits frequently resulted from preventable complications related to cardiovascular or respiratory diagnosis, infections, and procedural site complications. [11] The literature suggests that overall utilization of the ED from the community is lower in rural settings; however, it is unclear whether rural Medicare beneficiaries are at greater risk of an ED visit during a post-discharge period. Indeed, poorer access to key post-discharge services, like follow-up care, may increase the risk of an ED visit.[13]

Two factors may explain the low rate that rural beneficiaries receive follow-up after hospital discharge.[14] [15] [16] It is widely believed that increasing the frequency of follow-up care after hospitalization is a commonly noted for reducing hospital ED visits post-discharge;[13] however, beneficiaries in rural settings have access to fewer physicians than those urban areas,[17] and geographic barriers to care in rural areas may limit patients' access to follow-up care.[18] Finally, rural providers may face systematic barriers to ensuring rural beneficiaries receive appropriate post-discharge services.

Public and private payers have introduced incentives to hospitals to reduce unplanned 30-day readmissions, and improve post-discharge services. The Centers for Medicare and Medicaid Services (CMS) is considering post-acute bundled payments to incentivize providers to coordinate and communicate across acute, post-acute, and outpatient settings of care. Moreover, CMS may soon consider post-acute episodes of care longer than 30-days.[19] Despite these policy changes, providers serving rural beneficiaries may not have the necessary resources or incentives to invest in activities to improve post-discharge outcomes.[20] Thus, understanding rural beneficiaries' use of medical services during 60 days after hospital discharge is important.

This study seeks a greater understanding of follow-up care and health services utilization (hospital readmissions and ED use) among rural Medicare beneficiaries during the first 60 days after hospital discharge. We hypothesize that rural Medicare beneficiaries will have a lower likelihood of follow-up care and greater likelihood of a readmission and ED visit compared to urban beneficiaries.

Methods

Data Source. The Medicare Current Beneficiary Survey (MCBS), Cost and Use files from 2000-2010, is the main data source for this study. The MCBS is a longitudinal panel survey of a nationally representative sample of the Medicare population. Survey data are collected from each respondent three times a year over a four-year period. These data include beneficiaries' health status, access to care, household composition, health service use and expenditures and socio-demographic characteristics of the sample. Survey data are linked with Medicare claims, which are collected continuously for the duration of beneficiaries' participation in the MCBS. Claims data include beneficiaries' utilization of inpatient care, outpatient care, home health care and physician office based services. Hospital level characteristics were captured from CMS Provider of Service File, which comes from a yearly survey of Medicare certified hospitals.

Study sample. The sample included admissions to acute hospitals among Medicare beneficiaries in the MCBS from 2000 to 2010 that were: (1) $\geq$ 65 years; (2) discharged from a hospital to home; and (3) enrolled in traditional fee-for-service Medicare within the contiguous 48 states. The sample excluded admissions: (1) with a previous admission within 60 days to establish the beginning of an acute care episode (index admission); (2) that occurred within 60 days of the first year in which the participant was in the survey; and (3) for cancer management and a primary diagnosis of a psychiatric or rehabilitation condition (not usually in acute stay hospitals).[21] Of 41,970 admissions to an acute care hospital, 11,986 index admissions were included in the sample after selection criteria were applied (Figure 3.1).

Key Variables and Measures. The main dependent variables were days between discharge from the index hospital admission to the first hospital readmission, ED visit, and follow-up visit during the 60 days post-discharge. Hospital readmission was defined using the Yale/CMS all-condition 30-day unplanned readmission measure.[21] To account for planned readmissions, admissions for selected medical conditions were excluded from the sample, including maintenance chemotherapy or rehabilitation and readmissions in which at least one of 35 typically planned procedures occur without having a primary diagnosis of an acute event.[22] ED use included all ED visits that did not result in a hospitalization.[6] Time to follow-up care included follow-up visits that were coded as an Evaluation and Management visit in an outpatient or office based setting (HCPCS codes >=99241 & <=99245, >=99201 & <=99205, and >=99210 & <=99215) during the 60-day period after hospital discharge.[23]

Rural residency, the main explanatory variable, was created from the Rural-Urban-Commuting Codes (RUCA) and coded as a dichotomous variable (Rural vs. Urban). RUCA codes combine standard Census definitions with area commuting behaviors to capture functional and work relationships between regions; this rural-urban taxonomy offers a more precise definition of "rural" and has been used in other studies [18] and by federal agencies. [8]

Covariates*.* Demographic variables included both continuous (age and income) and categorical (race, gender, education, relationship status, Medicaid status and household composition) variables. Health status included number of limitations in activities of daily living

(ADLs) and instrumental activities of daily living (IADLs), length of the index hospitalization, and the Charlson Comorbidity Index (CCI). The CCI predicts risk of mortality based on beneficiaries' primary and secondary diagnosis[24] and is frequentally used to control for confounding of disease severity on post-discharge outcomes.[25, 26] Hospital facility-level variables included the number of beds, number of registered nurses, for-profit status and geographic location. [26-28]

Statistical Analysis*.* Descriptive statistics of the sample were weighted using full-sample cross-sectional weights for the year they were in the survey. We compared rural versus urban residency for the control and dependent variables using *t-tests* (continuous variables) and chi-square (categorical variables). To assess risk of readmission, ED use, and receipt of follow-up care, a survey weighted Cox Proportional Hazard model was employed with cross-sectional probability weights. Replicated weights with bootstrapped standard errors were used in the multivariate models. Observations were censored at the end of the 60 day post-discharge period. The hazard model was adjusted for demographic, health status, and hospital level characteristics. A smoothed hazard estimate was created for each dependent variable. Statistical tests for proportionality cannot be used for survey weighted data; thus, Kaplan Meyer curves were used to inspect any violation of this assumption. We found the proportionality assumption to be reasonably met for each dependent variable.

We first calculated an unadjusted hazard of rural residency on each dependent variable. For each outcome, we developed three Cox proportional hazard models adjusted for: (1) demographic characteristics only; (2) health and demographic characteristics; (3) health, demographic, and hospital-level characteristics, as well as year effects (fully-adjusted model). Sensitivity tests were run on a composite readmission/death variable which included those who died during the post-discharge period. These tests did not indicate differences in the outcomes, so we dropped those who died during the 60-day post-discharge period. A complete case analysis was used. This study was exempt from approval of University of North Carolina at Chapel Hill's Institutional Review Board.

Results

There were 7,943 beneficiaries with hospital admissions who resided in urban areas and 4,043 who resided in rural areas (see Table 3.1). Compared to urban beneficiaries, rural beneficiaries were slightly younger, less likely to have a high school education, have lower income, and more likely to be insured by Medicaid. There were no statistically significant differences in self-reported limitations in ADLs and IADLs; however, compared to urban beneficiaries, rural beneficiaries had a significantly lower CCI score (3.06 vs. 3.29, respectively, $p<0.01$). Moreover, 68% of rural beneficiaries were admitted to a rural hospital, whereas, less than 3% of urban beneficiaries were admitted to a rural hospital ($p<0.001$).

Hospital Readmissions. Rural beneficiaries did not have a significantly different risk of 60-day readmissions in either the unadjusted model or the model adjusting for demographic characteristics, compared to urban beneficiates (Table 3.2, Row 1). However, when controlling for health status and demographic characteristics, rural beneficiaries had a 10% greater risk of hospital readmission during a 60-day post-discharge period ($p < 0.05$). These effects were statistically insignificant once hospital-level characteristics were included in the full model. Hospital location was strongly associated with readmissions 60-days after hospital discharge. Beneficiaries admitted to isolated rural hospitals, compared to urban hospitals, had a 60% greater hazard for a readmission ($p<0.01$). Similarly, beneficiaries admitted to small rural and large rural hospitals had a 24% and 44% greater relative hazard of a readmission, respectively (p<0.01).

ED Visits. Rural beneficiaries had a 27% greater unadjusted risk of an ED visits compared to urban beneficiaries (p<0.01) (Table 3.2, Row 2). After adjusting for demographic, health status and, finally, hospital characteristics, rural beneficiaries maintained a 23% to 27% greater risk of ED use, compared to urban beneficiaries, during a 60 –day post-discharge period(p<0.01). Unlike the model for hospital readmissions, hospital location did not significantly predict the risk of ED use during a 60-day post discharge period. Figure 3.2 illustrates the survival curve for both rural and urban beneficiaries over 60-days post-discharge.

Follow-up Care. Rural beneficiaries, compared to urban beneficiaries, had a lower unadjusted hazard for follow-up care during a 60-day post-discharge (Table 3.2, Row 3). After adjusting for demographic, health status, year and hospital level characteristics, rural beneficiaries had 14% lower hazard of receiving a follow-up visit during a 60-day post-discharge period (p<0.01). There was no relationship between the rural location of the discharging hospital and follow-up care. Figure 3.3 displays the proportion of rural and urban beneficiaries receiving follow-up care over the post-discharge period.

Sensitivity Tests. We conducted multiple sensitive analyses to test the robustness of our results. In all models we added CAH status, teaching status, and whether the beneficiary was admitted for heart failure, chest pain, COPD, pneumonia, or digestive disorders, or was transferred from another acute hospital. These tests did not change the overall outcomes of our models. Finally, we ran the models on 30-day outcomes, which produced a similar trend in the coefficient direction, magnitude and significance.

Discussion

We found valuable evidence about the quality and outcomes of post-discharge care delivered to rural Medicare beneficiaries. Compared to urban beneficiaries, rural beneficiaries had higher rate of ED visits and a lower rate of follow-up visits. These findings are especially interesting in that rural beneficiaries did not have a greater risk of readmission, even though, all things being equal, beneficiaries who were discharged from rural hospitals were at greater risk of readmission. These findings might be explained by several factors.

First, the location of the discharging hospital may explain the risk of hospital readmission. Rural hospitals have lower caseloads, which can affect process and outcome level quality measures.[29] For example, evidence suggests hospital staff that more frequently manage care for patients with certain conditions provide better care than staff that manage fewer of these cases (for example, in isolated rural hospitals).[30] Rural hospitals also tend to have fewer resources, fewer providers and operate in poorer communities, which also limits the ability of hospital staff to coordinate and plan care transitions across settings.[20, 31]

Second, delays in receiving follow-up care may explain the risk of greater risk of ED use during a post-discharge episode. Studies identify few differences in overall hospitalizations and outpatient visits among rural and urban settings;[32] however, our findings suggest that rural beneficiaries, compared to urban beneficiaries, are more frequently using the ED, and are less frequently or seen in medical follow-up visits. Previous research suggested that patients in rural areas had more ED use and hospitalizations, in part because of poor access to primary care.[33, 34] For example, rural Medicare beneficiaries report having a “usual source of care” as often as urban beneficiaries. However, whether timely access to primary care is similar among rural and urban beneficiaries is not clear.[8] Indeed, recent work suggests that a greater number of reported barriers to care was associated with a greater number of ED visits that person had in a given year.[16] Rural Medicare beneficiaries may be experiencing a greater number of barriers to follow-up care, resulting to greater ED use during a post-discharge period.

Contrary to previous studies, this study did not find a relationship between rural residency and readmission. Previous work offers contradictory evidence. For example, readmission among rural diabetic beneficiaries appears to be lower than among urban beneficiaries.[35] Other studies found elderly rural veterans to have a slightly higher odds of readmission compared to their urban counter parts.[36] Unique to those studies, this study controls for characteristics of the discharging hospital that, once included in our final model, seemed to explain the association between rural residency and readmission.

These findings have implications for health care delivery systems and payment reforms. Medicare's Hospital Readmission Reduction Programs aims to improve post-discharge outcomes by penalizing hospitals with greater than expected 30-day readmission rates. Consistent with previous work on safety-net and low-volume hospitals, our study finds that rural hospitals serving elderly Medicare beneficiaries may be disproportionately penalized under this program; if so, poor readmission outcomes among these hospitals may exacerbated.[20, 37] Improving access to follow-up care among rural Medicare beneficiaries is a critical strategy for reducing unnecessary hospital readmissions, ED visits, and health care costs during a 60 day post-discharge period. Thus, investments in tele-health, care management, and transitional care interventions may be necessary steps to improve access to care and reduce readmissions among rural and low-income patients.[38-41] Moreover, reducing ED use also could reduce Medicare Part B expenditures and out of pocket costs for beneficiaries. Failure to overcome barriers to follow-up care may make it more difficult for providers in rural settings, and hospitals serving rural beneficiaries, to reduce inefficiencies and costs in a bundled payment context.

There are several limitations to this study. First, while this was a nationally representative sample of the Medicare population, the MCBS does not allow population estimates of hospitals. As such, we cannot generalize our findings to rural hospitals nationally. Additionally, Critical Access Hospitals are a key source of acute care for rural patients, yet they represented less than 2% of the overall sample of hospital discharges in our study. Secondly, this study uses claims data to identify utilization. So, we could not capture community-based post-discharge services that may affect the outcomes. Finally, sample size prevented our analysis from producing stratified samples based off disease cohorts, such as Congestive Heart Failure, which may have differential use and outcomes in rural settings.

We found that treatment in rural hospitals explained the risk of readmission among rural Medicare beneficiaries. Once controlling for hospital characteristics, there was no relationship between rural residency and readmission. However rural residency was associated with a greater risk of ED use and insufficient follow-up care during a 60-day post-discharge episode. These results point toward opportunities to improve post-discharge care for rural Medicare beneficiaries. Efforts to improve access to follow-up care is consistent with high quality care and have the additional benefit of reducing the risk of an ED visit and costs to both Medicare and beneficiaries. Finally, while our findings suggest that better follow-up care has the potential to improve outcomes, additional research is needed to better understand the direct effect of follow-up care in lowering the risk of ED use among rural beneficiaries. To better appreciate the value of services being provided to rural Medicare beneficiaries post-discharge, further research could explore short and long term Medicare costs associated with post-discharge care among rural Medicare beneficiaries.

Figure 3.1: Study sample selection of admissions in the MCBS, Cost and Use Files, 2000-2010. Selection criteria resulted in 11,986 total observations.

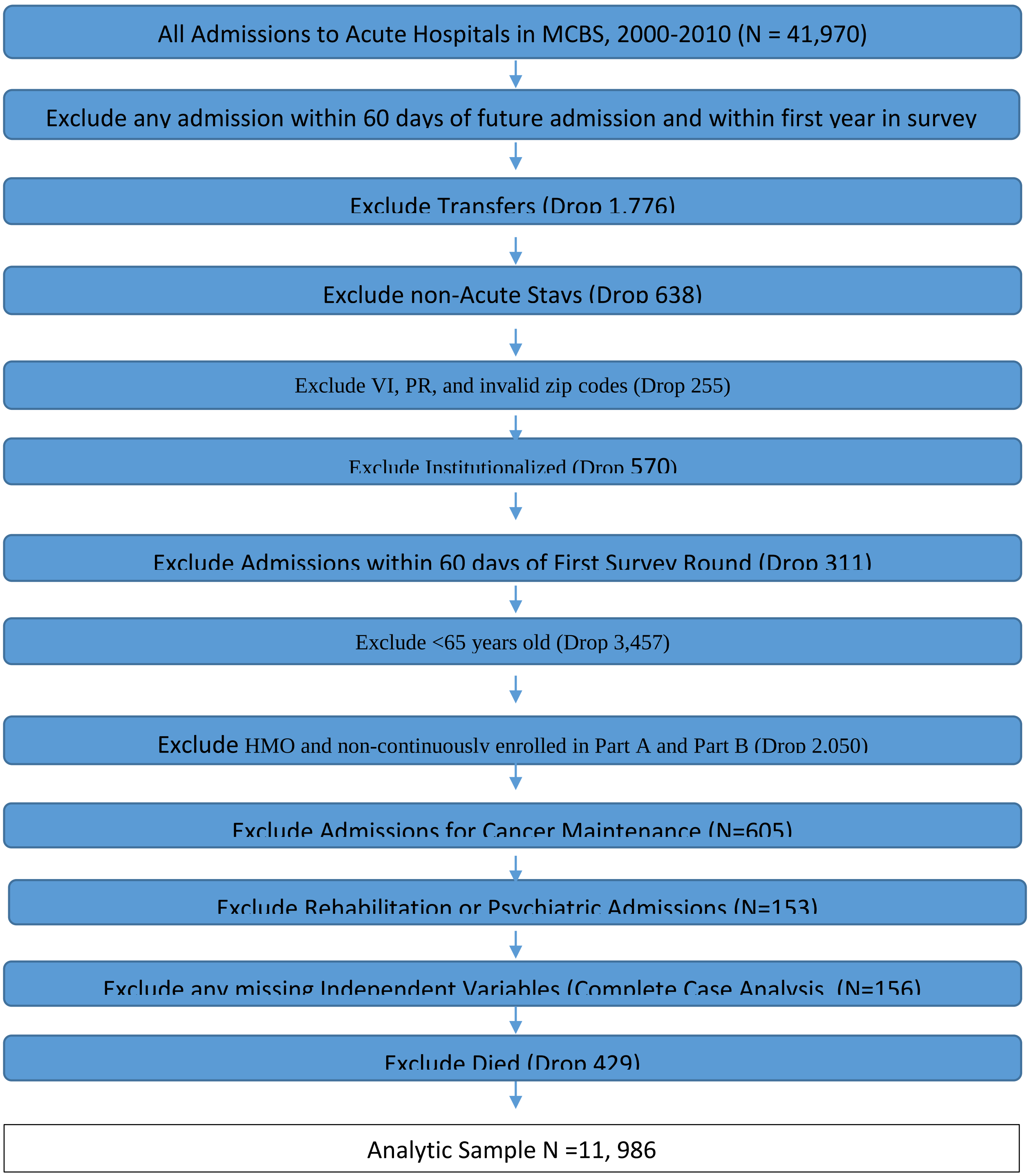

Figure 3.2: Adjusted Risk of ED Use for Rural and Urban Beneficiaries, MCBS, 2000-2010, N = 11,977. Adjusted for socio-demographic, health, and hospital characteristics.

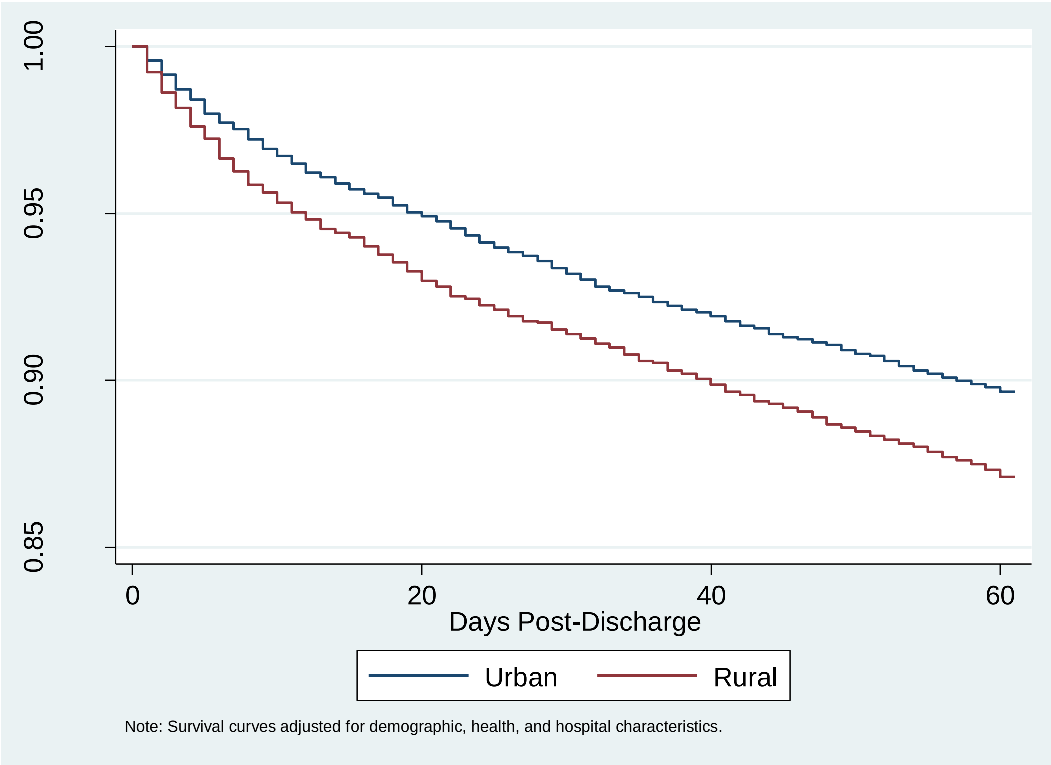

Figure 3.3: Adjusted Rate of Follow-Up Care among Rural and Urban Beneficiaries, MCBS, 2000-2010, N = 11,977. Adjusted for socio-demographic, health, and hospital characteristics

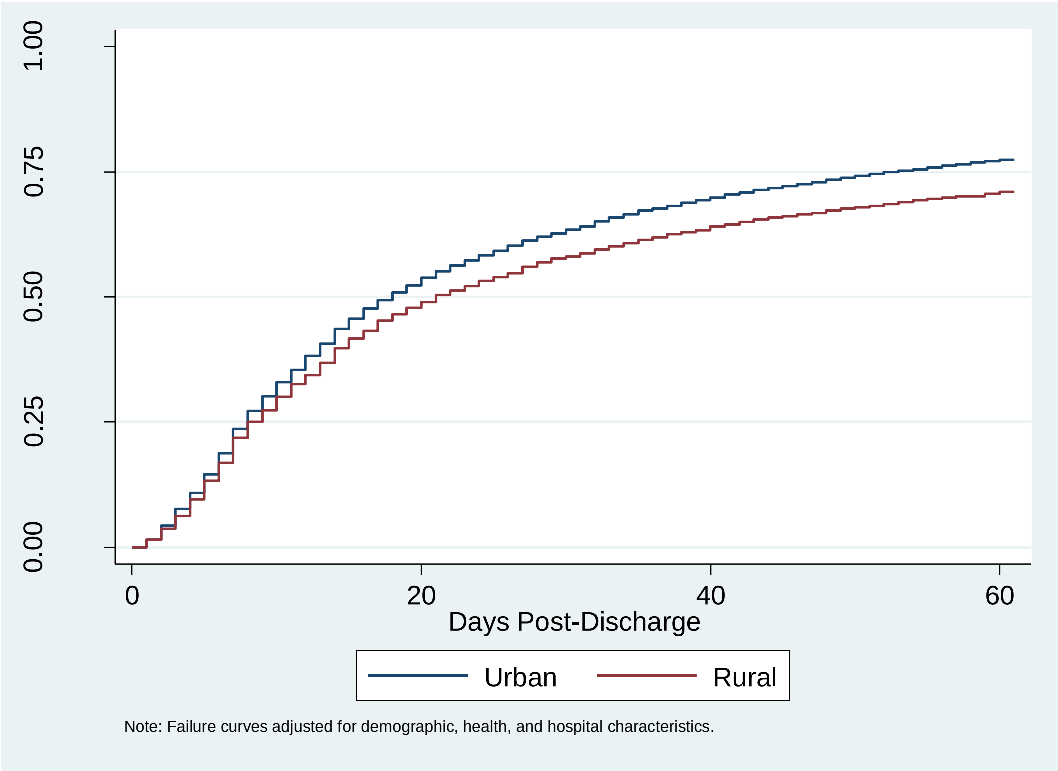

Table 3.1: Summary Statistics of Index Admissions among Medicare Beneficiaries by Rural Status, MCBS, N=11,986

	Overall (N= 11,986)	URBAN (N= 7,943) (Weighted N = 28,420,960)	RURAL (N= 4,043) (Weighted N = 12,610,029)	p
Mean (Standard Deviation) or %				
Age	77.15 (7.32)	77.33 (7.20)	76.72 (7.57)	0.004
Female	56.16	56.34	55.73	0.64
Race				<0.001
White	87.8	85.86	92.17	
Black	8.66	10.13	5.36	
Other	0.63	0.61	0.68	
Asian	1.04	1.43	0.17	
Hispanic	1.51	1.8	0.86	
Native American	0.26	0.08	0.65	
Unknown	0.09	0.09	0.1	
Education				<0.001
Less than High School	34.92	31.49	42.67	
High School	48.43	49.19	46.7	
College or Graduate	16.65	19.32	10.62	
Relationship Status				0.55
Married	50.65	50.44	51.11	
Widow	38.48	38.3	38.88	
Divorce	7.75	7.96	7.27	
Separated	0.81	0.89	0.64	
Never Married	2.32	2.41	2.1	
Living Situation				0.07
Lives alone	31.79	31.22	33.09	
Spouse Only	41.39	41.05	42.16	
Spouse and others	7.08	7.33	6.51	
Children only	9.21	9.31	8.99	
Children & Others	4.91	5.47	3.62	
Others Only	3.28	3.31	3.2	
Non-relative	2.34	2.3	2.42	
Income	29097.11 (47777.77)	30999.96 (53350.71)	24808.42 (27632.92)	<0.001
Medicaid Status	18.04	16.66	21.15	0.01
# ADLs	1.09 (1.59)	1.09 (1.55)	1.07 (1.68)	0.67
# IADLs	0.35 (0.70)	0.35 (0.68)	0.36 (0.75)	0.45

Charlson Comorbidity Score	3.22 (2.58)	3.29 (2.56)	3.06 (2.61)	0.002
Length of Stay	3.97 (3.63)	4.02 (3.74)	3.86 (3.28)	0.15
Hospital Location				<0.001
Urban	77.52	97.79	31.83	
Large Rural	15.36	1.58	46.42	
Small Rural	4.5	0.5	13.52	
Isolated Rural	2.62	0.13	8.22	
Profit Status				0.005
Non-profit	69.25	72.25	62.48	
For-profit	13.13	12.89	13.68	
Government	17.62	14.86	23.84	
Total Beds	371.36 (278.62)	428.04 (266.45)	243.61 (260.38)	<0.001
Total Full Time RNs	404.96 (418.75)	467.34 (424.60)	264.37 (358.84)	<0.001

P-values by weighted linear regression for continuous variables and weighted chi2 test for binary/categorical variables

Table 3.2: Adjusted Hazard Ratios of Rural Residency on Readmission, ED Use, and Follow-Up Care 60-days Post-discharge by Model Category, MCBS, 2000-2010, (N = 11,977)

	Unadjusted	Demographic Characteristics	Health Status and Demographic Characteristics	Full Adjusted with Hospital Characteristics
(1) Readmission				
Rural Residency	1.05 [0.96,1.15]	1.05 [0.95,1.15]	1.10* [1.01,1.21]	0.92 [0.79,1.08]
Hospital Location				
Urban				REF
Large Rural				1.24* [1.03,1.49]
Small Rural				1.44** [1.12,1.86]
Isolated Rural				1.60** [1.20,2.12]
(2) ED Use				
Rural Residency	1.27** [1.14,1.42]	1.23** [1.10,1.38]	1.26** [1.12,1.42]	1.27** [1.06,1.52]
Hospital Location				
Urban				REF
Large Rural				0.87 [0.71,1.07]
Small Rural				1.04 [0.78,1.39]
Isolated Rural				1.12

				[0.84,1.50]

(3) Follow-up Care				
Rural Residency	0.92**	0.91**	0.92**	0.86**
	[0.88,0.96]	[0.87,0.95]	[0.88,0.96]	[0.81,0.92]
Hospital Location				
Urban				REF
Large Rural				1.06
				[0.98,1.16]
Small Rural				1.02
				[0.90,1.17]
Isolated Rural				1.05
				[0.90,1.23]
N	11977	11977	11977	11977

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
Hazard Ratios; 95% CI in brackets using, replicated weighted with bootstrapped standard errors. Demographic characteristics include age, income, gender, marital status, living arrangement, education, and Medicaid status. Health characteristics included # limitations in ADLs and IADLs, length of stay, and Charlson comorbidity index. Hospital characteristics include # beds, hospital location, profit status, and # full time registered nurses. Nine observations were dropped because of censoring.

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CHAPTER 4: RURAL-URBAN DIFFERENCES IN THE EFFECT OF FOLLOW-UP CARE AND HOME HEALTH SERVICES ON POST-DISCHARGE OUTCOMES

Introduction

The Patient Protection and Affordable care Act introduced new incentives and reforms to reduce hospital 30-day readmission rates.[1] After hospital discharge, Medicare beneficiaries often have complex medical needs that complicate transitions from hospitals to home. Poor transitions in care lead to preventable hospital readmissions, emergency department (ED) visits, and mortality, costing Medicare $12 billion each year. [2-4] Studies demonstrate that high quality transitional care reduces hospital readmissions, lowers costs, and improves other outcomes by facilitating coordination and communication across providers and settings of care.[5, 6]

Key elements of a successful care transition often include an outpatient visit within 1-2 weeks and receipt of home health services. [6-8] An early follow-up visit can help the patient and doctor identify potential gaps in post-discharge care that, if addressed, may prevent acute service utilization. Additionally, as payers create financial incentives for healthcare providers to contain costs, effective use of home health services is increasingly seen as an important strategy for improving post-discharge outcomes. [8] CMS identifies re-hospitalization and ED use as key outcomes for home health services, but research on whether the use of home health services reduces the risk of these events are mixed. [9, 10]

The effective use of post-discharge services among rural Medicare beneficiaries is poorly understood; however, studies suggest that rural beneficiaries may be at greater risk of using acute care services post-discharge. Although rural and urban beneficiaries have similar access to overall care [11], a recent study found rural Medicare beneficiaries transitioning from the hospital to home had a 27% greater risk of visiting the ED and a lower rate of follow-up care during a 60-day post-discharge period, compared to urban beneficiaries. While there was no relationship between rural residency and readmission, beneficiaries discharged from a rural hospitals had a greater risk of readmission, compared to being discharged from an urban hospital. [12] Other studies show rural beneficiaries receive less follow-up care, but have lower readmission rates, relative to urban beneficiaries. [13, 14] These seemingly contradictory findings may be explained by three characteristics of rural (versus urban) beneficiaries: poorer access to appropriate post-acute care; cultural tendencies to avoid care; and less infrastructure to integrate and coordinate post-discharge services. [15, 16] If so, the effect of receiving follow-up care may differ by whether care is delivered in a rural versus urban setting.

Similarly, rural beneficiaries' limited access to home health services may contribute to poor outcomes. While type of home health services delivered varies by rurality, it is poorly understood whether the effect of home health services varies for rural and urban Medicare beneficiaries. [15, 17] Only a few studies have examined differences in post-discharge care and patient outcomes among rural versus urban beneficiaries. Limited available data suggest that beneficiaries receiving services from rural home health agencies may have more hospitalizations and less improvement in functional status. [18-20] We identified no study that examined outcomes for rural versus urban beneficiaries receiving home health care after hospital discharge.

While recent literature on the role of follow-up care and home health care in improving post-acute outcomes appears promising, most of this research comes from randomized control trials, in which these services were part of a broader intervention. [5] Other research, using secondary data or before-after designs, show the potential for early follow-up care or home health services to improve outcomes, but unobserved characteristics may bias these results by failing to account for selection bias inherent in the receipt of follow-up care and home health care. [21-23] To our knowledge, only one study addressed the selection bias in receipt of home health care on improving functional limitations [24], and none addressed unobserved endogeneity in the receipt of follow-up care.

Therefore, this study will model the effect of early follow-up care and home health care among rural and urban beneficiaries on 30- and 60-day readmission, ED use, and mortality using instrumental variables (IV) to correct for endogeneity. We hypothesize that accounting for selection bias in the effect of follow-up care and home health care will show that these treatments reduce the risk of readmission, ED use, and mortality, although these effects will be smaller among rural beneficiaries.

Methods

Data Source. The Medicare Current Beneficiary Survey (MCBS), Cost and Use files from 2000-2010, was the main data source for this study. The MCBS is a longitudinal panel survey of a nationally representative sample of the Medicare population. Survey data are collected from each respondent three times a year over a four year period. These data include beneficiaries' health status, access to care, household composition, health service use and expenditures, and socio-demographic characteristics. Survey data are linked with Medicare claims, which are collected continuously for beneficiaries over the duration of their participation in the MCBS. Claims data include utilization of inpatient care, outpatient care, home health care and physician office based services. Hospital level characteristics were captured from CMS Provider of Service File, which comes from a yearly survey of Medicare certified hospitals. County level characteristics were captured from the Area Resource File and the Dartmouth Atlas of Health Care.

Study sample. The sample included Medicare beneficiaries with an acute admission in the MCBS from 2000 to 2010 who were (1) $\geq$ 65 years; (2) enrolled in traditional fee-for-service Medicare within the contiguous 48 states; and (3) hospitalized for acute medical problems and subsequently discharged to home. To establish the beginning of acute care episodes (index admission), the sample excluded beneficiaries with a previous admission within 60 days, admissions that occurred within 60 days of the first survey year, admissions for cancer management, and admissions with a primary diagnosis of a psychiatric or rehabilitation condition (not usually in acute stay hospitals). [25] We excluded observations with a readmission, ED event, or mortality within 3 days of discharge as these acute events are more likely markers of quality of care delivered in the hospital. Those who died within 60-days discharge in the readmission and ED models were excluded. A complete case analysis was used. We started with 41,970 admissions to an acute care hospital from 2000 to 2010. After selection criteria were applied, our analytical sample was 11,487 for the readmission and ED models, and 12,299 for the mortality models.

Key Variables and Measures. The main dependent variables were 30- and 60-day readmission, 30- and 60-day ED use (treat and release), and 30- and 60-day mortality. Hospital readmission was defined using the Yale/CMS all-condition 30-day unplanned readmission measure. [26] Because it is difficult to assess unplanned admission using administrative claims data, we excluded admissions for maintenance chemotherapy or rehabilitation and readmissions in which at least one of 35 typically planned procedures occur without having a primary diagnosis of an acute event. [27]

The main independent variables were receipt of follow-up care within 7-days or 14 days post-discharge. We defined follow-up care as any Evaluation and Management visit in an outpatient or office based setting (HCPCS codes >=99241 & <=99245, >=99201 & <=99205, and >=99210 & <=99215) during the 7 and 14-day period before either an ED visit or hospital readmission. [7] We defined home health as having any home health claim within 14-days of the discharge date that occurred prior a post-discharge ED visit or hospital readmission. We created a variable for rural residency using Rural-Urban-Commuting Codes (RUCA), and coded it as a dichotomous variable (Rural vs. Urban). RUCA codes combine standard Census definitions with area commuting behaviors to capture functional and work relationships between regions.

Covariates*.* Demographic variables included both continuous (age and income) and categorical (race, gender, education, relationship status, Medicaid status and household composition) variables. Health status included number of limitations in activities of daily living (ADLs) and instrumental activities of daily living (IADLs), length of the index hospitalization, and the Charlson Comorbidity Index (CCI). The CCI predicts risk of mortality based on beneficiaries' primary and secondary diagnosis and is frequentally used to control for confounding of disease severity on post-discharge outcomes. [28, 29] Hospital facility-level variables included a categorical hospital location using RUCA codes (Urban, Large rural, Small rural, and Isolated rural), for-profit status, and a continuous number of registered nurses and number of beds.

Instrumental variables. Valid instruments must pass at least two criteria: 1) significantly explain variation in the endogenous treatment variable and 2) not predict the dependent variables except through the treatment variable. Unobserved factors may predict the use of follow-up care and home health care, and also increase the propensity to use acute care services. Endogeneity may have a positive bias in the effect of home health and follow-up care because sicker beneficiaries are more likely to both receive more outpatient services and acute services. That is, if the true effect is negative, the coefficients may show no effect or even a positive effect on readmission, ED use, and mortality. We acquired five potential IVs from the Area Resource File and from the Dartmouth Atlas of Health Care as potentially valid instruments.

Provider distance. Distance to provider has been used as instrument for health outcomes in other studies. [30] We argue that the closer a resident is to the discharging hospital, the more likely that person would receive a follow-up visit as they are more likely to live within that hospital's network of providers and outpatient facilities, simplifying care coordination. Once patient level demographic, health, and hospital characteristics are controlled for, distance to the hospital should have no relationship with the outcome, except through follow-up care. [31] First, we calculated the straight line distances between the geographic center of the beneficiaries' residency zip code to the: (1) center of the admitting hospital zip code and (2) nearest home health agency (HHA). Because of the skewed distribution of miles from the hospitals, we estimated log-distance from residency to admitting hospital (*distance to hospital*) and to HHA (*distance to HHA*).

Physician Supply. We used the Area Resource File to construct a county level primary care provider supply variable. This included total general practitioners, family practitioners and specialists per 10,000 elderly (*physician supply*). Physician supply should be strongly associated with follow-up care. [32] Some research suggests supply of primary care physicians reduces the number of preventable hospitalization in a county [33], yet we argue that the beneficial effect of physician supply on 30- and 60- day post-discharge outcomes is a result of better access to primary care and better continuity of care [34], which in this case would represent an early follow-up visit. Thus, *physician supply* can be validly excluded from our outcome models because its principal relationship with 30- and 60-day outcomes will be captured by whether the beneficiary receives an early follow-up visit. Residents living in in communities with a higher density of primary care providers should be more likely to receive a follow-up visit within 7 and/or 14 days of discharge, compared to residents living in areas with lower primary care density.

County Follow-up Rate. County level rates of 14-day primary care follow-up (*percent follow up*) were acquired from the Dartmouth Atlas of Health Care. We linked Federal Information Processing Standard (FIPS) values from the Dartmouth files with beneficiary zip-codes. Geographic practice patterns are frequently used as IVs in the literature and should be a good candidate for an IV in this analysis. [35, 36] County level 14-day follow-up care is an indicator of coordination of care within the county. [37] We argue that any relationship between county level rates of 14-day follow-up care with patient level outcomes in readmission, ED use, or mortality post-discharge can be attributed to whether a patient receives a physician visit post-discharge. Any additional correlation can be accounted for through our demographic, health, and hospital characteristics controls. We use years 2004, and 2008- to 2010. Imputed values for missing years were calculated by taking the average percent change between the actual values at the FIPS level, and applying to the missing year. Higher county level rates of 14-day follow-up care should be positively associated with the probability that a beneficiary with a residency in the same county would receive a follow-up visit.

HHA episodes. We used Dartmouth Atlas of Health Care files for home health episodes per 1000 beneficiaries at the county level during 2008 (*episodes*). We hypothesize that a higher number of episodes should predict better access to home health services. In turn, episodes should not be correlated with the propensity for an 30- or 60-day outcomes except through its relationship with access to home health services. Similar to our rational above, after adjusting for patient-level demographic, health, and hospital-level characteristics there should be no remaining relationship between *episodes* and the outcomes.

Statistical Analysis. We calculated descriptive statistics by adjusting for the complex survey design of the MCBS using cross-sectional weights. Bivariate comparisons by rural category were tested using chi-squared statistics for the categorical variables and t-tests for the continuous variables. We estimated the following equation using a difference-in-difference survey adjusted logit with replicate weights:

$$Prob(outcome\,|X) = \alpha + \beta_1(Rural) + \beta_2(Early\ Follow\ Up\,) + \beta_3(Home\ Health) + \beta_4(Rural * Follow\ Up) + \beta_5(Rural * Home\ Health) + \delta X + \varepsilon$$

Where $\beta_2 - \beta_5$ were the endogenous treatment variables, δ werethe coefficients on the control variables, and ε was the error term. We used IVs to correct for the endogeneity of the treatment variables. A two-stage residual inclusion strategy (2SRI) was used for the main analysis as a two-stage-least-squares approach yields inconsistent estimates in non-linear models. [38] This strategy entailed calculating the residual from the first stage equation, and including the first-stage residuals and the endogenous treatment variables in the second-stage equation. As there are four potentially endogenous treatment variables, we acquired four residuals by running two first-stage probits on follow-up treatment and home health treatment, calculated the residuals and interacted the residuals with a dichotomous rural residency variable.

During the specification testing for instrument strength we discovered that while our home health instruments passed the strength test of at least an F-statistic of 10 for home health utilization, at least one home health IV did not pass the exclusion restriction test. The exactly identified IVs did not pass the strength tests (X^2 = 9.50). Wooldridge [39] and Bound et al [36] warn that weak IVs can produce biased results, especially if there is any correlation between the instrument and the error term which the exclusion restriction test appears to imply. Thus, we settled on three instruments that satisfied the IV specification requirements for follow-up care, and treated home health as exogenous. The implications of this are that no causal inferences can be made about the relationship between home health use and the outcomes. We included logged distance from residence to admitting hospital (*distance to hospital*), physician supply per county (*physician supply*), and % of beneficiaries seeing a primary care doctor within 14-days of a medical discharge (*percent follow up*) as instruments for this analysis. The first stage probit consisted of our three exogenous IVs and controls:

$$1st\ Stage: Prob\left(Follow\ Up, \middle| Z_1,\ Z_{2,}\right)$$
$$= (\alpha + \beta_1(County\ Level\ Physician\ Supply)$$
$$+ \beta_2(\%\ 14\ day\ Follow\ up\ per\ County) + \ \beta_3(Logged - Hospital\ Distance)$$
$$+\ \delta X +\ \varepsilon)$$

Where $\beta_1 - \beta_3$ were the coefficients for the IVs, δ represented the coefficients for the control variable including demographic, health status, and admitting hospital characteristics, and year of admission, as described above, and ε represented the error term. The second stage equation consisted of a survey weighted multivariate logistic regression with difference in difference:

$$2st\ Stage: Prob(Y\ |X_1)$$
$$= (\alpha + \beta_1(Rural) + \beta_2(Early\ Follow\ Up\ ) + \ \beta_3(Home\ Health)$$
$$+ \beta_4(Rural * Follow\ Up) + \ \beta_5(Rural *\ Home\ Health) + \ \delta X$$
$$+\ \gamma Follow\ Up_{RES} + \lambda Rural * Follow\ Up_{RES})$$

Where $\beta_2\ and\ \beta_4$ were the endogeneity adjusted coefficients for the early follow-up treatment, and λ and γ were the coefficients on the residuals from the first-stage equation on the probability of follow-up treatment within 7-days and within 14-days.

We calculated average marginal effects of the treatment variables and the rural-interaction terms, and used bootstrapped standard errors. We report marginal effects of both the difference in difference logistic regression without IV and the 2SRI marginal effects.

Results

Descriptive statistics. Our sample included 7,995 hospital admissions among beneficiaries residing in urban areas and 4,055 admissions among beneficiaries residing in rural areas (Table 4.1). Compared to urban beneficiaries, rural beneficiaries were slightly younger, had less education, less income, and more likely to be on Medicaid.   There were no statistically significant differences in the unadjusted outcomes, except that rural beneficiaries used the ED more frequently at 30- and 60-days compared to urban beneficiaries (p<0.01).

Instrumental Variable Specification. Joint Wald tests on the three instruments in the first stage equation indicated that they strongly predicted the use of both 7- and 14-day follow-up care. The instruments for 7-day follow-up care were both individually and jointly significant predictors of receiving follow-up care within 7 days (X^2 = 52.92, p<0.01) and 14 days (X^2 = 68.86, p<0.01).

Table 4.2 displays the exclusion restriction tests, the test for exogeneity, and the preferred model for each dependent variable. We followed a method similar to Bollen et al. [40] for testing the over-identified restriction of the second stage model. We first calculated the predicted residuals of the first stage reduced form estimation of 7- and 14-day follow-up care with the identified IVs. We then included the over-identified restriction in the structural equation with the treatment variables and the predicted residuals from the first stage equation. We conducted a Wald test on the over-identified IV, where the null hypothesis was that the IV was validly excluded from the 2nd stage structural model (Column 1). Regardless of which IV was tested, all passed the over-identification test for 30- and 60-day readmission, 30- and 60-day ED use, and 30- and 60-day mortality with the exception of *physician supply.* Physician supply passed the over-identification tests for all models except for ED use (χ_1^2 = 6.40). Thus we modeled 30- and 60-day ED use with exact identification using only *distance to hospital* and *percent follow-up* for the ED models.

Column 2 of Table 4.2 presents the results of the exogeneity tests for the treatment variables, and the preferred models based off these tests. Because the 2SRI approach is similar to a variant of the Hausman test for exogeneity, the 2nd stage models were run with the residuals and a joint-test of significance was conducted on the residuals, where the null hypothesis is that the treatment variables are exogenous. If the treatment variables are exogenous, then the residuals should have no explanatory power and the non-IV logistic difference in difference model is preferred because the standard errors are more precise. We conducted joint Wald tests on the residuals and found that for all models, except for 7-day follow-up care on 30- and 60-day readmission, there was no evidence of endogeneity in 7-day or 14-day follow-up care treatment. Column 3 of Table 4.2 indicates the preferred estimation strategy for this model. We report results from both the logistic regression and the 2SRI below.

Main Results. For 30- and 60-day readmission, the marginal effects of the 2SRI models for 7-day and 14-day follow-up care were quite different from the logit models (Table 4.3). For 7-day follow-up care, the marginal effects are much larger for the 2SRI estimates than the logistic regression for both 30- and 60-day readmission, but both were not statistically significant. However, when we examined the marginal effect on 60 day readmission as the number of co-morbidities increased, 7-day follow-up was negatively associated with readmission (Figure 4.1). For example, the predicted 60-day readmission rate for a 75 year old individual with 4 co-morbidities who did not receive a follow-up visit within 7-days was 27.2%

(p<0.05), compared to 9% (p<0.05) had that person received a 7-day follow-up visit. The average marginal effect of 7-day follow-up care on 60-day readmission for a patient with a CCI score of 4 was a 22.2% points reduction in risk (p<0.05). The marginal effects of 14-day follow-up on 30- and 60-day readmission were similar in direction and magnitude in both the 2SRI and logit models, though the 2SRI estimates are non-significant. Based on the logistic regression model, the average marginal effect of 14-day follow-up care on 30 and 60-day readmission was 3.85% point and 2.68% point reductions for 30- and 60-day readmission, respectively (p<0.01). There were no treatment effect differences between rural and urban beneficiaries. Home health care did not have a statistically significant effect on readmission, and there were no rural-urban differences in home health use on readmission.

Table 4.4 presents 2SRI and logit average marginal effects for 30-and 60-day ED use. Like the readmission model, 2SRI effects were different from the logistic regression. For example, 2SRI results showed 7-day follow-up care had a 11.2% and 17% point reduction in 30- and 60-dayED use, compared to 0.6% and 0.2% point reduction in the non-IV model, but both were statistically insignificant. The 2SRI estimates for 14-day follow-up care on 30- and 60-day ED use were opposite of the logit model, but non-significant. For the logit models, the average marginal effect of 14-day follow-up care was a 3.1% point decrease in the risk of 30-day ED use (p<0.01), and 2.1% point decrease in the risk of 60-day ED use (p<0.01). Rural residency modified this effect by reducing the risk of 30-day ED use by 2.7% points, but had no interaction effect on 60-day ED use, compared to urban beneficiaries. Indeed, the effect of 14-day follow-up care on 30-day ED use among rural beneficiaries was a 5.0% point reduction (p<0.05) compared to a reduction of 2.2% among urban beneficiaries (p<0.05) (not shown). Figure 4.2

highlights the differences in effect size by rural status across illness severity. The greater the number or severity of comorbidities, the larger the reduction 14-day follow-up care on 30-day ED use. Again, home health utilization did not predict 30- or 60-day ED use, and there were no treatment differences by rural status.

Similar to the ED use models, the 2SRI estimates on 30- and 60-day mortality were non-significant (Table 4.5). The logistic regression models suggests that the average marginal effect of 7-day follow-up care on 30- and 60-day mortality was -0.9% and -1.0% points, respectively ($p<0.01$). Follow-up care within 14-days reduces 30- and 60-day mortality by 1.8% and 2.3% points on average, respectively ($p<0.01$). There were no differences in the effect of follow-up care on mortality between rural and urban beneficiaries. Home health care did not have a statistically significant effect on mortality. While the 2SRI models did not produce significance results, it is interesting to note that the average marginal effects are larger and in the opposite direction. The 2SRI effects indicate 7- and 14-day follow increase mortality by 8% to 10.6% points, respectively, but these point-estimates were insignificant.

Several sensitivity analyses were conducted**.** We defined home health use within 3-days post-discharge, which is consistent with CMS policy for a post-acute transfer; results remained statistically non-significant for all outcomes. Additionally, to explore the large effect sizes for our 2SRI models, we ran the models with exact identification and different combinations of *hospitals distance*, *provider supply*, and *percent follow up*. The results were similar to our original models.

Discussion

This study sought to determine whether early follow-up care or home health services reduce the risk of readmission, ED use, and mortality during 30- and 60-day post-discharge periods, and whether rural and urban beneficiaries experience different treatment effects. We found that when accounting for selection bias, 7-day follow-up significantly decreases the risk of a 60-day readmission among beneficiaries with multiple co-morbidities. We also found evidence that 14-day follow-up care reduces readmission, ED use and mortality during a post-discharge period. Rural beneficiaries experience a differential effect of 14-day follow-up care in reducing the risk of visiting the ED within 30-days post-discharge; however, there was no statistically significant difference in treatment effects for readmission and mortality. We did not find any treatment effects of home health care on our outcomes; neither did we find rural-urban differences. These findings have important implications.

First, our findings further support the importance of a physician follow-up visit soon after hospital discharge. [7, 23, 41] Specifically, we found that 14-day follow-up reduced the risk of 30- and 60-day readmission. Moreover, when correcting for endogeneity, the effect of 7-days post-discharge increased with the number of co-morbidities. This suggests that Medicare beneficiaries with multiple co-morbidities should be targeted for early follow-up care, particularly in the context of Medicare's Hospitals Readmission Reduction Program (HRRP). Additionally, current post-acute bundled payment demonstrations are considering 60 days as an appropriate time frame for an episode of care [42], suggesting that there may be a sustained benefit of early post-discharge care. Moreover, while we did not find treatment effect differences between rural and urban beneficiaries, rural beneficiaries benefited from a 14-day follow-up visit. Given recent concerns on how rural providers and patients will fare financially under HRRP and other reforms, targeting resources toward helping sicker patients to receive a 7-day or 14-day follow-up appointment may help reduce rural hospital costs of acute readmissions. [43, 44]

Second, 14-day follow-up care reduced the probability of 30- and 60-day ED use for both rural and urban beneficiaries. Contrary to our original hypothesis, rural beneficiaries appear to benefit more from a 14-day follow-up visit relative to urban beneficiaries. This finding does not necessarily indicate better quality of care in rural settings, but rather unmet need and relatively poorer access to primary care may in rural settings. [45, 46] Our findings suggest that rural beneficiaries who receive a follow-up visit within 14-days of discharge will also experience reduced probability of visiting the ED 30 and 60 days after hospital discharge. Policymakers and providers working to establish or design Accountable Care Organizations and post-acute bundled payments should consider whether to incentivize rural areas to invest in efforts to improve follow-up care. Doing so may benefit rural providers, payers, and beneficiaries by reducing costs associated with ED visits, Medicare Part B expenditures and reduced patient cost-sharing.

Finally, consistent with other studies [47, 48], 7- and 14-day follow-up visits were associated with lower rates of mortality 30 and 60 days after hospital discharge. These results provide further evidence that rural providers may have the opportunity to reduce 30-day mortality outcomes by investing in efforts to ensure an early follow-up visit. Indeed, earlier work shows that critical access hospitals (CAH), mostly serving rural beneficiaries, have higher risk adjusted

30-day mortality than non-CAHs. [4] As such, the findings of this study suggest that better follow-up care may be beneficial in helping to lower mortality in rural and urban settings.

There are several important limitations to this study. First, some of our conclusions are based on non-IV logistic regressions and may be biased. Indeed, results from the non-IV models may be under-estimating the magnitude of the effect size or, in the case of the 30- and 60-day mortality, may be biased in the opposite direction. Second, any conclusions drawn from the 2SRI models refer to the marginal patient who has a greater propensity to receive follow-up care as a function of the combination of our IVs. Thus, it is difficult to determine which patients experience beneficial effects on readmission within 60 days from 7-day follow-up visits. Finally, we could not find valid instruments for home health use. While we control for the most important predictors of home health use post-discharge, unobserved factors may bias our results. [49] For example, number of functional limitations at discharge (rather than self-reported throughout the year) may bias the effect upwards, making it appear that home health has a null or positive effect on readmission, ED use, and mortality.

In conclusion, we found that follow-up care within 14-days of hospital discharge can reduce 30-day and 60-day readmission, ED use, and mortality, and that rural beneficiaries experience a greater beneficial effect on 30-day ED use. Our findings also suggest that follow-up care within 7-days can reduce hospital readmission among beneficiaries with multiple co-morbidities. Investing in efforts to improve follow-up care in rural area may help reduce costs associated with ED use for rural providers and Medicare. Further, focusing efforts to ensure an early follow-up visit among beneficiaries with multiple co-morbidities may be an efficient use of resources. Further research is needed to better understand how follow-up care and home health may impact the cost of care at 30 and 60 days following hospital discharge.

Table 4.1: Summary Statistics of Index Admissions among Medicare Beneficiaries by Rural Status, MCBS, N=12,050

	TOTAL (N= 12,050)	**URBAN** (N= 7,995) (Weighted N = 28,642,382)	**RURAL** (N= 4,055) (Weighted N = 12,642,400)	P-value
Mean (Standard Deviation) or %				
		OUTCOMES		
30-Day Readmission	11.45	11.38	11.62	0.69
60-Day Readmission	18.31	18.04	18.92	0.18
30-Day ED Use	6.63	6.13	7.75	0.001
60-Day ED Use	10.69	9.92	12.43	<0.001
30-Day Mortality	1.38	1.34	1.45	0.67
60-Day Mortality	2.71	2.67	2.8	0.71
		DEMOGRAPHCS		
Age	77.20 (7.40)	77.38 (7.28)	76.77 (7.62)	0.002
Female	56	56.09	55.8	0.82
Race				<0.001
White	87.71	85.73	92.19	
Black	8.64	10.1	5.34	
Other	0.69	0.68	0.71	
Asian	1.08	1.48	0.15	
Hispanic	1.51	1.82	0.83	
Native American or Unknown	0.37	0.19	0.78	
Education				<0.001
Less than High School	35.16	31.77	42.82	
High School	48.09	48.81	46.46	
College or Graduate	16.75	19.42	10.71	
Relationship Status				0.5
Married	50.44	50.14	51.12	
Widow	38.55	38.43	38.83	
Divorce	7.78	8.03	7.23	
Separated	0.85	0.92	0.69	
Never Married	2.38	2.49	2.14	
Living Situation				0.03
Lives alone	31.88	31.37	33.02	
Spouse Only	41.17	40.69	42.26	
Spouse and others	6.96	7.21	6.39	

Children only	9.34	9.43	9.14	
Children & Others	4.89	5.51	3.47	
Others Only	3.35	3.38	3.28	
Non-relative	2.42	2.4	2.44	
Income	28.94 (47.56)	30.78 (53.08)	24.76 (27.50)	<0.001
Medicaid Status	18.29	17.03	21.15	0.02
HEALTH STATUS				
# ADLs	1.10 (1.61)	1.11 (1.56)	1.09 (1.70)	0.81
# IADLs	0.35 (0.70)	0.35 (0.68)	0.36 (0.75)	0.51
Charlson Comorbidity Score	3.26 (2.62)	3.34 (2.59)	3.10 (2.66)	0.001
Length of Stay	4.02 (3.74)	4.09 (3.90)	3.88 (3.26)	0.07
HOSPITAL CHARACTERISTCS				
Number of Beds	372.29 (279.82)	429.39 (267.80)	242.90 (260.29)	<0.001
Hospital Location				<0.001
Urban	77.52	97.77	31.67	
Large Rural	15.37	1.61	46.54	
Small Rural	4.56	0.49	13.77	
Isolated Rural	2.55	0.13	8.01	
Profit Status				0.004
Non-profit	69.2	72.3	62.17	
For-profit	13.19	12.93	13.76	
Government	17.62	14.77	24.07	
Total Full Time RNs	404.64 (419.48)	467.40 (425.75)	262.46 (357.12)	<0.001
INSTRUMENTAL VARIABLES				
Avg. % 14-Day Follow Up	43.81 (7.17)	42.44 (6.10)	46.93 (8.51)	<0.001
Distance to Hospital	41.13 (174.06)	36.53 (172.75)	51.55 (175.67)	<0.001
Physician Supply per 10000 Elderly	108.09 (69.73)	130.58 (68.68)	56.88 (32.02)	<0.001

P-values by weighted linear regression for continuous variables and weighted chi2 test for binary/categorical variables. Missing values in education (76 obs), relationship status (18 obs), living situation (31 obs), # ADL (48 obs), # IADL (52 obs), hospital location (1 obs) Avg % 14-Day Follow Up (36 obs), and Physician Supply per 10000 elderly (53 obs)

Table 4.2: Exclusion Restriction and Exogeniety Tests for Dependent Variables, MCBS, Cost and Use, 2000-2010

	(1)	(2)	(3)
DEPENDENT VARIABLES	**Exclusion Restriction for Over-identified IV (χ_1^2)**	**Hausman – Exogeniety Test (χ_2^2)**	**Preferred Estimation Method**
30-Day Readmission			
7-Day Treatment*	0.19	3.70	2SRI
14-Day Treatment	0.12	1.46	Logit
60-Day Readmission			
7-Day Treatment	0.36	6.21	2SRI
14-Day Treatment	0.28	2.03	Logit
30-Day ED use			
7-Day Treatment	6.45	2.37	Logit
14-Day Treatment	6.43	5.00	Logit
60-Day ED use			
7-Day Treatment	3.96	3.68	Logit
14-Day Treatment	3.88	1.81	Logit
30-Day Mortality			
7-Day Treatment	0.15	0.19	Logit
14-Day Treatment	0.01	0.16	Logit
60-Day Mortality			
7-Day Treatment	1.08	0.04	Logit
14-Day Treatment	0.97	0.28	Logit

Note: Column 1 displays a Wald test on physician supply. Each IV passed the exclusion restriction test, regardless of which IV was tested. A variant of the Hausman-Exogeniety Test consisted of a joint Wald test on the first-stage residual and the first-stage residual interacted with a dichotomous rural residency. *Because endogeneity was detected in the 60-day readmission model, and the 7-day follow up care residual was close to significance (p=.054) we decided 2SRI was appropriate.

Table 4.3: Average Marginal Effects of Follow Up Care and Home Health on Readmission				
	2SRI 7-Day Follow Up	**LOGIT** 7-Day Follow Up	**2SRI** 14-Day Follow Up	**LOGIT** 14-Day Follow Up
30-DAY READMISSION				
Follow Up Care	-0.115	-0.00507	-0.00848	-0.0385***
	(0.105)	(0.00628)	(0.125)	(0.00589)
Rural*Follow Up	0.000657	0.0170	0.0688	0.00548
	(0.009)	(0.0125)	(0.0712)	(0.0076)
Home Health	0.0682	0.00632	0.00678	0.0189
	(0.0768)	(0.00773)	(0.00853)	(0.013)
Rural * Home Health	-0.0137	-0.0143	-0.0133	-0.0152
	(0.0155)	(0.0142)	(0.0151)	(-0.0139)
60-DAY READMISSION				
Follow Up Care	-0.168	0.00333	-0.0632	-0.0268***
	(-0.0988)	(0.00740)	(0.132)	(0.00707)
Rural*Follow Up	0.0329	0.00483	0.0801	0.00931
	(-0.0803)	(0.0145)	(0.0868)	(0.00964)
Home Health	0.000115	0.00995	0.00805	0.0036
	(-0.0109)	(0.00985)	(0.0104)	(-0.014)
Rural * Home Health	0.00188	0.00637	0.00929	0.00568
	(-0.0198)	(0.0194)	(0.0199)	(0.0185)
Observations	11,487	11,487	11,487	11,487

Bootstrapped Standard errors in parentheses
*** p<0.01, ** p<0.05

Table 4.4: Average Marginal Effects of Follow Up Care and Home Health on ED Use				
	2SRI	**LOGIT**	**2SRI**	**LOGIT**
	7-Day Follow Up	7-Day Follow Up	14-Day Follow Up	14-Day Follow Up
30-DAY ED USE				
Follow Up Care	-0.112	-0.00632	0.0133	-0.0309***
	(0.135)	(0.00530)	(0.146)	(0.00526)
Rural*Follow Up	0.0371	-0.0104	0.0751	-0.0274**
	(0.0841)	(0.0111)	(0.0845)	(0.0112)
Home Health	-0.00499	-0.00007	0.000966	-0.000764
	(0.00915)	(0.00639)	(0.00853)	(0.00631)
Rural * Home Health	-0.00703	-0.00860	-0.00528	-0.00875
	(0.0146)	(0.0140)	(0.0150)	(0.0138)
60-DAY ED USE				
Follow Up Care	-0.170	0.00213	-0.0104	-0.0210***
	(0.121)	(0.00658)	(0.136)	(0.00625)
Rural*Follow Up	-0.00138	-0.00564	0.0619	-0.0162
	(0.0647)	(0.0134)	(0.0798)	(0.0128)
Home Health	0.00383	0.0137	0.0133	0.0129
	(0.0104)	(0.00820)	(0.00961)	(0.00818)
Rural * Home Health	-0.0132	-0.00969	-0.00641	-0.0102
	(0.0167)	(0.0176)	(0.0175)	(0.0175)
Observations	11,487	11,487	11,487	11,487

Bootstrapped Standard errors in parentheses
*** p<0.01, ** p<0.05

Table 4.5: Average Marginal Effects of Follow Up Care and Home Health on Mortality

	2SRI	**LOGIT**	**2SRI**	**LOGIT**
	7-Day Follow Up	7-Day Follow Up	14-Day Follow Up	14-Day Follow Up
30-DAY MORTALITY				
Follow Up Care	0.0807	-0.00944***	0.106	-0.0180***
	(0.206)	(0.00242)	(0.149)	(0.00283)
Rural*Follow Up	0.109	-0.00552	0.0841	-0.0009
	(0.136)	(0.0047)	(0.0722)	(0.00537)
Home Health	0.00106	-0.00148	0.000723	-0.00153
	(0.00363)	(0.00276)	(0.00302)	(0.00277)
Rural * Home Health	0.00509	0.00022	0.000989	0.000572
	(0.0132)	(0.0055)	(0.00916)	(0.00556)
60-DAY MORTALITY				
Follow Up Care	0.0189	-0.0102***	0.0275	-0.0228***
	(0.149)	(-0.00309)	(0.114)	(0.00332)
Rural*Follow Up	-0.00449	-0.00192	-0.0164	0.00295
	(-0.105)	(-0.00614)	(0.0658)	(0.00666)
Home Health	0.00583	0.0043	0.00612	0.00418
	(0.00467)	(-0.00386)	(0.004)	(0.00383)
Rural * Home Health	-0.00221	-0.00318	-0.0039	-0.00292
	(0.0114)	(-0.0077)	(0.00941)	(0.00767)
Observations	12,299	12,299	12,299	12,299

Bootstrapped Standard errors in parentheses
*** p<0.01, ** p<0.05

Figure 4.1: Average marginal effect of 7-day follow up on 60-day readmission by Charlson Co-morbidity score, MCBS, 2000-2010, N = 11,487

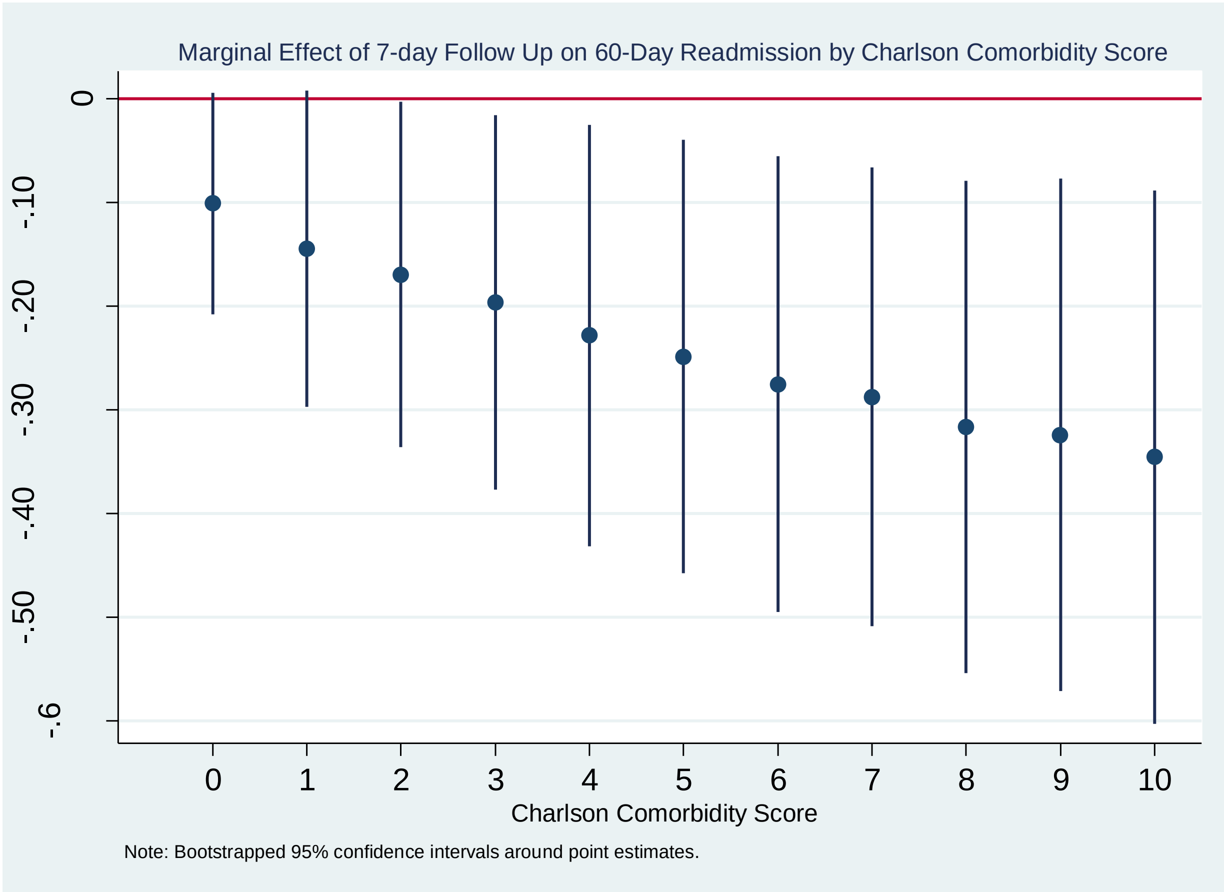
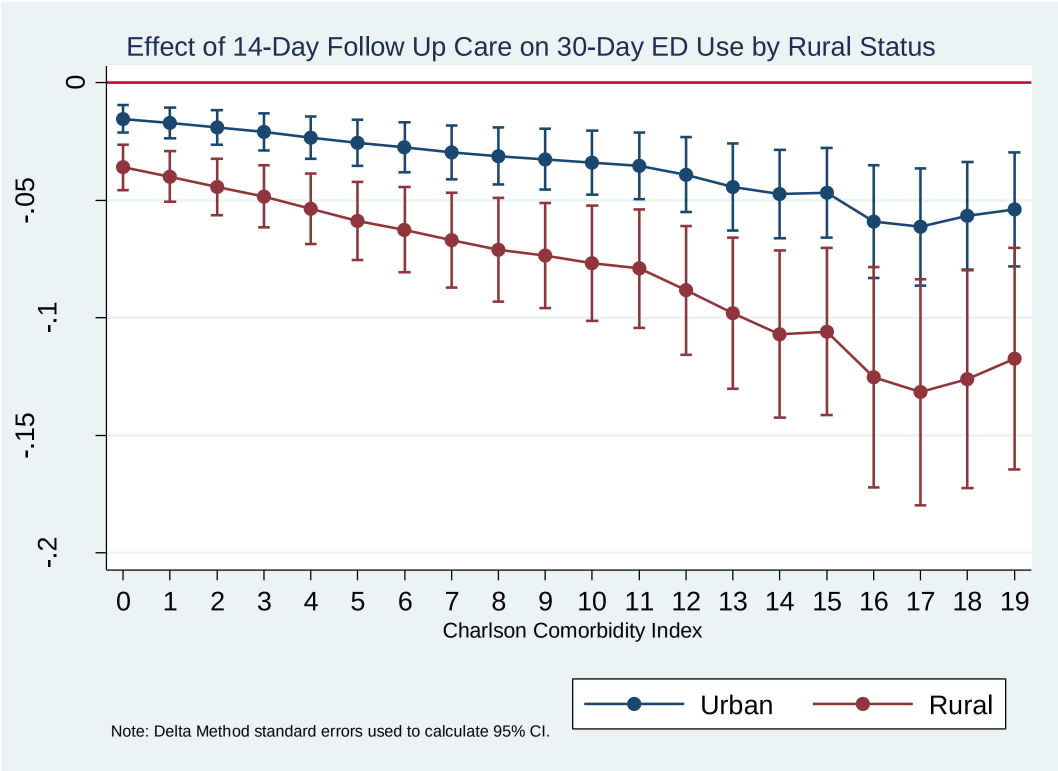


Figure 4.2:Average marginal effect of 14-day follow-up care on 30-day ED use by rural status, MCBS, 2000-2010, N = 11,487



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CHAPTER 5: IMPACT OF POST-DISCHARGE FOLLOW-UP CARE ON MEDICARE EXPENDITURES: DOES RURAL MAKE A DIFFERENCE?

Introduction

Medicare spending on post-acute services exceeded $63 billion in 2012. Spending on post-acute care is the largest contributor to geographic variation in Medicare spending.[1] Improving care transitions from the hospital to home is seen to play a critical role in improving quality and potentially lowering expenditures during the post-acute period.[2] Poor transitions in care lead to preventable acute and post-acute care, costing Medicare $12 billion annually.[3-5] Moreover, post-hospital transitions in rural settings may be further complicated by limited resources and barriers to accessing post-discharge care.[6, 7] Questions remain as to whether improving care transitions can reduce Medicare expenditures, and whether rural settings experience similar benefits. [2, 8] Elements of a care transition thought to reduce unnecessary acute and post-acute utilization and spending are having an early follow-up visit and home health care.[9-11]

An early follow-up visit can help the patient and doctor identify gaps in post-discharge care that, if addressed, may prevent additional acute and post-acute services. If so, the cost of the visit would be offset by the reduction of acute and post-acute services.[3, 12-14] However, rural beneficiaries may not realize the same reduction in post-discharge expenditures as their urban counterparts. Rural beneficiaries have poorer outcomes during a post-discharge period compared to urban beneficiaries, which may lead to higher expenditures.[7] Early follow-up care offers similar reductions in readmission, ED use, and mortality for rural and urban beneficiaries.[15] Moreover, follow-up care decreased 30-day ED use more for rural than for urban beneficiaries suggesting potential savings in Medicare expenditures from early follow-up visits for rural beneficiaries.[15]

Similarly, home health use may reduce Medicare expenditures during a post-discharge period, and other work points toward its cost-savings potential.[16, 17] There is limited research on whether the effect of home health on expenditures varies by rurality. Rural home health agencies provide fewer services [18, 19], yet there is similar home health use in rural and urban settings.[20] Whether there are rural-urban differences in post-hospitalization home health use on short and long term Medicare spending has not been evaluated.

The Centers for Medicare and Medicaid Services (CMS) is currently examining episode-based payment designs to encourage coordination and bundling of post-acute services across providers, including Part B physician follow-up services.[21] Understanding the role of these services in reducing short and long-term Medicare expenditures post-hospitalization is crucial.[22] Moreover, given differential payments to hospitals and physicians in urban areas than rural areas, and some evidence that points to lower inpatient related expenditures among rural hospitals, understanding whether rural beneficiaries experience a similar impact on Medicare expenditures is important.[20, 23] Indeed, further consideration of providers serving rural Medicare beneficiaries may be warranted.

An additional nuance is that the receipt of early follow up care and home health may have negligible effects on average post-discharge expenditures. Indeed, reviews of relatively expensive transitional care interventions on reducing unplanned acute care have been mixed. [9,

[24] However, there is some evidence that providing early follow up care and home health care may reduce short and long term Medicare expenditures for individuals who are at risk for high expenditures, but not have an effect on the average or less sick patient being discharged. [15, 25] This additional detail to post-discharge Medicare expenditures has not been fully examined.

Finally, early follow-up and use of home health care are likely confounded by observed and unobserved characteristics. {Hadley, 2003 #308}{Hernandez, 2010 #178} Indeed, severity of illness or the extent to which the beneficiaries have support from a caregiver are unobserved and likely predict receipt of follow-up care, as well as expenditures. As such, it is important to account for this possible selection bias or we may underestimate the actual effect of these treatment variables. To this end, an instrumental variable approach will be utilized.

The purpose of this study is to better understand the role of early follow up care (within 7 days) and home health care on reducing 30-, 60-, and 180-day expenditures, and whether rural beneficiaries experience a similar effect as urban beneficiaries. To account for the distribution of post-discharge expenditures, we use a quantile regression analysis.[26] We account for selection bias inherent in the receipt of these services through the use of instrumental variables (IV). We hypothesize that early follow-up care and home health will reduce post-discharge Medicare expenditures. We also hypothesize that these services will have a smaller reduction in expenditures among rural, compared to urban beneficiaries.

Methods

Data Source. The Medicare Current Beneficiary Survey (MCBS), Cost and Use files from 2000-2010 is the main data source for this study. The MCBS is a longitudinal panel survey of a nationally representative sample of the Medicare population; it contains: (1) survey data on health status, education level, household composition, and other socio-demographic characteristics and (2) claims data for utilization of inpatient care, outpatient care, home health care, physician office based services, skilled nursing facilities (SNF), hospice, and durable medical equipment (DME). Hospital level characteristics came from the CMS Provider of Service File, which contains a yearly survey of Medicare certified hospitals. County level characteristics were captured from the Area Resource File and the Dartmouth Atlas of Health Care.

Study sample. We included beneficiaries with index admissions to acute hospitals in the MCBS from 2000 to 2010 who were (1) $\geq$ 65 years; (2) enrolled in traditional fee-for-service Medicare; (3) living within the contiguous 48 states; and (4) discharged home from the index admission after an acute medical problems. An index admission was established by excluding beneficiaries with an admission: (1) within the previous 60 days; (2) that occurred within 60 days of the first survey year; (3) for cancer management; or (4) with a primary diagnosis of a psychiatric or rehabilitation condition. [27] We excluded observations with acute or post-acute expenditures within 3 days of discharge because these expenditures are 1) unlikely to be effected by a follow up visit and 2) indicators of care delivered in the inpatient setting. We used a complete case analysis by dropping observations with missing covariates. We excluded those who died within 180-days post-discharge for all models because end-of-life care frequently involves a different pattern of utilization and spending compared to those who are not at the end of life. (Riley 2010)

Key Variables and Measures. The main dependent variables were Medicare expenditures at 30-, 60-, and 180-days post-discharge from the index admission. These expenditures include Medicare payments for inpatient, outpatient, physician, DME, hospice, and SNF services.

The main independent variables were receipt of early follow up care post-discharge. Follow up care was defined as any Evaluation and Management visit in an outpatient or office based setting (Healthcare Common Procedure Coding System (HCPCS) codes ≥99241 & ≤99245, ≥99201 & ≤99205, and ≥99210 & ≤99215) during the 7 day period that takes place before any acute or post-acute expenditures.[10] Home health use was defined as home health claim within 14-days of the discharge date that occurred prior to an acute or non-home health post-acute expenditure. A dichotomous variable (rural versus urban residency) was created from the Rural-Urban-Commuting Codes (RUCA). RUCA codes combine standard Census definitions with area commuting behaviors to capture functional and work relationships between regions.

Covariates*.* Demographic variables included both continuous (age and income) and categorical (race, gender, education, relationship status, Medicaid status and household composition) variables. Health status included number of limitations in activities of daily living (ADLs) and instrumental activities of daily living (IADLs), length of the index hospitalization, and the Charlson Comorbidity Index (CCI). The CCI predicts risk of mortality based on beneficiaries' primary and secondary diagnosis and is frequentally used to control for confounding of disease severity on post-discharge outcomes. [28, 29] Hospital facility-level variables included a categorical hospital location, for-profit status, and a continuous number of registered nurses and number of beds.

Instrumental variables. Our treatment variables may be endogenous in that sicker patients are more likely to receive follow up services and/or home health services and have greater post-discharge expenditures. If so, the coefficients on our treatment variables would be biased upward, making it appear that follow-up and home health care increase post-hospital expenditures compared to not receiving these services. Valid instruments must pass at least two criteria: 1) significantly explain variation in the endogenous treatment variable and 2) not predict the dependent variables except through the treatment variable. We acquired five potential IVs from the Area Resource File and from the Dartmouth Atlas of Health Care.

Provider distance. First, we calculated the straight line distances between the geographic center of the beneficiaries' residency zip code to the: (1) center of the admitting hospital zip code and (2) nearest home health agency (HHA). We argue that the closer a resident is to the discharging hospital, the more likely that person would receive a follow up visit as they are more likely to live within that hospital's network of providers and outpatient facilities, simplifying care coordination. Because of the skewed distribution of miles from the hospitals, we estimated log-distance from residency to admitting hospital (*distance to hospital*) and to HHA (*distance to HHA*).

Physician Medicare Reimbursement. We used county level average of Medicare Part B reimbursement per enrollee from the Dartmouth Atlas of Health Care, 2000 to 2010. We link Federal Information Processing Standard (FIPS) values from the Dartmouth files with beneficiary zip-codes. We imputed 3 years using the average yearly change within the Federal Information Processing Standard code (FIPS). Dartmouth uses prices adjusted averages, thus the variation across FIPS should reflect service intensity. Variation in Medicare expenditures within Hospital Referral Regions (HRR) are mostly associated with post-acute service utilization, such as SNF, Home Health care, rehabilitative care and inpatient care. [30] As such physician reimbursement per enrollee at the county level can be validly excluded from models on 30-, 60-, and 180-day post-discharge expenditures because 89% of expenditure variation within HRR are a result of post-acute and acute service utilization. Thus, physician reimbursement per enrollee will have no explanatory power in an expenditure model once demographic, health, and hospital characteristics are controlled for.

County-Follow Up Rate. We used county level rates of 14-day primary care follow up (*percent follow up*) from the Dartmouth Atlas of Health Care. We used the available years 2004, and 2008- to 2010, and imputed the values for missing years by taking the average yearly change within the FIPS. . *Percent follow-up* is an appropriate IV for this study. Indeed, geographic practice patterns are frequently used as IVs in the literature and is an indicator of coordination of care within the county. [31, 32 33]

HHA episodes. We used Dartmouth Atlas of Health Care files for home health episodes per 1000 beneficiaries at the county level during 2008 (*episodes*) We hypothesize that a higher number of episodes per county should predict use, but not have a direct impact on individual level expenditures during a post-discharge period. A greater number of episodes may be correlated with greater competition, and thus higher prices for home health insured by private payers. However, Medicare payments are not sensitive to competition, and thus *episodes* is not directly related to individual level expenditures.

In sum, we have five total instruments; distance to hospital, distance to HHA, county-level physician reimbursement per enrollee, county-level 14-day follow-up rates, and county-level number of HHA episodes per enrollee. There are four endogenous treatment variables. Thus, we are able to conduct over-identification tests of our instruments, discussed below.

Statistical Analysis. For descriptive statistics, we adjusted for the complex survey design of the MCBS using cross-sectional weights. For bivariate comparisons, we used chi-squared and t-tests for categorical and continuous variables, respectively. Quantile regressions were used to illustrate the effect of our treatment variables across the distribution of the dependent variable. Indeed, this method is unique to ordinary least-squares (OLS) approach in that it is robust to outliers that can skew OLS coefficients. [26] We modeled 30-, 60-, and 180-day expenditures at the 10th, 25th, 50th, 75th, and 90th percentile of the logged dependent variable. Logged-dependent variables are frequently used in modeling health care costs because of its skewed distribution [34]. To account for the MCBS's complex survey design, we estimated bootstrapped standard errors adjusted for clustering at the strata and primary sampling unit level on the cross-sectional weighted point-estimates. The following equation was estimated using a difference-in-difference approach:

$$Q_\tau(Y\,|X) = \alpha + \beta_1(Rural) + \beta_2(Early\ Follow\ Up\,) + \ \beta_3(Home\ Health)$$
$$+ \beta_4(Rural * Follow\ Up) + \ \beta_5(Rural * \ Home\ Health) + \ \delta X + \ \varepsilon$$

Where $\beta_2 - \ \beta_5$ are the endogenous treatment variables, δ are the coefficients on the control variables, and ε is the error term. To correct for the endogeneity of the treatment variables, we use IVs. Using IVs in quantile regressions is relatively. [35] We used two-stage residual inclusion (2SRI) to facilitate interpretation of the coefficients. [36] This method adapts Lee's [37] control function approach to endogeneity in quantile regression, but for a binary treatment variable. This strategy entails calculating the residual from the first stage equation and then including the first-stage residuals and the endogenous treatment variables in the second-stage equation at each conditional distribution. As there are four potentially endogenous treatment variables, we acquired four residuals by running two first-stage probits on follow-up treatment and home health treatment, calculating the residuals, and interacting the residuals with a dichotomous rural residency variable. The first stage probit consisted of our five exogenous IVs and controls:

$$1st\ Stage: Prob(Treatment\ |Z_{1-5}, X)$$
$$= \alpha + \beta_1(County\ Level\ Physician\ Reimbursement)$$
$$+ \beta_2(\%\ 14\ day\ Follow\ up\ per\ County) + \beta_3(Logged - Hospital\ Distance)$$
$$+ \beta_4(HHA\ Episodes) + \beta_5(HHA\ distance) + \delta X + \varepsilon$$

Where $\beta_1 - \beta_5$ are the coefficients for the IVs, δ represents the coefficients for the control variables and ε represents the error term. We calculate the predicted residuals of both 1st stage equations and interacted the residuals with a rural dichotomous variable to create a total of four residuals to include in the 2nd stage equation. The 2nd stage equation consisted of a survey weighted quantile regression at the 10th, 25th, 50th, 75th, and 90th percentiles. We used Bollen et al. [38] method for testing the over-identified restriction of the second stage model. We ran the over-identification tests on the Quantile Regression at the 50th percentile. A Wald test was conducted on the coefficient of the over-identified IV, where the null hypothesis was that the IV was validly excluded from the 2nd stage structural model. The 2SRI approach is similar to a variant of the Hausman test for exogeniety. Thus we can test whether there is selection bias in the treatment variables by conducting a joint-test of significance on the residuals in the 2nd stage model, where the null hypothesis is that the treatment variables are exogenous. If the treatment variables are exogenous, then the residuals should have no explanatory power and the non-IV quantile regression is preferred because the estimators will be more precise. Hausman tests were conducted on the residuals across each distribution.

During the specification testing for instrument strength, our home health instruments did not pass the strength test (F-statistic > 10) for home health utilization. Strength tests results included a χ^2 of 9.58 (p = 0.09) for the entire sample, and of 8.53 for the analytic sample (p = 0.13). Furthermore, only *HHA episodes* was statistically significant in the first-stage home health equation (p<0.05). Weak IVs can produce biased results, especially if there is any correlation between the instrument and the error term. [39 32] Thus, we settled on three instruments that satisfied the IV specification requirements for follow-up care, and treated home health as exogenous. Doing so means that we cannot make causal inferences about the relationship between home health use and expenditures. Instruments included logged distance from residence to admitting hospital (*distance to hospital*), % of beneficiaries seeing a primary care doctor within 14-days of a medical discharge (*percent follow up*), and average Medicare Part B reimbursement per enrollee at the county level (*physician reimbursement*). .

We calculated average marginal effects of the treatment variables and the rural-interaction terms, and use bootstrapped standard errors. We report the quantile regression coefficients and the re-transformed marginal effects of both the naïve and 2SRI models. We calculated the marginal effects as follows:

$$Marginal\ Effect\ (\$) =$$

$$Q_\tau exp(logged\ y \mid \widehat{Treatment} = 1) - Q_\tau exp(logged\ y \mid \widehat{Treatment} = 0)$$

Results

Descriptive statistics. We started with 41,970 admissions, or 18,468 unique beneficiaries, to an acute care hospital from 2000 to 2010. After selection criteria were applied, our analytical sample was 10,958 hospital admission among 7,725 Medicare beneficiaries. (Table 5.1). Compared to urban beneficiaries, rural beneficiaries were slightly younger, less likely to have college education, less income, and more likely to have Medicaid. Urban beneficiaries had higher co-morbidities, and more likely to be admitted to larger, urban, and non-profit hospitals ($p<0.01$). Unadjusted differences in the outcomes indicate that rural beneficiaries expended less in 30-, 60-, and 180-day Medicare expenditures ($p<0.05$).

Instrumental Variable Specification Results. In the strength and over-identification tests (Table 5.2), the IVs sufficiently correlated with the treatment variables in both the 7-day and 14-day follow-up models ($\chi^2 = 51.70$, $p<0.001$, and $\chi^2 = 59.27$, $p<0.0001$, respectively). As expected, *distance* negatively correlated with follow-up care and *percent follow-up* and *reimbursement* positively correlated ($p<0.01$). *Percent follow up* passed the over-identification test for 30-day expenditures, but not for 60-day and 180-day expenditures. As such, we modeled 30-day expenditure model with over-identified IVs, and the 60-day and 180-day expenditure models with exactly identified IVs (*distance* and *reimbursement*).

Endogeneity was detected in most models, but not at every percentile. Joint tests indicated endogeneity in the 7-day follow up model on 30-day readmission in the 10^{th} and 90^{th} percentile ($\chi^2 = 6.30$, $p<0.05$, $\chi^2 = 11.21$, $p<0.001$, respectively), and in the 90^{th} percentile of the 14-day follow-up model ($\chi^2 = 6.43$, $p<0.05$). We discovered endogeneity in 7-day follow-up on 60-day expenditures in the 10^{th} percentile ($\chi^2 = 17.63$, $p<0.001$), and in the 14-day follow-up model in the 10th and 25th percentiles (χ^2 = 10.72, p<0.01, χ^2 = 6.65, p<0.05, respectively). Finally, 7-day and 14-day follow-up was endogenous in the 90th percentile on 180-day expenditures (χ^2 = 21.68, p<0.001, χ^2 = 15.86, p<0.001, respectively). Because we detected endogeneity in all the outcome models, the 2SRI models was preferred over the non-IV Quantile regressions.

Main Results. Table 5.3 displays the marginal effects of early follow-up care in re-transformed dollars and in logged – y coefficients on 30-day expenditures for both the IV models and non-IV models. . As expected, IV estimates indicate that early follow-up care significantly increased the 10th percentile of expenditures by 592% ($1,071) and the 25th percentile by 201% ($427.60). Early follow-up reduced expenditures by -223% ($5,361) and –305% ($49,386), respectively (p<0.05). Rural Medicare beneficiaries who received early follow-up care had 185% ($37,210) greater expenditures at the 90th percentile relative to urban beneficiaries (p<0.05). As expected, home health increased expenditures at the 10th, 25th, 50th, and 75th percentile of the 30-day distribution (p<0.05). Rural beneficiaries who received home health increased the 10th percentile of expenditures by 62% (p<0.05) compared to urban beneficiaries, but this difference only translated to $5.98 (not shown). Figure 5.1 illustrates the relationship between early follow-up care and 30-day expenditures across the distribution of expenditures.

The non-IV quantile regression results were as expected. Early follow-up care increased the percentiles across the distribution of 30-day expenditures. For example, early follow-up care increased 10th and 25th percentile of 30-day expenditures by 326% and 76%, respectively (p<0.01). In contrast to the IV results, early follow-up care increased the 50th and 75th percentiles by 41% and 23%, respectively ($p<0.01$). Rural beneficiaries who received an early follow-up visit expended 11% ($53.26) less in median expenditures compared to urban beneficiaries ($p<0.05$).

Results of the 2SRI models on 60-day expenditures show similar effects of follow-up care on the distribution of 30-day expenditures (Table 5.4). Early follow-up care increased the 10th percentile of 60-day expenditures by 819% ($201,448). While there were no statistically significant effects of early follow-up across the rest of the distribution. However, the coefficients at the 75th and 90th percentile are similar in size and direction for 30-day expenditures. Among urban beneficiaries only, we found that early follow-up care at the 90th percentile reduced expenditures by -230% ($35,301) ($p<0.05$; results not shown). There was no evidence of rural and urban differences in the effect of early follow-up care on the conditional distribution of 60-day expenditures. As expected, home health increased the 10th, 25th, 50th, and 75th percentile of 60-day Medicare expenditures ranging from 121% at the 10th to 21% at the 75th percentile ($p<0.05$). There were no rural-urban differences in the effect of home health on the conditional distribution of 60-day expenditures.

The naïve quantile regression results on 60-day expenditures are similar to the trend found on 30-day expenditures (Table 5.4). Without adjusting for selection bias, early follow-up care increased the 10th percentile of 60-day expenditures by 99%, and the 90th percentile by 10% ($p<0.05$). The relative effect was positive and statistically significant across the conditional distribution. There was no evidence of a rural-urban differences in the non-IV model. Compared to the 2SRI estimates, the marginal effect in dollars are smaller, and in the opposite direction at the higher quantiles.

Unlike the 2SRI models for 30-day and 60-day outcomes, there was no relationship between early follow up care and the lower quantiles of the 180-day expenditure distribution (Table 5.5). However, at the 90th percentile of the distribution, early follow-up care was associated with a -183% ($67,550) decrease in Medicare expenditures (p<0.05). While there was no relationship between early follow-up and the 75th percentile of 180-day expenditures, the effect among rural beneficiaries was a -178% ($17,552) decrease in expenditures. Additionally, rural beneficiaries who received a follow-up visit had 250% ($77,940) greater 90th percentile of 180-day expenditures compared to urban beneficiaries (p<0.05). Similar to other outcomes, home health increased 180-day expenditures across the distribution of 180-day expenditures. There were no rural-urban differences in the effect of home health on the conditional distribution of 180-day expenditures.

The naïve models for 180-day expenditures were similar to previous naïve models. Without adjusting for selection bias, early follow-up increases 180-day expenditures at all quantiles except the 90th percentile (p<0.01). The marginal effects in dollars are smaller than the 2SRI estimates, and in the opposite direction at the higher quintiles of the distribution. We ran a number of sensitivity analysis to confirm the robustness of our results. These included estimating an exactly identified 30-day expenditure model and removing the 3-day washout period. Additionally, we tested whether follow-up care over 14-days had different results than defining early follow-up care at 7-days. Defining early follow-up care at 14-days may be a better reflection of outpatient quality of care, as opposed to inpatient quality. However, the results of this analysis, and the other sensitivity tests were broadly consistent with the results outlined here.

Discussion

We found that when correcting for selection bias, early follow-up care following hospital discharge for an acute condition significantly increased expenditures for beneficiaries with the lowest expenditures (e.g. beneficiaries within the 10th and 25th percentile) at 30- and 60-days. We also found that early follow up care significantly decreased expenditures for beneficiaries with the highest expenditures at 30-, 60-, and 180-days (75th and 90th percentiles). High-expenditure rural beneficiaries receiving early follow-up care expended more at 30- and 180-days compared high-expenditure urban beneficiaries. We also found that home health use generally increased 30-day, 60-day, and 180-day expenditures. There are important implications to these findings.

First, this study is the first to demonstrate the effect of early follow-up care across the distribution of post-discharge expenditures. It appears that early follow-up care can significantly increase Medicare spending among low-cost beneficiaries; however, doing so greatly reduces Medicare spending among high cost beneficiaries. Other research examining care transition interventions that include follow-up care vary in their effect on expenditures.{Naylor, 2011 #250} Naylor et al{Naylor, 1999 #170} found an average reduction in expenditures of $3,000 over 180-days, while Gardner et a{Gardner, 2014 #321}l found an average reduction of $4,050. In contrast, the findings of this study illustrate that early follow-up care varies in the direction and magnitude of effect on the distribution of expenditures as opposed to the average. For example, early follow-up care for a beneficiary in the 10th percentile of 30-day expenditures increased the 10th percentile by $1,071, while reducing high-end (90th percentile) 30-day expenditures by $49, 386.

Second, these results can be helpful to providers and payers considering post-acute bundled payment arrangements. Indeed, targeting post-discharge resources toward those with high expected post-discharge expenditures could be expedient. While follow-up care is only one piece of successful care transition, these findings further confirm other research that indicates the effectiveness of targeting care-transition interventions on high-risk patients. [25] Similar research indicates that indeed, early follow-up care in an outpatient or clinic setting, has an additive effective at reducing readmissions as the number of co-morbidites increase. [15] Targeting post-discharge care resources toward beneficiaries with high expected expenditures will likely be beneficial in a payment context of shared-risk and rewards across acute and post-acute providers. Future research is needed in order to appropriately identify who high- and low-expenditure patients may be at discharge.

Third, early follow-up care among high-expenditure rural beneficiaries increased 30-day and 180-day Medicare expenditures compared to receiving follow up care among their urban counterparts. This finding is consistent with our hypothesis that rural beneficiaries would experience a smaller reduction in expenditures relative to urban beneficiaries. Three factor potentially explain this finding. First, it may be the case that once receiving a follow-up visit, rural beneficiaries with high post-discharge expenditures are using a different mix of services compared to urban beneficiaries with high post-discharge cost. For example, rural beneficiaries may rely more heavily on skilled nursing stays post-discharge compared to urban beneficiaries. However, these differences persisted even after removing SNF expenditures from the model. Second, rural providers have less infrastructure to integrate and coordinate care, suggesting there may more gaps coordination and communication that would contribute to a duplication of services, or unnecessary ED use and readmissions. [7, 40] Finally, there may be underlying unmet acute needs among beneficiaries with high expenditures. Ensuring early follow-up care may actually increase 30-day readmissions, and thus 30-day expenditures, in part because of identifying an unmet acute need. [41] Rural beneficiaries may receive worse inpatient care or may simply be sicker once they're discharged from the hospital compared to urban beneficiaries. [42, 43] Early follow-up care for these patients may then result in higher expenditures by ensuring needed medical care is obtained.

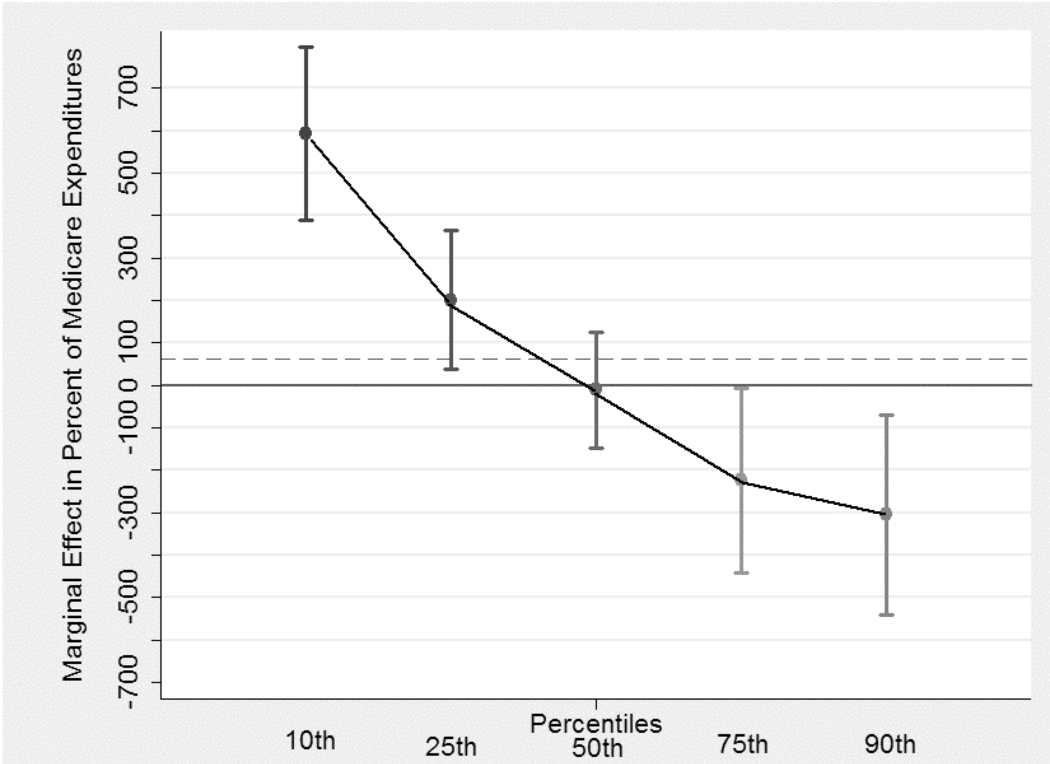
In the context of ACOs and bundled payments, rural providers serving sick rural patients may be dis-advantaged relative to their urban counterparts. [44] The bulk of the difference in rural-urban expenditures are most likely the result of acute or post-acute utilization. [1] Indeed, other research shows Medicare beneficiaries discharged from a rural hospital have a higher risk of readmission. [7] As such, financial penalties that result from the Hospital Readmission Reduction Program may further exacerbate the disparities in Medicare expenditures between high-expenditure rural and urban beneficiaries receiving follow-up care.

Finally, after adjusting for key predictors of home health use [45, 46], we found home health increased 30-, 60- and 180-day Medicare expenditures for both rural and urban beneficiaries in both low- and high-expenditure beneficiaries. While rural beneficiaries receiving home health services had greater Medicare expenditures in the 10th percentile than urban beneficiaries, this difference was not clinical significant. Generally, there were no rural-urban differences in the effect of home health on Medicare expenditures. This result is in contrast to our hypothesis that home health would result in a smaller reduction of expenditures compared to urban beneficiaries. Despite these findings, it is difficult to interpret these findings in light of omitted variable bias. Those receiving home health services are most likely sicker than those who did not receive home health services, resulting in estimates that suggest receiving home health increases overall Medicare expenditures over 30, 60- and 180-days post-discharge. Further work is needed in development of IVs for home health use on costs and outcomes.

This study has some important limitations. First, we did not consider whether the beneficiary died after the study period. Medicare costs for a beneficiary who died shortly after the study period would be different than costs for those who didn't, regardless of whether they received a follow-up visit. Second, we were unable to find valid IVs for the home health treatment variables, thus we are unable to make any causal inferences regarding the effect of home health on post-hospitalization expenditure. Third,, these results are not generalizable because they refer to the "marginal" patient whose propensity to have early follow-up care is effected by how close they live to a hospital, and whether they live in counties with higher average Part B payments per enrollee and 14-day follow-up rates. Finally, while early follow-up may reduce Medicare expenditures for high-expenditure beneficiaries, it is unclear how to identify high- and low-expenditure beneficiaries in a relatively healthy population. This could be direction for future research.

This study found that early follow-up care reduced Medicare expenditures for beneficiaries with high expenditures, and increased Medicare spending for beneficiaries with low expenditures. Follow-up care among high-expenditure rural beneficiaries increased Medicare expenditures compared to their urban counterparts. Providers and payers participating in bundled payments or ACOs may benefit from focusing post-discharge resources on high-expenditure patients, compared to ensuring all discharged patients receive follow-up care. Further, rural providers may be at a disadvantage in providing post-discharge care to high-expenditure rural beneficiaries, compared to urban providers. Additional research is needed to better understand quality and costs of post-discharge care among beneficiaries discharged to skilled nursing facilities and rehabilitation facilities, and whether disparities exist between rural and urban beneficiaries.

Figure 5.1: Treatment effects of early follow-up care across the distribution of 30-day expenditures, MCBS, 2000-2010, N = 10,957



Note: 95% confidence interviews with bootstrapped standard errors. Quantile regressions adjusted for demographic, health, year fixed effects, and hospital characteristics.

Table 5.1: Summary Statistics of Index Admissions among Medicare Beneficiaries by Rural Status, MCBS, N=10,958				
	TOTAL (N= 10,958)	**URBAN** (N= 7,286) (Weighted N = 26,179,288)	**RURAL** (N= 3,672) (Weighted N = 11,499,349)	P-value
Mean (Standard Deviation) or %				
OUTCOMES ($)				
30-Day Expenditures	1823.31 (5161.37)	1890.46 (5306.68)	1670.42 (4716.44)	0.04
60-Day Expenditures	3393.21 (7826.49)	3524.74 (8030.98)	3093.77 (7194.28)	0.004
180-Day Expenditures	7192.04 (13233.77)	7503.17 (13669.69)	6483.72 (11881.78)	0.002
DEMOGRAPHCS				
Age	77.01 (7.28)	77.22 (7.16)	76.55 (7.52)	0.002
Female	56.32	56.43	56.06	0.79
Race				<0.001
White	88.13	86.21	92.51	
Black	8.36	9.81	5.06	
Other	0.63	0.59	0.72	
Asian	1.08	1.48	0.17	
Hispanic	1.46	1.74	0.81	
Native American or Unknown	0.34	0.17	0.72	
Education				<0.001
Less than High School	34.5	31.2	42.01	
High School	48.64	49.31	47.12	
College or Graduate	16.86	19.5	10.86	
Relationship Status				0.39
Married	50.97	50.7	51.6	
Widow	38.18	38	38.58	
Divorce	7.8	8.08	7.16	
Separated	0.76	0.85	0.56	
Never Married	2.29	2.37	2.1	
Living Situation				0.06
Lives alone	31.82	31.27	33.08	
Spouse Only	41.84	41.48	42.65	
Spouse and others	7	7.17	6.62	
Children only	8.98	9.15	8.59	
Children & Others	4.82	5.43	3.43	

Others Only	3.23	3.28	3.11	
Non-relative	2.32	2.23	2.53	
Income (Thousand)	29.44 (49.34)	31.31 (55.10)	25.19 (28.25)	<0.001
Medicaid Status	17.4	16.27	19.95	0.04
HEALTH STATUS				
# ADLs	1.05 (1.57)	1.06 (1.53)	1.03 (1.65)	0.56
# IADLs	0.34 (0.69)	0.33 (0.67)	0.35 (0.73)	0.52
Charlson Comorbidity Score	3.10 (2.49)	3.18 (2.46)	2.94 (2.52)	0.003
Length of Stay	3.90 (3.54)	3.94 (3.65)	3.81 (3.20)	0.24
HOSPITAL CHARACTERISTCS				
Number of Beds	373.24 (280.16)	429.12 (268.13)	246.04 (262.64)	<0.001
Hospital Location				<0.001
Urban	77.69	97.8	31.89	
Large Rural	15.31	1.6	46.53	
Small Rural	4.44	0.47	13.49	
Isolated Rural	2.56	0.13	8.08	
Profit Status				0.008
Non-profit	69.38	72.26	62.85	
For-profit	13.08	12.91	13.48	
Government	17.53	14.84	23.68	
Total Full Time RNs	406.40 (421.82)	467.41 (427.80)	267.51 (362.73)	<0.001
INSTRUMENTAL VARIABLES				
Avg. % 14-Day Follow Up	44.07 (7.02)	42.79 (5.97)	46.99 (8.40)	<0.001
Distance to Hospital	41.74 (176.96)	37.05 (175.22)	52.41 (179.65)	<0.001
Physician Reimbursement per Enrollee	2010.69 (515.91)	2062.34 (491.74)	1893.13 (551.41)	<0.001

P-values by weighted linear regression for continuous variables and weighted chi2 test for binary/categorical variables.

Table 5.2: Instrument Strength for 7- and 14-day Follow Up and Exclusion Restriction for Expenditure Outcomes

	Probit Coefficients		**Exclusion Restriction Test**		
	7-Day Follow Up	14-Day Follow Up	30-Day (x_1^2)	60-Day (x_1^2)	180-Day (x_1^2)
	b/se	b/se			
Logged Distance to Hospital†	-0.026***	-0.042***	0.43	2.26	4.00*
	(0.007)	(0.007)			
% 14-Day Follow-up	0.001***	0.001***	3.34	15.25**	4.18*
	(0.000)	(0.000)			
Avg. Physician reimbursement	0.008***	0.010***	1.30	0.30	2.20
	(0.002)	(0.002)			
Unadjusted Wald Test	51.70	59.27			

* p<0.05, **p<0.01. Covariates include age, gender, income, education status, relationship status, household composition, CCI, limitations in ADL and IADL, length of stay, hospital size, hospital profit status, number of registered nurses, and hospital location. Bootstrapped SEs with survey weights.

† Hospital distance was marginal significant in the 7-day model on 180-day expenditures (p= 0.046), but passed the over-identification test in the 14-day model χ^2 =2.28, p=0.13.

Table 5.3: 2SRI Quantile Regression of Follow Up Care on 30-day Expenditures					
	Percentiles				
	10th	25th	50th	75th	90th
Marginal Effects on Ln(Y)					
7-Day Follow-Up	5.921***	2.012**	-0.113	-2.231**	-3.051***
	(1.073)	(0.829)	(0.655)	(1.07)	(1.134)
Follow Up* Rural	-1.186	0.613	0.702	0.274	1.854*
	(0.783)	(0.548)	(0.617)	(0.686)	(0.767)
Home Health	1.227**	0.566**	0.277**	0.305**	0.0187
	(0.276)	(0.0681)	(0.0574)	(0.0848)	(0.0795)
Home Health * Rural	0.618*	0.148	-0.144	-0.173	-0.125
	(0.243)	(0.129)	(0.121)	(0.153)	(0.149)
Marginal Effects ($)					
7-Day Follow-up visit	1,071	427.6	-38.64	-5,361	-49,386
	(2,818)	(521.3)	(308.9)	(11,082)	(177,990)
Rural-interaction	-486.7	238.4	245.2	1,635	37,210
	(2230)	(358.6)	(294.5)	(4406)	(130798)
Naïve Quantile Regression of Follow Up Care on 30-day Expenditures					
Marginal Effects on Ln(Y)					
7-Day Follow-Up	3.266**	0.755**	0.414**	0.228**	0.0657
	(0.0941)	(0.0394)	(0.0302)	(0.0514)	(0.0559)
Follow Up*Rural	-0.107	0.0161	-0.116*	0.115	0.230
	(0.0964)	(0.0816)	(0.0569)	(0.0859)	(0.123)
Marginal Effects ($)					
7-Day Follow-up visit	92.00***	95.50***	165.0***	276.0***	-26.15
	(9.292)	(6.787)	(14.32)	(91.81)	(378.3)
Follow Up* Rural	9.822	-3.657	-53.26**	131.2	1,034
	(11.96)	(13.15)	(23.13)	(138.8)	(615.8)
Observations	10,957	10,957	10,957	10,957	10,957

Standard errors in parentheses
** p<0.01, * p<0.05

Table 5.4: 2SRI Quantile Regression of Follow Up Care on 60-day Expenditures					
	Percentiles				
	10th	25th	50th	75th	90th
Marginal Effects on Ln(Y)					
7-Day Follow-Up	8.178**	0.433	-1.078	-0.86	-2.055
	-2.024	-0.858	-0.918	-1.12	-1.066
Follow Up* Rural	1.214	0.756	0.119	0.609	0.791
	(0.896)	(0.517)	(0.525)	(0.591)	(0.628)
Home Health	1.210**	0.410**	0.236**	0.206*	-0.151
	(0.138)	(0.06)	(0.0679)	(0.0823)	(0.0829)
Home Health * Rural	0.344	-0.0446	-0.0282	-0.0452	-0.0384
	(0.229)	(0.111)	(0.11)	(0.131)	(0.135)
Marginal Effects ($)					
7-Day Follow-up visit	201,448	151.3	-1,174	-3,374	-31,182
	(3313000)	(594.2)	(2464)	(11937)	(127823)
Rural-interaction	239,208	276.1	275.8	2,490	16,302
	(3886000)	(396.2)	(1218)	(6548)	(82474)
Naïve Quantile Regression of Follow Up Care on 60-day Expenditures					
Marginal Effects on Ln(Y)					
7-Day Follow-Up	0.986***	0.452***	0.279***	0.172***	0.0983**
	-0.0865	-0.0362	-0.0397	-0.0388	-0.045
Follow Up*Rural	0.184	0.122	0.0414	0.0566	0.0778
	-0.184	-0.083	-0.0865	-0.083	-0.134
Marginal Effects ($)					
7-Day Follow-up visit	92.00***	95.50***	165.0***	276.0***	-26.15
	(9.292)	(6.787)	(14.32)	(91.81)	(378.3)
Follow Up* Rural	-4.023	29.35	25.59	130.8	615.9
	(26.28)	(29.99)	(99.73)	(331)	(1273)
Observations	10,957	10,957	10,957	10,957	10,957

Standard errors in parentheses
** p<0.01, * p<0.05

Table 5.5: 2SRI Quantile Regression of Follow Up Care on 180-day Expenditures					
	Percentiles				
	10th	25th	50th	75th	90th
Marginal Effects on Ln(Y)					
7-Day Follow-Up	-0.188	-1.699	-0.701	-1.530	-1.832*
	(1.804)	(1.196)	(0.792)	(0.847)	(0.81)
Follow Up* Rural	0.36	1.073*	0.561	-0.364	2.503*
	(0.778)	(0.547)	(0.524)	(0.444)	(0.586)
Home Health	0.652***	0.329***	0.256***	0.0977*	0.652***
	(0.118)	(0.0759)	(0.0605)	(0.0581)	(0.118)
Home Health * Rural	0.136	0.154	0.113	-0.0948	0.117
	(0.159)	(0.102)	(0.0862)	(0.0839)	(0.0946)
Marginal Effects ($)					
7-Day Follow-up visit	-84.91	-3,510	-2,678	-17,004	-67,550
	(8788)	(13092)	(4814)	(19252)	(69872)
Rural-interaction	157.6	2,256	2,044	-827.3	77,940
	(8476)	(7325)	(2712)	(8362)	(49146)
Naïve Quantile Regression of Follow Up Care on 180-day Expenditures					
Marginal Effects on Ln(Y)					
7-Day Follow-Up	0.499***	0.315***	0.215***	0.130***	0.0635
	-0.0658	-0.0356	-0.0377	-0.0398	-0.039
Follow Up*Rural	0.0232	0.195**	0.132	0.0163	0.144
	(0.171)	(0.0848)	(0.0826)	(0.077)	(0.0973)
Marginal Effects ($)					
7-Day Follow-up visit	222.5***	349.7***	663.9***	1,200**	387.6
	-41.92	-71.74	-176.7	-487.5	-992.1
Follow Up* Rural	23.23	258.8**	521.6	55.02	2,557
	(91.1)	(127)	(325.6)	(755.8)	(1923)
Observations	10,957	10,957	10,957	10,957	10,957

Standard errors in parentheses
** p<0.01, * p<0.05

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CHAPTER 6: CONCLUSION

The overall objective of this project was to identify whether rural Medicare beneficiaries experience less favorable outcomes post-hospital discharge than their urban counterparts. Additionally, this project sought to identify policy-modifiable factors that impact outcomes and Medicare expenditures for this population. My central hypothesis was that rural beneficiaries experience poorer post-acute outcomes compared to urban beneficiaries. Further, I also hypothesized that, due to fewer post-discharge resources in the outpatient and post-acute setting and potentially poorer access to specialty providers for patients with chronic conditions,[1, 2] the beneficial effect of a 7 day or 14 day follow up (early follow-up care), and home health use on outcomes and costs will be smaller among rural beneficiaries. The findings of this study demonstrates partial support for these hypothesis, and indicate potential areas of focus for policy makers and providers in improving post-acute care for Medicare beneficiaries.

Aim 1 sought to determine whether rural beneficiaries had poorer post-acute outcomes compared to urban beneficiaries. I hypothesized that rural beneficiaries would have a higher rate of readmission and ED use, and lower rate of follow-up care over 60 days post-discharge. Consistent with my hypothesis, this study found rural beneficiaries had a higher rate of ED use, and a lower rate of follow-up care over 60 days. However, contrary to my hypothesis, there was no relationship between rural residency and readmission. Interestingly, a secondary finding of this analysis was that beneficiaries discharged from rural hospitals were readmitted at a higher rate than beneficiaries discharged from an urban hospital. Indeed, the risk of readmission among rural beneficiaries was explained by the risk associated with the discharging hospital. Results of these analysis were robust to a number of sensitivity tests, including controlling for county level provider supply. As most beneficiaries admitted to rural hospitals reside in rural settings, these findings lend support to the hypothesis that rural beneficiaries experience worse quality of care during a post-hospitalization.

Aim 2 compliments the findings of *Aim 1*. I hypothesized that rural residency would modify the effect of follow-up care and home health care on 30- and 60-day readmission, ED use, and mortality. There was no statistically significant relationship between home health on any of the outcomes, and I did not find evidence that there were rural-urban differences in the effect of follow-up care in most of the outcome models. However, given the findings in *Aim 1*, it is no surprise that *Aim 2* demonstrated that rural beneficiaries who receive 14-day follow-up care had a greater reduction in the risk of 30-day ED visit than urban beneficiaries. I originally assumed that fewer post-discharge resources would result in poorer quality of care, even after receiving a follow-up visit. Findings to the contrary does not indicate better quality of care, but rather may indicate unmet need in rural settings. Previous research suggests that poor access to primary care may contribute to higher ED use and hospital readmissions in rural settings. [3, 4] Recent work has also shown that rural patients are more likely to have non-emergent visits to the ED compared to urban patients, and suggests that better coordination of care and expanding access to primary care and safety-net providers may reduce the misuse of the ED in rural areas.[5] The findings of this study support that idea; rural beneficiaries may substitute the ED for follow-up care, and insuring early follow-up care can reduce 30-day ED use. Given that rural beneficiaries have a higher rate of ED use post-discharge, it stands to reason that an early follow-up visit offers a greater reduction in the risk of an ED visit, relative to urban beneficiaries.

A final nuance to the findings in *Aim 2* indicates while 7-day follow-up care did not have an average effect on 60-day readmission, it did significantly reduce the risk of 60-day readmission for beneficiaries with Charlson Comorbidity Index scores of 2 or more. Essentially, high risk beneficiaries experience a benefit of early follow-up in reducing the risk of readmission. These findings are consistent with other studies,[6] and lend further support for the need of targeted interventions or post-discharge resources to ensure better quality post-acute care. Indeed, *Aim 3* extends upon these findings by showing that when correcting for selection bias, early follow-up care significantly increases the 10^{th} and 25^{th} percentile of 30- and 60-day Medicare expenditure for beneficiaries with expenditures in those quantiles, while reducing the 75^{th} and 90^{th} percentiles of 30-, 60- and 180-day expenditures for beneficiaries at those quantiles. Consistent with my hypothesis, *Aim 3* found that rural beneficiaries who received follow-up care had a greater 90^{th} percentile of 30- and 180-day expenditures than urban beneficiaries who had a follow-up visit. Finally, Aim 3 also showed home health significantly increased expenditures across the distribution of the 30-, 60-, and 180-day outcomes.

It is hard to interpret the findings on home health use because of selection bias. As mentioned earlier, I was unable to find valid IVs for home health use. In light of this limitation, the use of home health post-discharge did not predict readmission, ED use or mortality, but did increase spending across the distribution of 30-, 60-, and 180-day expenditures. There were no rural-urban differences with exception to Medicare expenditures at the 10^{th} percentile of 30-days. These findings are counter to other work that suggests home health care plays a role in reducing readmissions and ED use,[7, 8] and other recent work that suggests home health use as a predictor of readmission in surgical patients.[9] While this study adjusts for key predictors of home health use, [10, 11] there is most likely selection-bias in that sicker individuals and more expensive to care for patients are receiving home health services. Additionally, it may be case that this sample was too healthy to meaningfully tease out home health effects on readmission. Indeed, in this sample, only 14.5% of beneficiaries who received home health were readmitted within 30-days. In contrast, MedPac reports that 29% of home health users are readmitted in 2014.[12] Furthermore, the role of home health in reducing readmission and ED is difficult to tease out, not only because of selection bias, but also because of the variation of services and personal delivered by home health agencies.[13] Rural HHAs tend to be understaffed and under-resourced,[14] potentially leading to a greater acute or post-acute spending, but this study is unable to make this conclusion in light of selection bias. In order to better understand the role of home health use on reducing preventable readmissions, ED use, and Medicare expenditures, further research is needed that addresses selection bias in the use of home health.

This study has implications that are relevant to both policy makers and providers. These findings provide some evidence on what contributes to a successful care transition for beneficiaries with multiple co-morbidities (MCC), as opposed to single diagnosis groups such as those with COPD or Heart Failure. Recent work attempts to rethink how care is delivered to individuals with MCC.[15] There is a growing movement away from a single-condition paradigm in thinking about what treatment regimens and guidelines, and towards thinking about the multiple levels of complexity inherent in caring for patients with multiple co-morbidities. The finding that early follow-up care reduces the risk of 60-day readmission among those with multiple co-morbidities is important for understanding successful models of care for those with MCC. An early follow-up visit may help with medication reconciliation or ensure communication between patient, caregivers, and the provider, key areas in which individuals with MCC are frequently challenged.[15] Thus early follow-up with 14-days care can not only, on average, reduce the risk of 30- and 60-day readmission, but receiving follow-up within 7-days post-discharge may be especially important for beneficiaries with MCC. Additionally, targeting high-cost beneficiaries for post-discharge follow-up care may reduce the 75th percentile and 90th percentile of 30-day Medicare expenditures by $5,953 and $50,000, respectively. Understanding who high-cost beneficiaries are will be important for hospitals and providers. Previous hospitalizations and number of co-morbidities are frequently used to target Medicare beneficiaries for transitional care interventions.[16] However, this sample of Medicare beneficiaries are healthier relative to other samples,[17] and is conditioned on having no hospitalizations for 60-days prior to the index admission. As such, future research should focus on identifying beneficiaries at risk for high-cost utilization, even among relatively healthy Medicare beneficiaries.

The Centers for Medicare and Medicaid Services (CMS) is currently examining episode based payment designs as a way to encourage coordination of post-acute services across providers. Part B services, including physician follow-up services are being considered as potentially included in the bundled payment[18]. In this context, policy makers and providers should pay special attention to interventions that target high-risk or high cost groups during a post-discharge episode. Indeed, the average 30-day total hospital costs for the most common chronic conditions range from $9,442 to $14,610.[19] Targeting post-discharge resources toward high-cost patients within these disease categories could reduce hospital costs and Medicare expenditures. For providers participating in a bundled payment arrangement, this may be an advantageous approach. On the other hand, early follow-up care for low-cost or low-risk patients may not be advantageous. Insuring early follow-up care for low-cost patients may only add to the cost of care, while not delivering any benefits in terms of reduced acute and post-acute services. Understanding the differential impact of early follow-up care across low-cost and high-cost beneficiaries may be important for rural providers in making decisions on where to devote limited post-discharge resources.

Findings from this study may also highlight some areas in which rural providers can control costs post-discharge. Indeed, many rural providers face financial pressures from reduced Disproportionate Share Payments, HRRP penalties, pay-for-performance payments and penalties, and low-volume.[20] Evidence from *Aim 1* suggests that rural beneficiaries may be substituting their primary care for an ED visit during a post-acute period. Recent work has also pointed to this kind of utilization, mainly because of shorter wait times and more convenient access to the ED.[5] Ensuring an early follow-up visit post-discharge may address this issue, reducing provider costs associated with unnecessary ED use, and Medicare expenditures for high-cost patients. However, it is not enough to recommend that follow-up care should be improved in rural settings. Indeed, it is important to consider and address the barriers to improving access to early follow-up care for rural providers.

Access to early follow-up care is a problem for rural beneficiaries. Yet, with some exceptions, receiving early follow-up care offers similar benefits in terms of reduced risk of 30-day and 60-day readmission, mortality, and expenditures for high-cost patients. In this context, policy makers considering payment and delivery system designs within Accountable Care Organizations, bundled payment programs, or other value based purchasing arrangements should pay special attention to providers serving rural beneficiaries. Policy-level and provider level efforts to support increased access to early follow-up care in rural settings may be appropriate. Some studies suggest tele-health management can play an important role in reducing readmission.[21, 22] Continuing or enhancing Medicare reimbursements for tele-health services in rural settings may be appropriate to helping insure rural beneficiaries have access to follow-up services post-discharge. Additionally, under the ACA, physicians and non-physicians are given a 10% bonus for engaging in primary care activities. While it is unclear whether this policy has affected use and outcomes for rural beneficiaries, continuing financial incentives for non-physicians engaged in primary care activities may be important to improving post-discharge outcomes in rural areas. As physician assistants and nurse practitioners are key to outpatient care in rural areas,[23] policies that address the salary gap between specialist, primary care physicians, and non-physicians providing primary care may be important.[24] Finally, ACOs that include providers serving rural beneficiaries may consider investing in effort to reduce barriers to care, such as transportation programs, mobile units, or extending clinic hours to the weekend.[25]

Alternatives to penalizing or rewarding hospitals on their readmission rates may be warranted. Previous research already points to low-volume and safety net hospitals as being disproportionately penalized relative to larger hospitals, of whom may have greater capacity to engage in post-discharge quality improvements.[26] Indeed, recent qualitative work confirms that lack of hospital resources to engage in post-discharge quality improvement activities is a key barrier to meeting readmission targets..[20] Rural hospitals face similar economic challenges, as evidenced by an unprecedented increase in hospital closures in the past 3 years.[27] Some alternative strategies include stratifying by socio-economic status, or measuring relative improvements in rates as opposed to comparing to national rates. MedPac recently described how stratifying by hospitals with a similar socio-economic mix of patients may help to reduce disparities in penalties across hospitals.[28] Although some work suggests little absolute difference in 30-day readmission between rural and urban hospitals, these differences become more pronounced at longer post-discharge periods.[29] As such, further analysis that includes stratification by low-volume or hospitals located in small or isolated rural settings can be helpful in understanding better strategies to penalize/award hospitals without disproportionately impacting hospitals with limited resources. Moreover, direct investments or grants to hospitals to improve post-discharge care, case management services, or engagement with community resources and independent outpatient providers, has been considered in other settings, and may be appropriate for rural providers.[20, 28, 30]

Finally, despite null findings on the relationship between home health and 30- and 60-day outcomes, post-acute home health care may still have the potential to play a key role in helping hospitals reduce post-acute readmissions and ED use. Many successful transitional care models include home health services as a key element.[8] As ACOs and post-acute bundled payment programs are introduced, HHAs are positioned to play an important role in facilitating coordination of care across ‘siloed’ acute and post-acute providers.[31] As mentioned above, future research is needed that address selection bias in the use of home health.

This study has several limitations. First, as discussed above, instrumental variables were not used to control for selection bias in the home health treatment variable. As such, the findings on the effect of home health on expenditures are most likely biased. That is, sicker beneficiaries may be more likely to be discharged with home health relative to being discharged without home health. This relationship would have a positive bias on both the utilization and cost dependent variables, suggesting home health is associated with greater utilization and expenditures. While previous work have found valid IVs for functional outcomes,[32] none to my knowledge have utilized IVs for home health on acute and post-acute utilization and expenditures. Further work is needed to develop methods to address unobserved selection bias in the role of home health on post-discharge outcomes.

Second, our conclusions on 14-day follow-up and readmission, ED use, are based off the non-IV logistic regressions and may be biased. Indeed, endogeneity tests have low-power to reject the null hypothesis of exogeniety.[33] Weak instruments may exacerbate this problem, and while our instruments passed the standard tests for strength, the large coefficients on the 2SRI marginal effects for readmission and ED use suggest the instruments may still be weak, or there is finite sample bias where the IV coefficients are biased in the same direction as the non-IV estimates.

Third, Aim 3 results do not report that early follow-up care reduces Medicare expenditures for the average beneficiary. Rather, the quantile regression results report the effect of follow-up care on the conditional distribution of the dependent variable. That is, the reported effects only pertain to beneficiaries within the conditional distribution (i.e. 10th percentile, 25th percentile, etc..). Further, it is unclear who low-cost and high-cost beneficiaries may be, making it difficult for providers to target for intervention. How providers are able to identify low-cost and high-cost beneficiaries in determining post-discharge follow-up care requires further research.

Finally, the IV results in both *Aim 2* and *Aim 3* refer to the marginal, not the average, beneficiary. That is, the results pertain to those beneficiaries who would receive follow-up care if they lived near to the discharging hospitals, and would not receive follow-up if they lived farther away. Thus, these results are not generalizable to the average Medicare beneficiary.

Post – hospital care transitions have become a major policy focus because of its high cost to Medicare and the potentially enormous consequence to the health of the patient. This study sought to better understand post-hospital discharge outcomes and costs among rural beneficiaries, and whether early follow-up care and home health makes a difference. This study found that rural beneficiaries fare worse during a post-acute period, but that with some exceptions early follow-up care offers similar benefits to rural and urban beneficiaries. Hospitals and providers should focus on targeting post-discharge resources towards beneficiaries discharged home with multiple co-morbidities, or who have a predicted high level of post-discharge expenditures. Policy makers and providers should consider efforts to improve access to early follow-up care for rural Medicare beneficiaries.

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