Event Analysis of All-Cause and Ambulatory Care Sensitive Hospitalization of Long-Stay Nursing Home Residents

Final Report, Nursing Home Resident Beneficiaries, for CMS Contract No. HHSM-500-2005-000201/T.O. 0001: Adverse Events Among Chronically Ill Beneficiaries: Variations by Geographic Area, Organization of Practice, and LTC Setting

Submitted To

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Abstract

The free-standing nursing home is the setting for ambulatory medical care for Medicare beneficiaries who are long-stay residents. About three-quarters of these long-stay beneficiaries have one or more chronic conditions. To gain insight into factors associated with more effective care for chronic illness, the study used event (survival) analysis to analyze the relationship between nursing home characteristics and the risk of all-cause hospitalization and hospitalization for ambulatory care sensitive (ACS) conditions for long-stay nursing home residents with and without specific chronic illness diagnoses.

Study Design: Time to event for two types of hospitalization was modeled as a function of resident, nursing home, market area and state policy factors. ACS hospitalization was defined according to an expanded definition adapted to the nursing home setting. The event analysis approach enabled appropriate treatment of censoring by death, discharge and observation time, including left-censoring for long-stay residents in hospital at the start of observation. The multivariate models estimated the impact of nursing home characteristics, including staffing, on length of time to hospitalization while adjusting for individual beneficiary characteristics, most importantly health and disability status.

Population Studied: Medicare Aged beneficiaries with and without identified chronic illness who were long-stay (> 3 months) residents of freestanding nursing homes. Using MDS data, 74,279 beneficiaries were identified as long-stay residents as of 1/1/2000 in the Medicare 5% sample. 54,250 lived in free-standing nursing homes that could be matched from OSCAR files. 75.2% of long-stay beneficiaries had a chronic illness diagnosis.

Principal Findings: Nursing home and area characteristics (ownership, staffing by type, any special care unit, nurse aide training in the home, Medicaid rate, state bed hold policy, hospital beds per elder) were significant predictors of time to all-cause and ACS hospitalization

for long-stay residents even after accounting for individual health and other characteristics. Greater registered nurse (RN) hours per resident day were protective against risk of adverse event; each additional hour of RN staff time increased time to hospitalization by a factor of 1.24 for all-cause hospitalization and by 1.29 for ACS hospitalization. Nursing assistant (NA) hours per resident day were not significantly associated with time to either type of hospitalization. Nonprofit ownership was protective against hospitalization, lengthening time to event. Time to both types of hospitalization was greater if the state paid higher Medicaid rates or did not have a policy of paying for beds while Medicaid residents are hospitalized.

Conclusions: The analysis uses a novel approach (event analysis) that corroborates findings of previous research concerning the impact of nursing home resources (RN staffing, Medicaid rate), orientation (ownership, proportion Medicare, special care units) and environment (bed hold policy, hospital bed availability) on hospitalization of long-stay residents. A definition of ACS hospitalization for nursing home residents is proposed that combines features of previous definitions, but findings are not highly sensitive to the definition employed.

Implications for Policy, Delivery or Practice: The nursing home is the setting for chronic illness care for the Medicare beneficiaries who live there. Nursing home RN staffing and services may be significantly associated with the risk of adverse events for long-stay residents, suggesting that care for beneficiaries with chronic illness may be improved by increasing certain nursing home care resources.

1. Introduction

1.1 Overview: The Nursing Home as a Setting for Chronic Illness Care

The nursing home is the setting of care for a substantial number of Aged Medicare beneficiaries, many with chronic conditions. In 2004, for example, approximately 1.3 million persons aged 65 and older were counted as nursing home residents by the National Nursing Home Survey (National Center for Health Statistics 2008). On any given day, many of these beneficiaries are receiving intensive rehabilitative and other post-acute care services to address an acute illness or injury, and will soon transition to other settings of care. However, a large fraction of those observed in nursing homes are long-stay residents, who live permanently in nursing homes.

Long-stay nursing home care is not directed toward treating acute or chronic illness but instead is accessed to address functional limitations associated with physical and/or cognitive disabilities that are due to illness or injury. This separation of health services from functional disability services is reflected in public and private insurance systems, which make a distinction between health services and long-term services and supports for functional disability. Nevertheless, nursing home residents need and receive acute and chronic health services, services that would be called ambulatory care if received by community residents. Physicians visit nursing home residents to monitor their health status and manage chronic and episodic illness; therapy services are available in the nursing home if needed and paid for; and the nursing home provides nursing services to manage beneficiaries' chronic illness care, through medication administration and skilled nursing treatment as needed. When feasible, nursing home residents travel out to specialty services, for example dental and medical specialty care, as they would if

they were living in the community. The nursing home thus is the setting for ambulatory care for its long-stay residents, even though long-term care services are required because of functional disability rather than health services needs. In ideal circumstances, the nursing home, with the potential for around-the-clock nursing monitoring of beneficiaries' condition and access to physician services, should serve as a setting for ambulatory care that reduces the exacerbation of chronic illness.

However, circumstances in nursing homes are not always ideal. Just as there are concerns about breakdowns of ambulatory care for chronically ill community-resident beneficiaries, there are concerns about the effectiveness of ambulatory care for nursing home residents with chronic illness. Such challenges may be especially salient for three aspects of care. First, the beneficiary's physician may or may not be available for unscheduled visits to the home when the beneficiary needs medical assessment or treatment,[1] and nursing home practices may facilitate or hinder access to physician services and implementation of physician orders. Second, nursing homes where nursing care resources are stretched to the limit likely find it difficult to carry out physician orders and otherwise treat a resident experiencing an exacerbation of a chronic illness. Third, low quality of long-term care services, provided to address functional disability,

[1] Nursing homes do not supply physician services as part of their service, although they may recommend physicians to their residents so that many residents are under the care of the same physician. Physician services for Medicare beneficiaries who are nursing home residents are covered under Medicare Part B, and the beneficiary is expected to choose his/her own physician; this choice is often made with the assistance of the nursing home (Levy, Palat and Kramer 2007).

may cause or exacerbate medical problems, for example pressure ulcers and urinary tract infections.

Considered as a site of ambulatory care, the nursing home is an important component of the nation's care for Aged Medicare beneficiaries with chronic illness. In this study sample representing 5% of the long-stay (3+ months) nursing home residents living in non-hospital-based nursing homes on January 1, 2000 (defined fully below), 75.2% had one or more chronic conditions as defined by the Adjusted Clinical Groups (ACG) method (see Section 3.5.1 and Appendix Exhibit 1). [2] Community-resident Medicare beneficiaries with these chronic conditions were being cared for in hospitals, in post-acute care beds and with community-based ambulatory care; using these same definitions of chronic illness, it is estimated that these long-stay nursing home residents (3.1% of Aged Medicare beneficiaries) represent 10.8% of Aged Medicare beneficiaries

[2] Chronic conditions have been defined in many ways in recent literature. One of the objectives for this project as requested by the Centers for Medicare and Medicaid Services was to gain information on Medicare Aged beneficiaries with chronic conditions using the Chronic Conditions Warehouse (CCW) data source, which uses a carefully developed definition of chronic condition (Centers for Medicare and Medicaid Services 2010). As described in the report, the CCW identifiers for chronic conditions could not be used because many require two or three years of prior observation on each beneficiary, and the project was based on CY 2000 data, for which only one prior year was available. Chronic conditions are therefore identified here using ACG definitions and methods (Johns Hopkins University 2010).

with congestive heart failure, 8.7% of the beneficiaries with chronic kidney disease, 13.8% of those with stroke, and 6.1% of those with diabetes.[3]

Hospitalization rates for persons with chronic conditions have been used by others as an indicator of the effectiveness of ambulatory care. Because some hospitalizations are appropriate and inevitable as acute illness develops, hospitalization measures have been further refined to focus on so-called ambulatory-care sensitive (ACS) conditions. This approach can be applied to the ambulatory care functions of the nursing home setting: the all-cause hospitalization risk may be a marker for the effectiveness of the nursing home as a setting for chronic illness care, and may be further refined to estimate a nursing home analog for ACS hospitalization risk. Hospitalizations that could be avoided with better nursing home care represent potential cost savings to Medicare as well as missed opportunities for better quality of care for residents.

This study sought to build knowledge about variations in the quality of care for chronic illness provided in nursing homes by using the hospitalizations and ambulatory care-sensitive hospitalizations experienced by nursing home residents as markers for adequacy of the nursing home as a setting of ambulatory care. This study's focus was on the impact of the availability of nursing resources (nursing hours per resident day) and other nursing home characteristics on the risk of these adverse events. Specifically, it addressed the following three research questions:

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[3] Source: authors' computations from CCW files; see Appendix Exhibit 1: Proportion of Aged Beneficiaries Identified with Selected CCW Chronic Conditions, 5% Medicare Beneficiaries

1. What is the impact of nursing home characteristics on time to all-cause hospitalization, after beneficiary and location-related characteristics have been accounted for?

2. What hospitalization diagnoses are likely to represent conditions sensitive to nursing home care, so that they can be used as a nursing home analog for ambulatory care sensitive conditions?

3. What is the impact of nursing home characteristics on time to hospitalization for a nursing home analog of ambulatory care sensitive conditions, after beneficiary and location-related characteristics have been accounted for?

Previous studies of the rate or risk of hospitalization of nursing home residents have not been able to account appropriately for competing risks: long-stay nursing home residents may die before they are ever hospitalized, for example, so the risk of hospitalization may not be well modeled by a rate measuring hospitalizations per unit time. To deal with this, a novel approach is used here: the analysis identifies long-stay nursing home residents at a point in time and uses event (survival) analysis to identify the impact of nursing home and beneficiary covariates on time to an adverse event for long-stay nursing home residents with and without specific chronic illness diagnoses.

1.2 Plan of the Report

The report begins with a brief review of the literature on the impact of organization level factors on hospitalization of nursing home residents. Next the analytical strategy, study sample, data sources and variable construction are presented in the methods section, along with a discussion of alternative definitions of ambulatory care sensitive (ACS) hospitalization for the nursing home setting. Results of the statistical analyses are presented in three sections: the first presents descriptive statistics on hospitalizations and factors hypothesized to affect hospitalizations by type; the second presents multivariate analyses examining factors associated with time to hospitalization for long-stay nursing home residents; and the third presents similar multivariate analyses

for factors associated with time to ACS hospitalization. The report concludes with a discussion of the findings.

2. Background: Hospitalizations and Nursing Homes

A number of studies have shown that variation in risk of hospitalization for nursing home residents is not entirely due to resident health status and other personal characteristics and that nursing home attributes also play a role. The evidence suggests that residents in non-profit nursing homes are at decreased risk and those in for-profit nursing homes are at greater risk (Murtaugh and Freiman 1995; Zimmerman, Gruber-Baldini, Hebel, Sloane et al. 2002; Carter 2003a; Carter 2003b; Carter and Porell 2003; Intrator, Zinn and Mor 2004; Carter and Porell 2006; Gozalo and Miller 2007; Intrator, Grabowski, Zinn, Schleinitz et al. 2007). Several studies have also shown risk to be greater for residents of nursing homes affiliated with a corporate chain (Zimmerman, Gruber-Baldini, Hebel, Sloane et al. 2002; Intrator, Grabowski, Zinn, Schleinitz et al. 2007). Size also appears to be related to hospitalization rates, with residents in larger nursing homes at a decreased risk (Carter 2003a; Carter 2003b; Carter and Porell 2003; Carter and Porell 2006; Intrator, Grabowski, Zinn, Schleinitz et al. 2007), although Intrator and colleagues found that nursing homes with fewer than 100 beds were associated with a decreased risk for hospitalizations (Intrator, Zinn and Mor 2004).[4] A separate study led by the same first author found that nursing occupancy rates were also associated with hospitalization, where residents in nursing homes with 95% or more of

[4]This association was only marginally significant.

their beds occupied had lower odds of being hospitalized (Intrator, Grabowski, Zinn, Schleinitz et al. 2007).

Nursing home payer mix has also been hypothesized to affect hospitalization rates, as different payment rates may result in incentives to send residents to the hospital. Past research has found some association of hospitalization with payer mix, although the evidence is not entirely consistent. In several studies Carter and colleagues found that higher proportions of Medicaid paid days was associated with increased risk for hospitalization (Carter 2003a; Carter 2003b; Carter and Porell 2003; Carter and Porell 2006). Several studies also found that higher proportions of Medicare paid days decreased the likelihood of residents' hospitalization (Carter 2003a; Carter 2003b; Carter and Porell 2003). Other studies have found that residents in nursing homes with higher proportions of private pay residents were at decreased risk of hospitalization (Intrator, Zinn and Mor 2004; Gozalo and Miller 2007; Intrator, Grabowski, Zinn, Schleinitz et al. 2007).

Although less frequently examined, nursing home racial composition has also been associated with variation in hospitalizations. Gozalo and Miller found that residents in nursing homes with higher proportions of non-Whites faced greater risk of hospitalization (Gozalo and Miller 2007). Similarly, Gruneir and colleagues found that nursing homes with higher proportions of Black elders resulted in increased odds of hospitalization for their residents (Gruneir, Miller, Feng, Intrator et al. 2008). In that study, nursing homes were placed into quartiles based on the proportion of residents identified as Black. The study showed that not only did nursing homes with more Black

residents have higher hospitalization odds, but that the magnitude of the effect was systematically larger for nursing homes in the higher percent-Black quartiles.

Nursing home staffing has also been associated with hospitalization, although the directions of the relationships are not always clear. The focus of these studies is on nursing department staffing (registered nurses, licensed practical nurses and nursing assistants). Two studies by Intrator and colleagues found that risk of hospitalization increased with higher nurse-to-bed or nurse-to-resident ratios (Intrator and Mor 2004; Intrator, Zinn and Mor 2004), but a separate study led by the same researcher found that nursing staff hours per resident day above the amount recommended by an expert review panel (4.55 nursing staff hours per resident day) decreased risk (Intrator, Grabowski, Zinn, Schleinitz et al. 2007).[5] In contrast, a comprehensive study conducted by Abt Associates for CMS suggests that there is a staffing level threshold such that risk of resident hospitalization (as indicated by membership in the lowest-performing decile of facilities for hospitalization of short stay residents) decreases as staffing approaches the threshold from below and does not decrease as staffing levels increase above the threshold, i.e. there are no incremental gains in this measure of quality for staffing above the threshold (Centers for Medicare and Medicaid Services 2002). This same report found that retention and nursing wages were associated with reduced risk of being in the lowest-performing decile of facilities.

[5] This staffing level was recommended by a panel that was convened in 1998 to review the literature on staffing and quality (Harrington, Kovner, Mezey, Kayser-Jones et al. 2000).

There is some evidence that supports the hypothesis that better registered nurse (RN) staffing is associated with fewer hospitalizations. In two studies, Intrator found that higher proportions of registered nurses (RNs) to total nursing decreased risk (Intrator, Zinn and Mor 2004; Intrator, Grabowski, Zinn, Schleinitz et al. 2007). Similarly, Carter and Porell found that probability of being hospitalized was lower when a higher proportion of facility nursing staff expenses were associated with RN staffing (Carter and Porell 2006). Another study found that while RN staffing had no effect on the risk of being hospitalized in general, more RNs per beds was associated with lower odds of an ambulatory care sensitive hospitalization (Carter 2003b). Higher RN turnover has also been associated with increased risk (Zimmerman, Gruber-Baldini, Hebel, Sloane et al. 2002). Carter and Porell have shown in several studies that hospitalization risk increases as the proportion of total expenses that are related to LPNs grows (Carter 2003a; Carter 2003b; Carter and Porell 2003; Carter and Porell 2006).

Findings concerning the relationship between Certified Nursing Assistants (CNAs) or aides and hospitalization are less consistent. One study found that risk of ambulatory care sensitive hospitalization increased when CNAs comprised a greater proportion of total nursing staff (Intrator, Zinn and Mor 2004). But two other studies found no relationship (Intrator, Castle and Mor 1999; Zimmerman, Gruber-Baldini, Hebel, Sloane et al. 2002). One study by Intrator and colleagues found that having an aide training program onsite decreased risk of both ambulatory care sensitive and all-cause hospitalizations (Intrator, Zinn and Mor 2004). The authors speculate that the presence of an onsite aide training program, which represents an investment in the

education and training of a nursing home's direct care staff, may be a marker for their commitment to quality.

The effect of physician staffing on risk of hospitalization is also unclear. Physicians are generally not employed by nursing homes, but some nursing homes use a closed staff model (employed physicians treat and bill residents) or employ a part time medical director. Several studies have found that paid physicians on staff decrease risk (Intrator, Castle and Mor 1999; Intrator and Mor 2004), but another study found that risk of all and ambulatory care sensitive hospitalizations was greater for residents in nursing homes with more than one-half FTE physician (Intrator, Zinn and Mor 2004). The evidence thus far suggests that nurse practitioner and physician assistant staffing decreases risk of hospitalization (Intrator, Castle and Mor 1999; Intrator and Mor 2004; Intrator, Zinn and Mor 2004; Intrator, Grabowski, Zinn, Schleinitz et al. 2007).

3. Methods and Data

3.1 Analytic Model

Based on the literature, the current study hypothesizes that a nursing home resident's risk of hospitalization is affected by individual health status, aspects of the nursing home as a setting of ambulatory care, accessibility of hospital beds, and practices and policies that vary by locale. Similarly, it hypothesizes that risk of ambulatory care sensitive (ACS) hospitalization (a subset of all-cause hospitalization) is affected by the same factors, but is more closely tied to factors that reflect the effectiveness of care.

(1) Time to hospitalization = f (health status, NH characteristics, hospital beds, policy)

These hypothetical models were implemented using event analysis, commonly called survival analysis because it was developed to model survival time to death as the

event of interest. The times and events of interest in the present case are, first, time to first hospitalization and second, time to first ACS hospitalization (even if preceded by a non-ACS hospitalization). For each outcome, time to first event in 2000 is modeled as a function of beneficiary characteristics and health status for 1999, nursing home characteristics, location variables, and policy variables for 2000.

An important strength of event analysis is that censored observations can contribute information to the analysis. The analysis approach can account for both right-censoring and left-censoring. Right-censoring occurs when the event of interest did not happen during the observation period prior to the censoring event. For example, if a nursing home resident lived in the nursing home for 200 days in 2000 without a hospital admission, this is useful information that should be included in the analysis even if the resident died or left the nursing home at 200 days. If a resident remains without a hospitalization throughout the entire year, the observation is censored at 365: the analysts can at least say that the event did not happen for 365 days. For the analyses using the year 2000 time window, death or discharge during 2000 and survival to the end of 2000 (December 31, 2000) without a hospitalization represent censoring events.

Observations are considered "left-censored" if they are a legitimate part of the sample but are not eligible for the event of interest. In typical event analyses, left-censoring is applied when a one-time event is known to have occurred prior to the observation period; for example, a study of smoking risk for an adolescent population may need to account for the fact that some members of the population may have started smoking prior to adolescence before the study observation period begins. These individuals must be included in the study because they are part of the population, but they

are entered as left-censored – the information that some individuals began smoking prior to the observation age for the study can be included in the estimation. In the current study, observations were considered left-censored for the hospital admission and ACS hospital admission analyses when a nursing home resident was experiencing a hospital stay or ACS hospital stay (respectively) at the start of observation, on January 1, 2000. These nursing home residents experiencing left-censoring must be considered part of the long-stay nursing home resident cohort but were not eligible to experience a first hospital admission (or first ACS hospital admission) at the start of the observation period.

For the two types of hospitalization (all-cause, ACS), the time to event analysis uses multivariate maximum likelihood estimation to model the (natural log of) time to event, which produces estimates of relative risk for the occurrence of the event of interest. The SAS procedure Proc Lifereg was used to estimate parametric regression models with the censored survival data. It was necessary to use this technique rather than Cox proportional hazard regression because of the existence of left-censored observations.

This study used the prior year (1999) as a baseline period for identifying resident health status. Time to hospitalization was counted from January 1, 2000, and the hospitalization outcomes were observed over a one-year observational period, from January 1, 2000 through December 31, 2000. Thus time to hospitalization could be as short as one day and as long as 365 days.[6]

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[6] The initial plan for the study was to model time to hospitalization over a three-year observation period (January 1, 2000 through December 31, 2002) and to use two shorter observation periods (one year

3.2 Data Sources

The analysis used data from the Chronic Condition Warehouse (CCW) claims files from 1999-2002 for a 5% sample of Medicare beneficiaries. The CCW includes ambulatory, inpatient and assessment data with a unique person-level key that allows linking of data for each beneficiary across these files. For this study, Minimum Data Set (MDS) assessments were used to identify long-stay nursing home residents. Residents are required to have an assessment upon admission, annually thereafter (with reviews every quarter), and whenever there is a substantial change in health status (including at readmission after a hospital stay) (Research Data Assistance Center 2010). The assessment data were used to determine which beneficiaries were continuing nursing home residents and how long they had been living in a nursing home. Once a long-stay group was identified, the CCW unique identifier was used to pull all of their inpatient and ambulatory care claims.

To identify nursing home characteristics, an extract of the Online Survey Certification and Reporting (OSCAR) data set was purchased.[7] OSCAR is derived from mandated periodic state surveys of certified nursing homes. Nursing homes are surveyed

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and two years) for sensitivity analyses. These analyses tested whether baseline covariates (for 1999) became less predictive of outcomes for the longer time windows. These analyses revealed that the 12-month time window was substantially better for estimating effects on time to event; the effects of the independent variables measured at baseline attenuated when longer periods were used. Time to event is necessarily censored by the end of the observation period for more of the beneficiaries when the one-year period is used; these beneficiaries did not have a hospitalization until year 2 or year 3. However, the models for the 12-month time window is preferred and is presented here.

[7] The OSCAR data set was prepared by the Cowles Research Group.

approximately annually, with a lag that can be as much as 14 to 15 months. The data request was for the facility survey for each nursing home that was closest to January 1, 2000. This information was linked to beneficiaries using facility identifiers in the MDS record.

Finally, to determine characteristics of the nursing home's market area, a small number of variables from the Area Resource File (ARF) were constructed. In particular, hospital supply factors (hospital beds per person) were of interest. Several other variables associated with nursing home demand and supply (proportion elders in poverty, elders as a percent of population, nursing home beds per person aged 65 and older) were used.

3.3 Study Sample

Approximately 74,000 beneficiaries aged 65 and older in the CCW 5% sample were observed on MDS assessments to have resided in the nursing home for at least 90 days prior to January 1, 2000. This was the long-stay nursing home resident cohort. Health status and beneficiary characteristic variables were determined from 1999 Medicare claims

To construct variables reflecting nursing home and market area characteristics, data from OSCAR and ARF were merged onto the core file of long-stay beneficiaries. The nursing home of residence for 85% of the long-stay beneficiaries could be matched from the OSCAR file; the remaining 15% were dropped from all nursing home analyses. Their nursing homes may have closed prior to or opened after the OSCAR survey capture date. All residents residing in hospital-owned nursing homes were dropped from the sample because these institutions are quite different from free-standing independent

nursing homes. Dropping beneficiaries in hospital-owned nursing homes left a final sample of 55,240 beneficiaries. Further observations were removed from the multivariate analyses due to missing or extreme observations for certain nursing home variables.[8]

3.4 Dependent Variable Definitions and Development

3.4.1 **Dependent Variable: Time to First All-Cause Hospitalization**

The admission dates for all admissions occurring in the year 2000 were examined and the time from January 1 to the first admission of the year became the dependent variable, time to first hospitalization. As detailed above, observations were considered left-censored if the beneficiary was in the hospital on January 1 and right-censored if he or she died, left the nursing home, or reached December 31, 2000 without a hospital admission. In the case of right censoring, the values for observed time without hospitalization were, respectively, time to death, time to nursing home discharge, or time to the end of the year (365).

3.4.2 **Dependent Variable: Time to First ASC Hospitalization**

Defining ASC Hospitalization for Nursing Homes. Over the past decade there has been growing attention directed toward avoiding hospitalizations as a way to reduce healthcare expenditures. This work is in part grounded in research from the 1980s that sought to develop better risk adjustment methods for capitation payments (Anderson and Steinberg 1984; Ellis 1995). In a 1988 report to the Health Care Financing Administration, Ellis and Ash (1988) recommended categorizing hospitalization

[8] Nursing home staffing data was considered misreported if total hours per resident day were less than one or greater than 9.5, at the upper and lower 1% cut points for the distribution of non-hospital-based nursing homes on the OSCAR file.

diagnoses by level of physician discretion, which had been defined using a survey of physicians about this issue. This was done as a way to improve risk adjustment, but the concept has been extended to other areas of research, including studies of variation in health services quality and access.

Building on this work, attempts have been made to identify conditions for which hospitalizations can be avoided. However, conditions vary from study to study. In 1990, Billings and Teicholz were the first to use avoidable hospitalizations as a marker for poor access to effective primary care (Billings and Teicholz 1990). Subsequent work defined a set of ACS conditions for which hospitalization could be avoided among the non-elderly population (Billings, Zeitel, Lukomnik, Carey et al. 1993). This list includes the following conditions: congenital syphilis, immunization-related conditions, severe ear, nose and throat infections, chronic obstructive pulmonary disease (COPD), diabetes, convulsions, gastroenteritis, asthma, congestive heart failure, angina, bacterial pneumonia, tuberculosis, hypertension, cellulitis, hypoglycemia, kidney or urinary tract infections, dehydration-volume depletion, iron deficiency anemia, nutritional deficiencies, failure to thrive, pelvic inflammatory disease, and certain dental conditions. This list is widely used and has been adapted to define avoidable hospitalizations for seniors (Kane, Homyak, Bershadsky, Lum et al. 2005). However, this definition has not been validated, and others have recommended a different list of diagnoses. The Agency for Healthcare Research and Quality (AHRQ), for example, uses a set of 14 conditions, including perforated appendicitis, hypertension, and adult asthma (Friedman and Basu 2004; Agency for Healthcare Research and Quality 2010). Research further suggests that

ACS hospitalizations are actually population- and context-specific (Blustein, Hanson and Shea 1998; Roos, Walld, Uhanova and Bond 2005; Chang and Pope 2009).

Although the Billings and AHRQ lists are valuable, there was reluctance to use them for the current analysis because they were developed for the general population rather than for the aged specifically. There have been efforts to define and monitor avoidable hospitalizations for the aged population. Several of these definitions, in addition to the ones discussed previously, were reviewed in the context of the present study as candidates for nursing home resident ACS conditions. Carter (2003) used a list of ACS conditions in a study of nursing home resident hospitalizations. Although this list is similar to the one used by Billings, it also includes failure to thrive and excludes bacterial pneumonia and congestive heart failure.

Two lists that were developed specifically for elders were also reviewed for this study. In a report to CMS, McCall and colleagues created a list of conditions for which hospitalization can be avoided for an aged Medicare population (McCall 2004). This list was generated by examining definitions used in prior studies and vetting candidate conditions through physician review. For the current study, the original list of 24 was pared down to a final list of 11 conditions. These conditions include: asthma, cellulitis, chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), dehydration, acute diabetic events (including ketoacidosis, hypoglycemia, hyperosmolality), lower limb peripheral vascular disease in beneficiaries with diabetes, pneumonia, septicemia, stroke and urinary tract infection (UTI).

In unpublished documents, Andrew Kramer has proposed using an alternative, condensed list of conditions to identify potentially avoidable hospitalizations for nursing

home residents (Centers for Medicare and Medicaid Services 2009, p.7 footnote 4 and Q&A p. 6 and 7, Question 28). These conditions are CHF, electrolyte imbalance, respiratory infection (acute bronchitis, pneumonia, influenza and pneumonitus), sepsis, UTI and anemia. Hospitalizations due to these conditions are considered preventable if a resident is receiving effective care in the nursing home setting.

Although the Kramer list has an advantage in that it was developed for nursing home residents, it was decided that this list was not sufficiently inclusive. Because nursing home residents receive their primary care within the nursing home, a nursing home care sensitive conditions list should include conditions for which effective primary care can avert hospitalizations. For example, good primary care in the nursing home should reduce hospitalizations for acute events related to manageable chronic conditions like diabetes and asthma. Thus it was decided to use both the McCall and Kramer lists (separately and combined) to conduct several analyses to better understand rates of hospitalization and how these rates change using different definitions of ACS hospitalizations.

3.5 Independent Variable Definitions and Development

The variables used in the analysis capture beneficiary characteristics and nursing home characteristics, including characteristics of the market environment of the nursing home, that have been shown to be associated with hospitalizations from the nursing home.

3.5.1 **Beneficiary Characteristics**

A number of beneficiary characteristics were derived from the last MDS assessment prior to January 1, 2000. The indicators for the presence of chronic illness

were derived from Medicare claims for 1999. A definition of each variable is provided below.

Payment status: A beneficiary's primary payer can change over time. After considering many different ways to define payer, information from the beneficiary's last MDS assessment (prior to January 1, 2000) was used. Multiple payers are often reported on the MDS. In particular, residents receiving Medicaid-paid nursing home care must contribute almost all of their income toward their care, and so both Medicaid and private pay are listed as payment sources. The hypothesis being tested with this variable concerns whether risk of hospitalization is different for residents whose care is paid for at the Medicaid rate, either because this rate is almost always lower than private price or due to state policies that pay to hold a Medicaid resident's bed open while he or she is hospitalized. The Medicaid payer indicator variable was set equal to one if Medicaid was a payer, which implies that the resident was paid for at the Medicaid rate set by the state. The private pay indicator was set to one only if the last MDS form reported that the resident's stay was paid for with private funds and Medicaid was *not* a payer.

Chronic condition indicators: A series of chronic condition indicators were calculated using the ACG software (Johns Hopkins University 2010). The ACG method uses as input each individual's inpatient and ambulatory diagnoses for one year, here 1999. The output for the ACG process is a series of condition indicators based on the diagnostic profile. A comparison of some aspects of the ACG method to the CCW method is presented in Appendix Exhibit 2.

Frailty indicator: The frailty indicator signals the presence of specific diagnosis profiles that are consistent with frailty according to the ACG approach. It was also created by the ACG software.

Demographics: The demographic data used for this analysis include age, sex, and race from the Medicare Denominator File. Age was represented as a continuous variable, in years, and also by the square of age in years, to support estimation of any nonlinear effects of age. Sex was included as an indicator variable set equal to one for female, zero otherwise. The race indicators on the Denominator File were collapsed into an indicator variable equal to one if White race, zero otherwise.

ADL Score: Performance on Activities of Daily Living (ADLs) is used to measure functional status for persons with disability. The original six ADLs (measuring need for personal or mechanical assistance with bathing, dressing, feeding oneself, toileting, transferring and mobility inside (Katz and Ford 1963)) have been refined and further specified in many studies of functional status. Functional items collected in the MDS are adapted from the long research tradition that has built on the ADL concept and its measurement. Morris and colleagues used the MDS items to develop a functional scale that has been reproduced for this analysis (Morris, Fries and Morris 1999). The scale is based on four functional items (personal hygiene, toileting, locomotion and eating) and the associated level of assistance they require to perform each activity (independent, supervised, limited assistance, extensive assistance and total dependence). Scoring for the scale is shown in Exhibit 1. For the analyses, several versions of this variable (e.g. scale, indicator 0/1 variable truncated at different points) were tested. Ultimately an indicator variable was defined that is set to 1 when the resident had a score

of 4, 5 or 6 (categorized as "Extensive 2," "Dependent" or "Total" dependence as detailed in the right-most column of Exhibit 1) and zero if the score was 0 to 3 ("Independent," "Supervision," "Limited" or "Extensive 1" in Exhibit 1) was used.

Exhibit 1: Activities of Daily Living (ADL) Score

ADL Level	Score	Category
Independent in all 4 ADLs	0	Independent
At least supervision in one ADL; less than limited assistance in all four ADLs	1	Supervision
Limited assistance in one ADL and less than extensive assistance in all ADLs	2	Limited
At least extensive assistance in personal hygiene or toileting; less than extensive assistance in eating and locomotion	3	Extensive 1
Extensive assistance in eating or locomotion, but not total dependence in either of these two	4	Extensive 2
Total dependence in eating and/or locomotion	5	Dependent
Total dependence in all four ADLs	6	Total dependence

Source: Developed by authors from Morris, Fries and Morris (1999).

Cognitive impairment: To capture cognitive impairment, an indicator variable for dementia as reported on the MDS was created.

Hospitalizations in the past year: Recent health services use is generally an excellent marker for severity of individual illness. Indicator variables for the number of hospitalizations the beneficiary experienced in the past year (1, 2, 3, 4+; 0 is the omitted case) were included in some of the models. However, residents of nursing homes that are more likely to hospitalize their residents will have higher values for recent hospitalization, so this is not strictly an individual characteristic.

3.5.2 **Nursing Home Characteristics**

Ownership: Nursing home ownership was characterized as nonprofit, government, or multi-enterprise for-profit chain; the omitted category was independent for-profit. A

simple indicator of chain ownership was not used, because nursing homes belonging to nonprofit multi-enterprise groups would be included in this designation. They appear to have different objectives from the for-profit corporate chains.

If a nursing home was identified in OSCAR as hospital-based, residents were not included in the analysis. Hospital-based nursing homes tend to serve more short-stay Medicare patients and differ in other unmeasured ways from long-stay residential nursing homes.

Size, Services: Variables to indicate size (beds, residents at the time of the OSCAR survey) and payer mix (proportion Medicare) were developed from OSCAR data. [9] The OSCAR survey form requests information about the presence of nine types of special care units: for care of HIV-AIDS, Alzheimer's disease, dialysis, disabled children/young adults, head trauma, Huntington's disease, hospice, ventilator/respiratory care, other specialized rehabilitation. The special care unit indicator variable was set to one (otherwise 0) if the nursing home reported any special care unit.

Staff hours: Variables indicating staff hours per resident day were based on OSCAR reports of full-time, part-time and contract staff. Measures of hours provided per resident day were constructed using approaches that have become standard in the literature. Specifically, total hours for each nursing type (registered nurses, licensed practical nurses and nursing assistants) were computed as the number of full-time workers times a 35 hour week plus the number of part-time workers times 17.5 hours per

[9] Size indicators were ultimately not used in the multivariate analyses, but are reported in the descriptive statistics.

week plus the number of contract hours, divided by the days in the time period to obtain hours available at the nursing home on an average day, which was then divided by the number of residents to arrive at hours per resident day. Total nursing department hours per resident day were also computed. In addition, variables were developed to indicate the presence on the staff of physician extenders, whether physician assistants or nurse practitioners.

In the most common model of physician services delivery in the nursing home, residents receive physician services from their designated physicians, who are paid by the patient and his or her insurance rather than by the nursing home for this care (open staffing). However, some nursing homes employ physicians and bill for their services (closed staff model) (Levy, Palat and Kramer 2007). Nursing homes with a closed staff model or with a medical director providing substantial paid hours might be expected to provide more timely access to medical advice. An indicator variable was developed to capture greater physician presence in the nursing home, set equal to one if a physician was on staff for more than 17.5 hours per week, otherwise zero (Intrator, Zinn and Mor 2004).

Two variables capture characteristics of the nursing home's resident mix. First is the proportion of residents with "do not resuscitate" (DNR) orders. Second is the proportion of residents whose care is paid for by Medicare. Both of these are computed from OSCAR data.

3.5.3 **Market Factors**

Two county level variables were included in the models to control for factors that prior research has shown to be associated with hospitalizations. These were hospital beds

per person residing in the county and the county proportion of elders aged 65 and older living below the federal poverty limit. Both of these variables were obtained from the Area Resource File. Two additional county variables were considered for inclusion in the model, and are reported in the descriptive statistics: nursing home beds per county resident aged 65 and older, and physicians per county resident.

3.5.4 **State Policies**

The models included two policy variables that have been shown to affect hospitalization of nursing home residents. First is a variable indicating whether the state had any form of a bed hold policy in place, whereby a state agrees to pay for some portion of the per diem Medicaid rate should a resident be transferred to a hospital. The second variable is the state's per diem Medicaid payment rate. Both of these variables were taken from a study published by Intrator and colleagues (Intrator, Schleinitz, Grabowski, Zinn et al. 2009).

4. Results

4.1 Description of Long-Stay Cohort

4.1.1 **Outcomes: Time to First All-cause Hospitalization, Time to First ACS Hospitalization**

The proportions of the long-stay nursing home residents who experienced each outcome (an all-cause hospitalization, an ACS hospitalization) or were censored, by type of censoring, are presented in Exhibit 2, along with time to event for each type of event. ACS hospitalization was determined based on the primary diagnosis for each inpatient stay during the year (refer to the Appendix: Alternative Definitions, Appendix Exhibit 3 for a detailed list of conditions). This Exhibit includes in the ACS column residents who

have experienced *any* type of ACS hospitalization, i.e. those included in either the McCall or Kramer definition or in both. As discussed further below, the McCall and Kramer definitions each exclude about the same number of beneficiaries in the sample, so results are not very different for the two definitions.

Exhibit 2: Outcomes, Long-stay Nursing Home Residents, 2000

Characteristics of Outcomes	First Hospital Admission	First ACS Admission
Proportion experiencing event	0.299	0.172
Proportion died without event (right censored)	0.156	0.201
Proportion survived to 12/31/2000, no event (right censored)	0.530	0.619
Proportion in hospital (all-cause and ACS) 1/1/2000 (left censored)	0.014	0.008
Time to event, if experienced, mean days	141.02	143.64
Time to event, if experienced, standard deviation	107.41	107.96
Time to death, if died without event, mean	154.09	160.03
Time to death, if died without event, standard deviation	112.72	112.21
N= 54250		

Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR matched data.

The all-cause and ACS hospitalization analyses are separate analyses: if a beneficiary's first ACS admission occurs after a non-ACS hospitalization, that beneficiary contributes an elapsed time (from January 1 to first hospitalization) to one analysis and a (longer) elapsed time (also from January 1 to first ACS hospitalization) to the other analysis. If a beneficiary's first hospitalization of the year is an ACS hospitalization, he or she is shown as having experienced the event of interest in both analyses, with identical time to event. Because ACS hospitalizations are a subset of

hospitalizations, fewer beneficiaries experienced any ACS admission, and by the same token more beneficiaries died or reached the end of the observation period without experiencing an ACS admission.

4.1.2 **Independent Variables: Factors Affecting Time to Hospitalization**

Descriptive statistics for the analytic study group for all independent variables used in the analysis are shown in Exhibit 3.

Exhibit 3: Descriptive Statistics for Analytic Sample, Long-Stay Nursing Home Residents

Variable Name	Mean[†]	Standard Deviation	Minimum	Maximum
Nursing Home Characteristics				
Nonprofit ownership[‡]	0.257	0.437	0	1
Government ownership[‡]	0.060	0.238	0	1
For-profit chain ownership[‡]	0.461	0.498	0	1
RN hours per resident day	0.342	0.243	0	4.168
LPN hours per resident day	0.654	0.322	0	7.385
Nursing assistant (NA) hours per resident day	1.979	0.584	0	8.131
Any special care unit	0.296	0.457	0	1
NA training program	0.403	0.491	0	1
Proportion residents with "do not resuscitate" (DNR) orders	0.616	0.262	0	1
Any physician extender hours	0.233	0.423	0	1
Proportion residents paid for by Medicare	0.086	0.086	0	1
County and State Characteristics				
State bed-hold policy	0.829	0.376	0	1
State average Medicaid rate	109.938	22.668	66.57	160.660
Hospital beds per person, county	0.029	0.022	0	0.490
Proportion in poverty, population aged 65+, county	0.093	0.041	0.017799	0.388
Resident Characteristics				
Female	0.797	0.402	0	1
Age	84.275	7.762	65	100
Age squared	7162.5	1293.9	4225	10000
White race	0.878	0.328	0	1
Frailty	0.466	0.499	0	1
Congestive heart failure	0.345	0.475	0	1
Chronic obstructive pulmonary disease	0.206	0.404	0	1
Renal failure	0.062	0.242	0	1
Depression	0.265	0.441	0	1
Diabetes	0.261	0.439	0	1
Hypertension	0.543	0.498	0	1
Ischemic heart disease	0.337	0.473	0	1
Asthma	0.040	0.197	0	1
Dementia	0.428	0.495	0	1

Variable Name	Mean†	Standard Deviation	Minimum	Maximum
ADL Index = 4, 5 or 6	0.549	0.498	0	1
Last MDS reported payment by Medicaid	0.610	0.488	0	1
Last MDS reported private payment, no Medicaid	0.251	0.434	0	1
1 hospitalization in 1999	0.186	0.389	0	1
2 hospitalizations in 1999	0.087	0.282	0	1
3 hospitalizations in 1999	0.044	0.206	0	1
4+ hospitalizations in 1999	0.047	0.212	0	1
Additional Nursing Home and County Characteristics				
RN hours as a proportion of licensed nursing hours	0.343	0.193	0	1
Total residents	131.977	89.683	6	898
Total beds	151.187	96.688	13	908
Occupancy rate	0.872	0.124	0.301	1.092
Nursing home beds per person aged 65+, county	0.055	0.024	0	0.933
Physicians per person, county	0.002	0.002	0	0.020

N= 54250

Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR

†Mean values for indicator (0-1) variables represent the proportion of sample members with the characteristic.

‡As noted in the text, the omitted case for the ownership indicator variables is for-profit independent (non chain) ownership.

A large majority (75.2%) of long-stay nursing home residents who are Aged Medicare beneficiaries have at least one of the 21 chronic conditions identified using the ACG method (Exhibit 4).

Exhibit 4: Percent Long-stay Nursing Home Residents with One or More Chronic Conditions, 2000

Number of Conditions	Number of Beneficiaries	Percent
0	18,417	24.8%
1	14,059	18.9%
2	14,773	19.9%
3	12,036	16.2%
4+	14,994	20.2%
TOTAL	74,279	100.0%

Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR matched data.

4.1.3 **Descriptive Analysis of ACS Hospitalization Definitions**

An important task for the descriptive analysis of time to ambulatory care sensitive (ACS) hospitalization is to explore the impact of alternative definitions for ACS hospitalizations. The definitions developed by McCall and Kramer each identify hospitalizations of nursing home residents that may be preventable, with somewhat different underlying logic (refer to Section 3.4.2, Dependent Variable: Time to First ASC Hospitalization). The McCall definition was developed for community-resident populations, while the Kramer definition focuses on problems that are associated with poor nursing home care. Although Kramer and McCall cover many similar conditions, each has defined a unique set of ICD-9 codes that they deem to be care-sensitive (see Appendix Section 7 for discussion and a detailed list of diagnosis codes). As a result, the same event may qualify as a care sensitive hospitalization under one definition but not the other.

The data for the long-stay nursing home cohort for 2000 revealed substantial overlap between the groups of beneficiaries identified by the McCall and the Kramer definitions of ACS hospitalization (Exhibit 5). Sixty-five percent of beneficiaries with a care sensitive hospitalization identified by either definition meet both definitions. The McCall definition picks up an additional 18 percent (or 2,063 long-stay nursing home residents) who are not identified as having an ACS hospitalization under the Kramer definition. Similarly, Kramer picks up 16.5 percent or an additional 1,877 beneficiaries.

Exhibit 5: Distribution of Long-Stay Nursing Home Resident Beneficiaries by ACS Status, Kramer and McCall Definitions

ACS Definition	McCall (No)	McCall (Yes)	TOTAL
Kramer (No)	--	2,063	--
Kramer (Yes)	1,877	7,409	9,286
TOTAL	--	9,472	11,349[†]

Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR matched data.

Descriptive statistics were computed for the independent variables in order to compare the characteristics of the two groups, those experiencing a McCall-defined ACS hospitalization during 2000, and those experiencing a Kramer-defined ACS hospitalization (Exhibit 6). These two groups of beneficiaries overlap, as noted above, and look quite similar in terms of both beneficiary characteristics and characteristics of the nursing homes in which they reside. In fact, for most descriptors, including chronic condition indicators, the two groups are within one percentage point of each other. The similarity across the nursing home characteristics suggests certain types of nursing homes are not more likely to have beneficiaries with either a McCall or Kramer ACS condition. This either means the two concepts (ambulatory care sensitive and nursing home

sensitive hospitalizations) are interrelated or that the Kramer definition is not effectively picking up issues unique to nursing home care.

Exhibit 6: Characteristics of Beneficiaries with ACS Hospitalizations, Alternative ACS Definitions

	McCall		Kramer	
Variable Name	**Number**	**Percent**	**Number**	**Percent**
Nonprofit ownership‡	1660	20.61%	1721	21.51%
Government ownership‡	411	5.10%	398	4.98%
For-profit chain ownership‡	4022	49.93%	3939	49.24%
RN hours per resident day	0.32	---	0.32	---
LPN hours per resident day	0.67	---	0.68	---
Nursing assistant (NA) hours per resident day	1.94	---	1.95	---
Any special care unit	2063	25.61%	2058	25.73%
NA training program	3067	38.07%	3039	37.99%
Proportion residents with DNR orders	4604	57.15%	4570	57.13%
Any physician extender hours	1763	21.88%	1801	22.51%
Proportion residents paid for by Medicare	747	9.27%	727	9.09%
State bed hold policy	6735	83.60%	6677	83.46%
State average Medicaid rate	108.07	---	108.07	---
Hospital beds per person, county	0.03	---	0.03	---
Proportion in poverty, population aged 65+, county	0.10	---	0.10	---
Female	6106	75.79%	5932	74.15%
Age	83.62	---	83.90	---
Age squared	7051.83	---	7097.27	---
White race	6773	84.07%	6734	84.18%
Frailty	4580	56.85%	4569	57.11%
Asthma	561	6.96%	492	6.15%
Congestive heart failure	4033	50.06%	3932	49.15%
Chronic obstructive pulmonary disease	2574	31.95%	2406	30.08%
Renal failure	846	10.50%	823	10.29%
Depression	2589	32.14%	2502	31.28%
Diabetes	3029	37.60%	2865	35.81%
Hypertension	5397	66.99%	5257	65.71%
Ischemic heart disease	3791	47.06%	3722	46.53%
Dementia	3362	41.73%	3455	43.19%

	McCall		Kramer	
Variable Name	**Number**	**Percent**	**Number**	**Percent**
ADL Index = 4 , 5 or 6	4550	56.48%	4753	59.41%
Last MDS reported payment by Medicaid	4798	59.56%	4787	59.84%
Last MDS reported private payment, no Medicaid	1661	20.62%	1672	20.90%

‡As noted in the text, the omitted case for the ownership indicator variables is for-profit independent (non chain) ownership.

Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR matched data.

4.2 Multivariate Analysis: Factors Associated with Time to All-Cause Hospitalization

Descriptive statistics for long-stay residents experiencing each outcome during 2000 (hospitalized, all cause; died; survived to the end of the year; in hospital on January 1, 2000) reveal that long-stay residents who experienced a hospitalization during the year 2000 differed in a variety of ways from residents who did not, who either survived through the year without a hospitalization or died without going into the hospital (presented in full in Appendix Exhibit 4). Nursing home residents who were hospitalized in 2000 were more likely to be in for-profit chain nursing homes, more likely to reside in a nursing home with fewer registered nurse and nursing assistant hours per resident day, less likely to be female and more likely to have a chronic illness diagnosis.

The estimated coefficients for two models regressing the log of time to event on the resident, nursing home, market area and state policy variables are presented in Exhibit 7. Model 1 includes resident characteristics and nursing home characteristics, including location and state policy variables. Model 2 adds indicator variables for the number of

hospitalizations in the previous year (one, two, three, four or more; none is the omitted case). Models including only resident-specific variables and only nursing home specific variables (including market area characteristics) are shown in Appendix Exhibit 5. A model including state fixed effects (omitting the two state-specific variables, Medicaid rate and bed hold policy) is presented in Appendix Exhibit 6.

Exhibit 7: Estimated Models, Time to All-Cause Hospitalization for Long-Stay Nursing Home Residents

	Model 1			Model 2: Including Prior Hospitalization		
Variable Name	**Estimated Coefficient**	**Standard Error**	**Significance**	**Estimated Coefficient**	**Standard Error**	**Significance**
Intercept	9.6494	1.0652	<.0001	9.7813	1.0534	<.0001
Nursing Home Characteristics						
Nonprofit ownership‡	0.1283	0.0336	0.0001	0.1096	0.0332	0.0010
Government ownership‡	0.1608	0.0544	0.0031	0.1508	0.0538	0.0050
For-profit chain ownership‡	0.0396	0.0286	0.1665	0.0342	0.0283	0.2267
RN hours per resident day	0.2134	0.0515	<.0001	0.2200	0.0507	<.0001
LPN hours per resident day	-0.0994	0.0333	0.0028	-0.0952	0.0331	0.0041
Nursing assistant (NA) hours per resident day	0.013	0.0202	0.5209	0.0178	0.0200	0.3736
Any special care unit	0.0989	0.0258	0.0001	0.0963	0.0255	0.0002
NA training program	0.0712	0.023	0.002	0.0739	0.0227	0.0012
Proportion residents with DNR orders	0.3201	0.045	<.0001	0.3186	0.0445	0.0000
Any physician extender hours	0.0586	0.0268	0.0288	0.0405	0.0265	0.1270
Proportion residents paid for by Medicare	-0.65	0.1256	<.0001	-0.4563	0.1252	0.0003
County and State Characteristics						
State bed hold policy	-0.1347	0.0305	<.0001	-0.1050	0.0302	0.0005
State average Medicaid rate	0.0056	0.0005	<.0001	0.0041	0.0005	<.0001
Hospital beds per person, county	-1.0855	0.4621	0.0188	-0.9737	0.4588	0.0338
Proportion in poverty, population aged 65+, county	-1.948	0.2688	<.0001	-1.7223	0.2661	<.0001
Resident Characteristics						<.0001
Female	0.2764	0.0269	<.0001	0.2464	0.0266	<.0001
Age	-0.0681	0.0258	0.0083	-0.0572	0.0255	0.0249
Age squared	0.0004	0.0002	0.005	0.0003	0.0002	0.0264
White race	0.1185	0.0332	0.0004	0.1152	0.0328	0.0005
Frailty	-0.406	0.0234	<.0001	-0.2232	0.0238	<.0001
Congestive heart failure	-0.4529	0.0244	<.0001	-0.3276	0.0244	<.0001
Chronic obstructive pulmonary disease	-0.4317	0.0264	<.0001	-0.2777	0.0264	<.0001

	Model 1			Model 2: Including Prior Hospitalization		
Variable Name	**Estimated Coefficient**	**Standard Error**	**Significance**	**Estimated Coefficient**	**Standard Error**	**Significance**
Renal failure	-0.4483	0.0383	<.0001	-0.2893	0.0382	<.0001
Depression	-0.2133	0.0244	<.0001	-0.1332	0.0242	<.0001
Diabetes	-0.347	0.0245	<.0001	-0.3024	0.0243	<.0001
Hypertension	-0.3467	0.0248	<.0001	-0.2002	0.0250	<.0001
Ischemic heart disease	-0.3841	0.0244	<.0001	-0.2316	0.0246	<.0001
Asthma	-0.2634	0.0478	<.0001	-0.1393	0.0474	0.0033
Dementia	0.0623	0.0228	0.0062	0.0689	0.0226	0.0022
ADL Index = 4 , 5 or 6	-0.0562	0.0226	0.0129	-0.0156	0.0224	0.4876
Last MDS reported payment by Medicaid	0.3025	0.0301	<.0001	-0.0695	0.0314	0.0269
Last MDS reported private payment, no Medicaid	0.3323	0.0361	<.0001	0.0782	0.0361	0.0302
1 hospitalization in 1999				-0.6396	0.0304	<.0001
2 hospitalizations in 1999				-0.9493	0.0384	<.0001
3 hospitalizations in 1999				-1.0754	0.0477	<.0001
4+ hospitalizations in 1999				-1.4432	0.0471	<.0001
Scale	1.4388	0.0104		1.4848	0.0109	
Weibull Shape	0.695	0.005		0.6735	0.0049	
-2 Log Likelihood	109363			108127		

‡As noted in the text, the omitted case for the ownership indicator variables is for-profit independent (non chain) ownership.

Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR matched data.

Note: A positive coefficient indicates a protective effect against hospitalization – longer time to first hospitalization and a negative coefficient indicates an increase in risk – shorter time to first hospitalization.

Overall, the model supports many of the hypotheses about factors that affect hospitalization risk. The coefficients indicate that many of the identified factors have highly statistically significant impacts, either risk-reducing or risk-increasing, on time to

hospitalization for long-stay residents. Tests for significance of the model parameters as a group, using test statistics based on two times the log likelihood (Appendix Exhibit 7), rejected the hypothesis that estimated coefficients were zero for these models.

Interpreting the coefficients. Exhibit 8 shows the impact of each variable as a multiplier for the time to first hospitalization for a long-stay resident with that characteristic in comparison to one without it (for an indicator variable) or for a one-unit increase (for a continuous variable). The coefficients for this type of time-to-event analysis show the estimated multiplicative impact of each factor. For example, the estimated coefficient for nonprofit ownership in the full model is .128; this means that for a beneficiary with any characteristics, time to hospitalization is multiplied by $e^{1*.128}$ = 1.137 if he or she resides in a nonprofit nursing home and by $e^{0*.128}$ = 1 if he or she does not. This indicates that time to first hospitalization, other things constant, is on average 13.7% longer in nonprofit homes than in the omitted ownership type, independent for-profit; thus nonprofit ownership has a protective effect. To generalize, time to hospitalization for residents with a given characteristic is e^b times that for residents without it, where b is the estimated coefficient for that characteristic

Although the prior year hospitalization variables added significantly to model explanatory power, concerns about endogeneity suggest that more will be learned from a model excluding past hospitalizations, which are presumably generated by the same nursing home processes last year as they are in the current year, as well as by beneficiary health status. Therefore the focus of the remaining discussion is on Model 1, which includes resident characteristics and excludes past year hospitalization and also includes variables for two state policy characteristics rather than state fixed effects (which would

capture all state variation, including policy differences, but would preclude identification of policy impacts).

Exhibit 8: Estimated Multiplicative Impact of Independent Variables, Time to All-Cause Hospitalization, Model 1

Variable Name	Estimated Coefficient	Estimated Impact of One Unit Increase Multiplies Risk By:	
Intercept	9.649		
Nursing Home Characteristics			
Nonprofit ownership‡	0.128	1.137	
Government ownership‡	0.161	1.174	
For-profit chain ownership‡	0.040	1.040	ns
RN hours per resident day	0.213	1.238	
LPN hours per resident day	-0.099	0.905	
Nursing assistant (NA) hours per resident day	0.013	1.013	ns
Any special care unit	0.099	1.104	
NA training program	0.071	1.074	
Proportion residents with DNR orders	0.320	1.377	
Any physician extender hours	0.059	1.060	
Proportion residents paid for by Medicare	-0.650	0.522	
County and State Characteristics			
State bed hold policy	-0.135	0.874	
State average Medicaid rate	0.006	1.006	
Hospital beds per population, county	-1.086	0.338	
Proportion in poverty, population aged 65+, county	-1.948	0.143	
Resident Characteristics			
Female	0.276	1.318	
Age	-0.068	0.934	
Age squared	0.000	1.000	
White race	0.119	1.126	
Frailty	-0.406	0.666	
Congestive heart failure	-0.453	0.636	
Chronic obstructive pulmonary disease	-0.432	0.649	
Renal failure	-0.448	0.639	

Variable Name	Estimated Coefficient	Estimated Impact of One Unit Increase Multiplies Risk By:	
Depression	-0.213	0.808	
Diabetes	-0.347	0.707	
Hypertension	-0.347	0.707	
Ischemic heart disease	-0.384	0.681	
Asthma	-0.263	0.768	
Dementia	0.062	1.064	
ADL Index = 4, 5 or 6	-0.056	0.945	
Last MDS reported payment by Medicaid	0.303	1.353	
Last MDS reported private payment, no Medicaid	0.332	1.394	

‡As noted in the text, the omitted case for the ownership indicator variables is for-profit independent (non chain) ownership.

Note: All coefficients significant at .05 or better, except as indicated by ns (not significant)

Note: A positive coefficient indicates a protective effect against hospitalization – longer time to first hospitalization and a negative coefficient indicates an increase in risk – shorter time to first hospitalization. The impact for each factor is computed as $e^{coefficient}$ and shows a multiplier for time to first hospitalization; a multiplier less than one indicates that the factor reduces time to first hospitalization (increases risk) and a multiplier greater than one indicates that the factor increases time to first hospitalization (reduces risk). Any coefficient with a significance level better than .05 generates a multiplier with a 5% confidence interval that does not include 1.00.

Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR matched data.

4.2.1 Impact of Resident Characteristics on All-Cause Hospitalization

As expected, resident characteristics are comparatively effective in explaining variation in the time to hospitalization. (Readers interested in the ability of resident characteristics alone to predict hospitalization risk may refer to Appendix Exhibit 7; reduction from the null case in -2 log likelihood is much greater for the resident variables

alone than for the nursing home characteristics alone). As shown in Exhibits 7 and 8, and consistent with previous studies, women are significantly less likely to be hospitalized (time to admission is significantly longer). The inclusion of the quadratic age term allows age to have a changing effect on time to hospitalization; hospitalization risk increases with increasing age to age 85, after which it is estimated to decline with each additional year of age. Residents identified as White on their MDS assessments have a time to admission, other things constant, approximately 12.6% greater than those who are not identified as White.

All but one of the chronic condition indicators have a large negative effect on time to hospitalization, indicating a shorter time to first hospitalization (and thus increased risk of hospitalization), with diabetes, hypertension, and asthma having somewhat smaller negative effects. In contrast, dementia is significantly protective against hospitalization, increasing the time to hospitalization by approximately 6%, other things constant. Frailty (based on medical diagnosis) has a much larger negative impact on time to hospitalization (multiplier for time to hospitalization is .67, i.e. time to hospitalization is 33 percent shorter with frailty than without it) than poor functional status (multiplier for time to hospitalization is .95, i.e. time to hospitalization is 5% shorter with poor functional status than without it). Both Medicaid and private-pay residents (as identified on their most recent MDS) have a longer time to hospitalization (multipliers for time to hospitalization are 1.35 and 1.39 respectively) than residents in the omitted category, those paid for by other sources, mostly Medicare.

4.2.2 Impact of Nursing Home Characteristics on All-Cause Hospitalization

The nursing home and market area factors also affect time to hospitalization (Exhibits 7 and 8). Time to hospital admission is 14% longer for long-stay residents in nonprofit homes, other factors constant, than in the omitted ownership type, independent for-profit; government nursing homes also provide a protective effect against hospitalization in comparison to their for-profit counterparts. Time to hospitalization is not significantly different in for-profit chain nursing homes than in the remaining ownership category, for-profit independent nursing homes. With respect to nursing staff hours, it appears that registered nurse hours per resident day are highly effective in reducing the risk of hospital admission, with each additional quarter hour of nurse staffing lengthening time to hospitalization by about 5.4%.[10] More LPN hours per resident day are associated with significantly greater risk of hospitalization, consistent with previous literature. Nursing assistant hours per resident day are not significantly associated with hospital admission risk. The presence of physician extenders (nurse practitioners or physician assistants) on the nursing home staff provides a protective effect. Experiments with reported physician hours, both in total (presence of a half time physician, presence of a half time medical director) and per resident day (physician hours

[10] The estimated coefficient implies that an additional hour of RN time per resident day would increase time to hospitalization by 23.8%; however, RN staffing averages .342 hours for the sample, with a standard deviation of .243 hours. It is unlikely that many nursing homes would increase RN staffing by an hour per resident day, so the estimate provided per quarter hour represents the effect of a large but more feasible increase.

per resident day) did not uncover any relationship between these variables and time to hospitalization (results not shown).

Nursing homes providing special care units appear to protect residents from hospital admission, as do those that provide on-site training for nursing assistants. The reported proportion of residents with "do not resuscitate" (DNR) orders is strongly associated with longer time to hospital admission, other things constant, while a higher proportion of Medicare patients in the nursing home's patient population is associated with shorter time to hospital admission.

Residents of nursing homes in areas with more hospital beds are likely to be hospitalized sooner, as shown by the negative coefficient estimated for hospital beds per person. Poverty among elders in the county also had a large and significant negative effect on time to hospitalization. Another variable of interest, nursing home beds per thousand elders, did not have a significant effect on hospitalization risk (results not shown).

The state Medicaid payment rate, included as an indicator of the resources available for care for Medicaid residents, was positively associated with time to hospitalization: a one dollar increase in the state Medicaid rate is associated with a .6% increase in time to hospitalization, suggesting that a $10 increase would yield a 5.8% increase in time to hospital admission (reduction in hospitalization risk).[11] Finally, a state policy to pay to hold beds for Medicaid residents admitted to the hospital is associated with a greater risk of hospitalization, other things constant.

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[11] Computed as $1.006^{10} = 1.0576$

4.3 Multivariate Analysis: Time to Ambulatory Care Sensitive Hospitalization

4.3.1 **Model of Time to ACS Hospitalization**

Analysis of time to ACS hospitalization was carried out using three definitions: McCall, Kramer and a combination of the two. Because of their substantial practical overlap (despite differing approaches), the union of the McCall and Kramer definitions increases the number identified by only 19.8% over the McCall definition and only 22.2% over the Kramer definition (refer to Exhibit 5). The multivariate analyses were substantially similar for the three definitions, strongly suggesting that the same factors increase the risk of an ACS hospitalization regardless of fine differences in definitions. As a result, this report presents analysis of the time to event for an ACS hospitalization that meets *either* definition, McCall and Kramer. Note that 65.3% of these beneficiaries are identified as having an ACS hospitalization using *both* definitions.

The estimated coefficients for two models regressing the log of time to first ACS hospitalization on the resident, nursing home, market area and state policy variables are presented in Exhibit 9. Model 1 includes resident characteristics and nursing home characteristics, including location and state policy variables. Model 2 adds indicator variables for the number of hospitalizations in the previous year (one, two, three, four or more; none is the omitted case). Models including only resident-specific variables and only nursing home specific variables (including market area characteristics) are shown in Appendix Exhibit 8. A model with state fixed effects was also estimated (results not included).

Exhibit 9: Estimated Models, Time to ACS Hospitalization for Long-Stay Nursing Home Residents

	Model 1			Model 2: Including Prior Hospitalization		
Variable Name	**Estimated Coefficients**	**Standard Error**	**Significance**	**Estimated Coefficients**	**Standard Error**	**Significance**
Intercept	12.9141	1.456	<.0001	13.2451	1.4476	0.0000
Nursing Home Characteristics						
Nonprofit ownership‡	0.2396	0.046	<.0001	0.2160	0.0457	0.0000
Government ownership‡	0.2517	0.075	0.0008	0.2382	0.0745	0.0014
For-profit chain ownership‡	0.0387	0.0382	0.31	0.0317	0.0379	0.4040
RN hours per resident day	0.2568	0.0697	0.0002	0.2702	0.0690	0.0001
LPN hours per resident day	-0.1331	0.0439	0.002	-0.1285	0.0438	0.0034
Nursing assistant (NA) hours per resident day	0.0212	0.0273	0.44	0.0252	0.0272	0.3550
Any special care unit	0.1013	0.0352	0.004	0.0989	0.0350	0.0047
NA training program	0.0897	0.0312	0.004	0.0927	0.0310	0.0028
Proportion residents with DNR orders	0.4438	0.0607	<.0001	0.4367	0.0604	0.0000
Any physician extender hours	0.0647	0.0364	0.07	0.0461	0.0361	0.2014
Proportion residents paid for by Medicare	-0.7823	0.1665	<.0001	-0.5937	0.1666	0.0004
County and State Characteristics						
State bed hold policy	-0.1553	0.0413	0.0002	-0.1228	0.0410	0.0027

	Model 1			Model 2: Including Prior Hospitalization		
Variable Name	**Estimated Coefficients**	**Standard Error**	**Significance**	**Estimated Coefficients**	**Standard Error**	**Significance**
State average Medicaid rate	0.0067	0.0007	<.0001	0.0050	0.0007	0.0000
Hospital beds per person, county	-0.8414	0.6336	0.18	-0.7624	0.6339	0.2291
Proportion in poverty, population aged 65+, county	-2.9706	0.3518	<.0001	-2.7443	0.3500	0.0000
Resident Characteristics						
Female	0.3967	0.036	<.0001	0.3668	0.0357	0.0000
Age	-0.1122	0.0352	0.001	-0.1044	0.0350	0.0028
Age squared	0.0007	0.0002	0.002	0.0006	0.0002	0.0063
White race	0.1025	0.0441	0.02	0.0950	0.0438	0.0302
Frailty	-0.3893	0.0318	<.0001	-0.1933	0.0324	0.0000
Asthma	-0.3507	0.0617	<.0001	-0.4716	0.0332	0.0000
Congestive heart failure	-0.6044	0.0331	<.0001	-0.3982	0.0352	0.0000
Chronic obstructive pulmonary disease	-0.5594	0.0351	<.0001	-0.2429	0.0504	0.0000
Renal failure	-0.402	0.0504	<.0001	-0.0257	0.0331	0.4369
Depression	-0.107	0.0332	0.001	-0.3861	0.0327	0.0000
Diabetes	-0.4327	0.0328	<.0001	-0.1538	0.0342	0.0000
Hypertension	-0.3127	0.0338	<.0001	-0.2278	0.0333	0.0000
Ischemic heart disease	-0.3907	0.033	<.0001	-0.2239	0.0615	0.0003
Dementia	0.0088	0.0307	0.8	0.0165	0.0305	0.5901

	Model 1			Model 2: Including Prior Hospitalization		
Variable Name	**Estimated Coefficients**	**Standard Error**	**Significance**	**Estimated Coefficients**	**Standard Error**	**Significance**
ADL index = 4, 5 or 6	-0.4009	0.0311	<.0001	-0.3546	0.0309	0.0000
Last MDS reported payment by Medicaid	0.2512	0.0403	<.0001	-0.1316	0.0421	0.0018
Last MDS reported private payment, no Medicaid	0.3272	0.049	<.0001	0.0681	0.0491	0.1660
1 hospitalization in 1999				-0.7152	0.0415	0.0000
2 hospitalizations in 1999				-1.0169	0.0518	0.0000
3 hospitalizations in 1999				-1.0680	0.0641	0.0000
4+ hospitalizations in 1999				-1.5026	0.0621	0.0000
Scale	1.4764	0.0143		1.4670	0.0142	
Weibull Shape	0.6773	0.0066		0.6816	0.0066	
-2Log Likelihood	73914			73186		

‡As noted in the text, the omitted case for the ownership indicator variables is for-profit independent (non chain) ownership.

Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR matched data.

Note: A positive coefficient indicates a protective effect against hospitalization – longer time to first hospitalization; a negative coefficient indicates an increase in risk – shorter time to first hospitalization.

In general, the model is effective in explaining the variation in time to ACS hospitalization. Almost all coefficients reveal highly significant effects of the independent variables on time to ACS hospitalization for long-stay residents. Tests for significance of the model parameters as a group, using test statistics based on -2 times the log likelihood (Appendix Exhibit 9), rejected the hypothesis that estimated coefficients were zero for all three models fitted: a model using only resident-specific variables, a model using only nursing home specific variables (including market area characteristics) and a model using both types of variables.

As with the all-cause models, prior year hospitalization variables added significantly to model explanatory power, but concerns about endogeneity still suggest that more will be learned from a model excluding past hospitalizations, which are presumably generated by the same process last year as they are in the current year. Therefore the focus of the remaining discussion of ACS hospitalization is on Model 1, which includes resident characteristics except past year hospitalization and also includes variables for two state policy characteristics rather than state fixed effects.

Exhibit 10 shows the impact of each variable as a multiplier for the time to first ACS hospitalization for a long-stay resident with that characteristic in comparison to one without it (for an indicator variable) or for a one-unit increase (for a continuous variable). The impacts computed from the estimated coefficients for the ACS hospitalization analysis are remarkably similar to the impacts for all hospitalizations. This suggests (although an hypothesis of significant difference cannot be tested for different dependent variables) that the factors that affect ACS hospitalizations are not very different from the factors leading to all-cause hospitalization – i.e. that the same forces that protect against

or subject beneficiaries to greater risk of hospitalization also work on risk of ACS hospitalization as a subset of all hospitalizations for this population. In other words, ACS hospitalizations do not appear to be generated by a distinctly different process from all hospitalizations (of which they are of course a part).

Exhibit 10: Estimated Impact of Independent Variables, Time to ACS Hospitalization, Model 1

Variable Name	Estimated Coefficient	Estimated Impact of One-Unit Increase Multiplies Risk By:	Significance
Intercept	12.9141		<.0001
Nursing Home Characteristics			
Nonprofit ownership‡	0.2396	1.2707	<.0001
Government ownership‡	0.2517	1.2862	0.0008
For-profit chain ownership‡	0.0387	1.0395	0.31
RN hours per resident day	0.2568	1.2928	0.0002
LPN hours per resident day	-0.1331	0.8754	0.002
Nursing assistant (NA) hours per resident day	0.0212	1.0214	0.44
Any special care unit	0.1013	1.1066	0.004
NA training program	0.0897	1.0938	0.004
Proportion residents with DNR orders	0.4438	1.5586	<.0001
Any physician extender hours	0.0647	1.0668	0.07
Proportion residents paid for by Medicare	-0.7823	0.4574	<.0001
County and State Characteristics			
State bed hold policy	-0.1553	0.8562	0.0002
State average Medicaid rate	0.0067	1.0067	<.0001
Hospital beds per person, county	-0.8414	0.4311	0.18
Proportion in poverty, population aged 65+, county	-2.9706	0.0513	<.0001
Resident Characteristics		1.0000	<.0001
Female	0.3967	1.4869	
Age	-0.1122	0.8939	0.001
Age squared	0.0007	1.0007	0.002
White race	0.1025	1.1079	0.02
Frailty	-0.3893	0.6775	<.0001
Asthma	-0.3507	0.7042	<.0001
Congestive heart failure	-0.6044	0.5464	<.0001
Chronic obstructive pulmonary disease	-0.5594	0.5716	<.0001
Renal failure	-0.402	0.6690	<.0001
Depression	-0.107	0.8985	0.001
Diabetes	-0.4327	0.6488	<.0001
Hypertension	-0.3127	0.7315	<.0001

Variable Name	Estimated Coefficient	Estimated Impact of One-Unit Increase Multiplies Risk By:	Significance
Ischemic heart disease	-0.3907	0.6766	<.0001
Dementia	0.0088	1.0088	0.8
ADL index = 4, 5 or 6	-0.4009	0.6697	<.0001
Last MDS reported payment by Medicaid	0.2512	1.2856	<.0001
Last MDS reported private payment, no Medicaid	0.3272	1.3871	<.0001

‡As noted in the text, the omitted case for the ownership indicator variables is for-profit independent (non chain) ownership.

Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR matched data.

As with the analysis for all hospitalizations, resident characteristics are comparatively effective in explaining variation in the time to hospitalization (refer to Appendix Exhibit 9; reduction in -2 log likelihood is much greater for the resident variables alone than for the nursing home characteristics alone). The protective effect of being female appears to be greater for ACS hospitalization than for all-cause hospitalization (odds 1.48 of surviving to any given time without an ACS hospitalization, vs. 1.31 for all-cause hospitalization). ACS hospitalization risk increases with increasing age to age 80, after which it is estimated to decline with each additional year of age; this maximum-risk age is lower than the 85 years of age computed from the age coefficient estimates for all-cause hospitalization. Residents identified as White on their MDS assessments have a time to admission, other things constant, approximately 11% greater than those who are not identified as white.

The chronic condition indicators all have a large negative effect on time to ACS hospitalization. ACS hospitalizations are shown to be substantially more likely for beneficiaries with congestive heart failure, COPD and diabetes. A diagnosis of depression appears to have less effect on the odds of ACS hospitalization than it does on

the odds of all-cause hospitalization. Dementia has neither a protective nor a risk-increasing impact on ACS hospitalization; in contrast to the hospitalization analysis, the coefficient for this variable is not significant. The indicator for functional status (score of four or greater on the ADL scale) shows a shorter time to ACS hospitalization when functional status is poor; poor functional status has a greater risk-increasing impact on the risk of ACS hospitalization than it has on the risk for all-cause hospitalization. Both Medicaid and private-pay residents (as identified on their most recent MDS) have a smaller risk of ACS hospitalization than residents paid for by other sources, mostly Medicare.

4.3.2 **Impact of Nursing Home Characteristics on ACS Hospitalization**

Nursing home and market area factors also affect time to ACS hospitalization. Time to hospital admission is 27% longer for long-stay residents in nonprofit homes, other factors constant, with government nursing homes also providing a protective effect against hospitalization of similar magnitude. These effects are substantially greater than the 14% and 17% increases in time to all-cause hospitalization found in the previous analysis. Time to ACS hospitalization is not significantly different for residents of for-profit chain nursing homes from that for residents in the reference ownership category, independent for-profit nursing homes. With respect to nursing staff hours, it appears that registered nurse hours per resident day are highly effective in reducing the risk of ACS hospital admission, as they are with all-cause hospitalization. In the full model, more LPN hours per resident day are associated with significantly greater risk of ACS hospitalization and nursing assistant hours per resident day are not associated with ACS admission risk, consistent with the all-cause hospitalization analysis.

Nursing homes providing special care units appear to protect residents from ACS hospital admission, as do those which provide on-site training for nursing assistants. The reported proportion of residents with "do not resuscitate" orders is strongly associated with longer time to ACS hospital admission, other things constant, while a higher proportion of Medicare patients is associated with shorter time to ACS hospital admission, even though few of these long-stay residents are themselves Medicare-paid.

Although residents of nursing homes in areas with more hospital beds are more likely to be hospitalized, as shown by the coefficient estimated for hospital beds per population aged 65 and older in the hospital model, the coefficient for this variable is not significant at conventional levels for the ACS model. This coefficient is greater than its standard error, however, and has the expected sign (negative). The proportion of elders in poverty in the county has a large and significant effect on ACS hospitalization risk.

The state Medicaid rate, included as an indicator of the resources available for care for Medicaid residents, was positively associated with time to ACS hospitalization, and a state bed-hold policy reduced the time to an ACS hospitalization, other factors constant.

5. Discussion, Policy Implications

This research has successfully employed event (survival) models to analyze the relationship between nursing home characteristics and the risk of adverse events (all-cause hospitalization and hospitalization for ACS conditions) for long-stay nursing home residents with and without specific chronic illness diagnoses.

5.1 Summary of Findings

The findings for all-cause and ACS hospitalization exhibit consistencies across various analyses and are generally consistent with findings of previous research.

First, as expected, individual beneficiary health conditions and characteristics play a large role in explaining the use of hospital care, because the underlying health of the beneficiary is the initial risk factor for hospitalization. The presence of any of the specific chronic conditions included in the models increased the odds of an adverse event both significantly and substantially. Previous researchers have not found such powerful and consistent effects for chronic illness diagnoses, perhaps because previous methods did not support the appropriate inclusion of information about censored observations (in particular, death during the observation period). Underlying patterns of risk by age and dementia are consistent with care systems that may appropriately provide disruptive medical interventions conservatively to the oldest and most cognitively impaired nursing home residents.

Second, the concept of the nursing home as a setting for ambulatory medical care for the residents who live there is supported by these findings, to the extent that hospitalizations are indicators of less effective ambulatory care. After individual characteristics are accounted for, the nursing home is found to be an important determinant of the risk of hospitalization. A number of key nursing home variables emerged from the analyses. Of greatest interest is the role of registered nurse (RN) staffing, which appears to have a strong protective effect, in the sense that it defers both all-cause and ACS hospitalization. Many nursing homes meet state requirements for licensed nursing staff with licensed practical nurses rather than with RNs. The results

indicate that lower RN staffing (and higher LPN staffing) are associated with greater risk. This is consistent with previous studies that have found that both levels of RN staffing and RN to total nursing ratios reduce risk of hospitalization (Zimmerman, Gruber-Baldini, Hebel, Sloane et al. 2002; Carter 2003b; Intrator, Zinn and Mor 2004; Intrator, Grabowski, Zinn, Schleinitz et al. 2007)

An initial hypothesis for this study was that personal care as well as licensed nursing care would have a significant effect on adverse outcomes. The logic was that more nursing assistant hours per resident day provide greater protection against problems related to long-term functional disability (pressure ulcers, UTIs) as well as better monitoring and general care, and thus are likely associated with lower risk of hospitalization. This hypothesis was not supported: neither analysis showed a significant relationship between nursing assistant hours per resident day and hospitalization. Previous research has yielded mixed findings on the impact of aide staffing, and future analyses should consider modeling this staffing to discern possible threshold effects like those found by the Abt Associates study of nursing home staffing (Centers for Medicare and Medicaid Services 2002).

Provider characteristics reflecting the orientation of the nursing home were found to be associated with lower risk of all-cause and ACS hospitalization. Nonprofit or government ownership was associated with greatly reduced risk of hospitalization. Residents of nursing homes that provide special care services and physician extender services also have lower risks of hospitalization, after other factors are accounted for. Much previous research has presented similar findings showing that hospitalization rates are lower in non-profit nursing homes when other factors are accounted for (Zimmerman,

Gruber-Baldini, Hebel, Sloane et al. 2002; Carter 2003a; Carter 2003b; Carter and Porell 2003; Intrator, Zinn and Mor 2004; Carter and Porell 2006; Gozalo and Miller 2007; Intrator, Grabowski, Zinn, Schleinitz et al. 2007).

Another aspect of the nursing home's orientation toward care is reflected in the proportion of residents who have "do not resuscitate" (DNR) orders; where this is higher, residents were found to be less likely to be hospitalized. This is similar to findings of research investigating the presence of hospice care as an influence on practices in the nursing home for residents not directly participating in hospice (Gozalo and Miller 2007; Grabowski, Stewart, Broderick and Coots 2008). Improvement in the accuracy of reporting DNR and "do not hospitalize" orders on MDS assessments would support analysis concerning whether the impact of advance directives occurs mostly for the residents involved or has spillover effects supporting less disruptive care for all residents in a home.

The finding that Medicaid payment for a beneficiary is protective against risk of hospitalization was contrary to original hypotheses, because nursing homes are paid lower per diem rates for Medicaid residents than for private pay or Medicare post-acute patients. The Medicaid payment indicator may also be associated with residents with very long stays, long enough to spend down to Medicaid; these residents are well beyond a settling-in phase of their nursing home stay, when adverse health events may be more frequent given age and diagnosis factors. Inclusion of a variable representing length of stay prior to January 2000, not reliably available on the MDS, might have captured this effect. Further, the omitted case for the payment variables, last 1999 MDS listing Medicare (not Medicaid or private only) as the payer, may be marking a tendency to be

hospitalized.[12] It should be noted that the coefficient for Medicaid payment has the expected negative sign in models that include variables reflecting the resident's hospitalization in the prior year.

The nursing home market and regulatory environment are also important. The analyses found that higher average Medicaid rates are associated with lower risk of hospitalization; higher rates do not guarantee that more resources are available for resident care, but low rates restrict care resources. Residents of nursing homes in areas where there are more hospital beds per elderly population are more likely to be hospitalized, both in general and for ACS conditions. The current findings corroborate findings of others that a state Medicaid policy to pay for a bed vacated temporarily by a hospitalized Medicaid-paid resident increases risk of hospitalization, other things constant (Gozalo and Miller 2007; Grabowski, Stewart, Broderick and Coots 2008).

The exploration of preventable hospitalizations in the nursing home context is a contribution of this study worth pursuing further. Treating the nursing home as a setting for ambulatory medical care led to an adaptation of the definition of ambulatory care sensitive (ACS) hospitalizations for the nursing home setting. Previous research on nursing homes has transferred the concept of ACS hospitalizations from the general community; this is appropriate insofar as this concept captures hospitalizations for conditions that could have been avoided with appropriate medical care. But nursing

[12] The daily care for long-stay nursing home residents is generally paid for by Medicare as the primary payer for a number of days after they return to their (Medicare certified) nursing home from a hospitalization.

homes provide a care environment that may be able to handle some medical situations that would result in a hospitalization for a community-resident elder. In addition to the role of poor medical care, poor nursing home care can itself be the cause of adverse medical events that may then require (avoidable) hospitalization. This suggests that the definition of an ACS hospitalization for the nursing home should be both broadened, to include medical problems that nursing homes should be able to address, and made more specific, to include problems induced by poor nursing home care. One contribution of this research has thus been consideration of the implications of two previous types of ASC definitions – McCall's, developed for community-based care for older adults, and Kramer's, which, while highlighting potential shortfalls of nursing home care, also captures many McCall hospitalizations. The overlap between the two approaches is instructive, and the analyses found that the effects of individual and nursing home factors on the risk of either or both types of ASC hospitalization did not exhibit great differences.

5.2 Study Limitations

The study faced data and analytic issues that could be overcome in future research. Issues with data are almost always a challenge for empirical research, and this study is no exception. Especially notable is the difficulty in constructing measures that capture status on a particular date from MDS data. The MDS assessment items are known to vary over time for individuals, and the periodicity of the MDS assessments is not fixed. Knowing the source of payment for each resident at the start of observation (January 1, 2000) would have been preferred, but the payment indicator on the resident's last prior assessment in 1999 was the only information available; this assessment could have been conducted as long as six months prior to the observation start date. Timing

was also an issue for other measures from the MDS that are known to vary over time, including ADL status and dementia. Imprecision in OSCAR reporting is well known, and will not be further emphasized here.

Although it would have been preferable to use the chronic illness definitions used by the Chronic Condition Warehouse, the study time frame did not permit this. As noted above, the time frame was chosen to allow three years of follow up for each resident, providing a long time to observe the first hospitalization. Given the project start date, this meant beneficiaries had to be tracked starting on the first day of the year 2000, and therefore the project had data from only one calendar year (1999, the first year available in the CCW) for assessing baseline health status. Because some of the CCW chronic illness definitions require as many as three years of prior observation, the ACG grouper was used to assign chronic illness indicators. Future research should use the CCW definitions with these hospitalizations.

Any study of nursing homes and their residents uses intercorrelated variables that make it challenging to definitively assign causality to particular factors. This occurs because nursing home residents seek nursing homes that are appropriate for their care. Nursing home characteristics thus may be markers for unobserved aspects of resident case mix. Nursing home residents cannot be randomly assigned to nursing homes, so researchers must cope with these selection effects as best they can and results must be read with caution.

Several area variables were included in the current analysis to capture the market environment. While the supply of hospital beds has the expected negative relationship on time to hospitalization (where supply is greater, time to hospitalization is less), it is not

clear why the proportion of elders in poverty should be associated with shorter time to first hospitalization. This variable may be capturing unmeasured aspects of elder health status, nursing home incentives regarding Medicaid-paid residents, or something else. The supply of nursing home beds per population, which might capture variation in the proportion of the elderly population who are nursing home residents and thus unmeasured aspects of nursing home case mix, was not found to be significant and was not included in the final models. Future research could add more precise nursing home market variables by aggregating OSCAR and other data to the county or defined market level.

5.3 Directions for Future Research

The concept of care-sensitive hospitalizations should be further explored for the nursing home context. It seems logical that care sensitive hospitalizations should be more preventable and more affected by care resources than all-cause hospitalizations, which include inevitable, unpreventable adverse events. However, the initial hypothesis that the model for time to ACS hospitalization would have more explanatory power than the model for all-cause hospitalization was not supported. This suggests that the ACS definitions available to this study may not capture this underlying concept of preventable hospitalization. Further research is recommended to develop a group of Nursing Home Care Sensitive hospitalization diagnoses built up from a list of admissions diagnoses that are avoidable with good medical care in the nursing home (the ambulatory care analog the current study attempted to capture) and also good personal and functional care. The McCall and Kramer lists, even in combination, do not appear to meet this goal; and it is not sufficient to adapt lists developed for the general community-resident population. Instead, preventable adverse events that are special problems for nursing home

populations due to age, frailty, chronic condition and functional disability should be the focus. Further, such a list should identify conditions for which the nursing home system of care exercises discretion over hospitalization based on capacity strains or other situations not related to resident condition. For example, a resident experiencing a worsening chronic condition during a short-staffed holiday night shift might be sent to the emergency department and hospitalized, while a resident experiencing the same condition during a well-staffed day shift might receive appropriate care from facility nurses.[13]

A validated list of Nursing Home Care Sensitive hospitalizations could serve as a focus for quality improvement and cost containment efforts.

5.4 Implications for Policy

Concern about the cost, quality and continuity of care for elders with chronic conditions has not been focused specifically on the nursing home as a setting for chronic care. A large proportion of nursing home residents are living with serious chronic illness, and Medicare costs can be contained by managing these illnesses effectively. This study has shown that the nursing home characteristics associated with care resources (staffing, special care units, physician extenders, state Medicaid rate) can avert costly hospitalizations and ACS hospitalizations which have direct costs to Medicare. In this

[13] In addition, resident and family wishes may affect discretionary hospitalization, further complicating establishment of a list of care-sensitive hospitalization diagnoses for the nursing home setting. Discretion may be exercised differently for similar resident conditions based on resident and family wishes (e.g. "do not hospitalize" requests).

way, supporting nursing homes to provide better care for residents with chronic illness could have a payoff for Medicare.

6. Appendix: Chronic Illness and Long-Stay Nursing Home Residents

Long-stay nursing home residents exhibit greater prevalence of chronic illness even using the conservative CCW definitions (Appendix Exhibit 1).

Appendix Exhibit 1: Proportion of Aged Beneficiaries Identified with Selected CCW Chronic Conditions, 5% Medicare Beneficiaries

Chronic Conditions	5% of Aged Beneficiaries	5% of Long-stay Nursing Home Residents	Percent who are Long-Stay Nursing Home Residents	Relative Prevalence: Nursing Home/Not Nursing Home
All (with and without chronic conditions)	2,418,870	74,263	3.1%	1.00
Acute myocardial infarction	18,866	995	5.3%	1.76
Atrial fibrillation	104,465	7,350	7.0%	2.39
Cataracts	367,357	11,145	3.0%	0.99
Congestive heart failure	283,056	30,535	10.8%	3.82
Chronic kidney disease	88,841	7,696	8.7%	2.99
COPD	157,610	10,917	6.9%	2.35
Depression	143,325	16,556	11.6%	4.12
Diabetes	286,123	17,434	6.1%	2.05
Hip fracture	15,153	1,636	10.8%	3.82
Ischemic heart disease	468,980	28,583	6.1%	2.05
Stroke/ Transient Ischemic Attack	82,630	11,406	13.8%	5.06
Breast cancer	18,456	642	3.5%	1.14
Colorectal cancer	11,918	608	5.1%	1.70
Endometrial cancer	1,570	57	3.6%	1.19
Lung cancer	11,979	299	2.5%	0.81
Prostate cancer	26,716	566	2.1%	0.68
Osteoporosis	152,181	8,852	5.8%	1.95
Glaucoma	132,220	3,722	2.8%	0.91

Source: 2000 chronic condition summary file, developed from Medicare 5% sample, using ACG definitions

The chronic conditions experienced by the full group of long-stay residents are shown in Appendix Exhibit 2. This exhibit shows the ACG chronic condition designations, derived from 1999 ambulatory and inpatient claims. For comparison, CCW chronic conditions were computed

for 2000; these are derived from one to three years of claims data, so even using 2000 data, many designations are indeterminate. [14]

As shown in the Exhibit, chronic obstructive pulmonary disease (COPD) and ischemic heart disease are both relatively common conditions among nursing home residents using either taxonomy (over one-third in both cases). Arthritis and depression, which are only identified in the CCW, are about as prevalent as diabetes (approximately one-fifth of long-stay beneficiaries). Stoke and cataracts are less common, but each affects about 15 percent of the sample.

[14] 2000 is the first year in which most CCW chronic conditions are available; Alzheimer's disease is not available until 2001. The "CCW" group met the CCW criteria for the condition based on a detailed set of diagnostic criteria; the "CCW unable to determine" group are those who, for whatever reason, did not have enough information to be ruled in or out of the disease group. Changes in eligibility or being a new member of the 5-percent sample probably explain most of these cases.

Appendix Exhibit 2: Chronic Conditions Determined for Long-Stay Nursing Home Residents, Based on Data for 1999 and 2000, Percent

	ACG 1999	CCW 2000	CCW, Unable to Determine
Number	74,279	74,279	
Acute myocardial infarction	---	1.34	10.15
Alzheimer's disease	---		100
Atrial fibrillation	---	9.9	10.15
Cataract	---	15.01	10.15
Chronic kidney disease	---	10.36	12.07
COPD	20.62	14.7	10.15
CHF	34.56	41.12	12.07
Diabetes	25.72	23.48	12.07
Glaucoma	---	5.01	10.15
Hip fracture	---	2.2	10.15
Ischemic heart disease	33.38	38.49	12.07
Depression	25.97	22.29	10.15
Osteoporosis	---	11.92	10.15
Arthritis (rheumatoid, osteo-)	---	23.47	12.07
Stroke	---	15.36	10.15
Breast cancer	---	0.86	10.15
Colorectal cancer	---	0.82	10.15
Prostate cancer	---	0.76	10.15
Lung cancer	---	0.4	10.15
Endometrial cancer	---	0.08	10.15
Renal failure	6.29	---	---
Hyperlipidemia	7.43	---	---
Hypertension	54.24	---	---
Lower back pain	13.14	---	---

Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR matched data.

7. Appendix: Alternative Definitions of Ambulatory Care Sensitive Hospitalization for Nursing Home Residents

Researchers have developed definitions of ambulatory care sensitive (ACS) hospitalizations for the general population or community dwelling Medicare beneficiaries (see Section3.4.2 for review and references). Some of these have been applied or adapted to nursing home resident populations. After examining these definitions, it was determined that McCall's definition, which was developed for Medicare, was most appropriate for a nursing home context (McCall 2004). However, Kramer has taken the concept of the ACS hospitalization one step further to create 'nursing home sensitive' hospitalizations (Centers for Medicare and Medicaid Services 2009). In theory, these are hospitalizations that might have been avoided through good ongoing management of chronic health conditions in the nursing home, for example through good nutrition, appropriate ADL care and medication management. The diagnoses used to define these hospital admissions are compared in Appendix Exhibit 3.

These two approaches show a striking similarity in the major diagnosis categories – all but one of Kramer's categories are captured in the McCall definition. Within the overlapping categories, the Kramer definition tends to use a broad set of ICD-9 codes. For example, for bacterial pneumonia, Kramer has 18 diagnoses that are not included in McCall. The picture is similar for dehydration and urinary tract infections. For CHF, each author has a somewhat different definition. However, Kramer and McCall line up exactly for septicemia.

In contrast to the breadth of the Kramer definition, the McCall definition is more focused within each disease group and includes a longer list of conditions; the McCall definition includes five disease groups that are not on the Kramer list.

Regardless of their differences, these two different lists capture essentially the same beneficiaries – each definition identifies only about 2,000 beneficiaries that the other definition does not capture (see Exhibit 5: Distribution of Long-Stay Nursing Home Resident Beneficiaries by ACS Status, Kramer and McCall Definitions, page 30). It could be important to explore the extent to which co-morbidities cause certain beneficiaries to be captured by both definitions for different reasons. The overlap may be purely definitional, but some of it may be coincidental or correlational. The latter would mean that the overlap would likely vary for differing samples and years.

Moving forward, a new definition of nursing home sensitive hospitalizations should combine the logic of Kramer with the clinical specificity of McCall. In addition, the Kramer list could be expanded to include additional indicators of adequate nursing home care. Candidates for nursing home care sensitive hospitalizations include hospitalizations due to falls, accidents, adverse drug interactions and overdoses, and stage III or IV pressure sores that develop while the beneficiary is in the home. Nursing home residents receive all their primary care in the nursing home setting, as well as chronic care and prescription management, assistance with the activities of daily living, nourishment and hydration. Thus, the concept of care-sensitive hospitalizations for nursing home residents should differ from that for older adults in the community.

Appendix Exhibit 3: Definitions for McCall and Kramer ACS Hospitalizations

McCall group	McCall ICD-9	Kramer group	Kramer ICD-9
CHF	40201# 40211# 40291# 40401# 40411# 40491# 428 4280 4281 4289	CHF	398.91# 4280 4281 42820# 42821# 42822# 42823# 42830# 42831# 42832# 42833# 42840# 42841# 42842# 42843# 4289
Bacterial Pneumonia	481 482 4820 4821 4822 4823 48230 48231 48232 48239 4824 48240 48241 48249 4828 48281 48282 48283 48284 48289 4829 483 4831 4830 4838 485 486	Respiratory Infection: acute bronchitis, pneumonia, influenza and pneumonitis due to inhalation of food or vomitus	466.0# 480# 480.1# 480.2# 480.3# 480.8# 480.9# 481 482.0 482.1 482.2 482.3 482.30 482.31 482.32 482.39 482.4 482.40 482.41 482.49 482.8 482.81 482.82 482.83 482.84 482.89 482.9 483 483.0# 483.1 483.8 484.1# 484.3# 484.5# 484.6# 484.7# 484.8# 485 486 4870# 4871# 4878# 507.0#
Dehydration	2765	Electrolyte Imbalance: fluid, electrolyte and acid-base balance	2760# 2761# 2762# 2763# 2764# 2765 2766# 2767# 2768# 2769#
Septicemia	038 038.0 038.1 038.10 038.11 038.19 038.2 038.3 038.4 038.40 038.41 038.42 038.43 038.44 038.49 038.8 038.9	Sepsis	038 038.0 038.1 038.10 038.11 038.19 038.2 038.3 038.4 038.40 038.41 038.42 038.43 038.44 038.49 038.8 038.9
Urinary Tract Infection	599.0 599.9#	Urinary Tract Infection: kidney infections, cystitis, urethritis, urethral stricture and inflammatory prostate	59000# 59001# 59010# 59011# 5902# 5903# 59080# 59081# 5909# 595.0# 595.1# 595.2# 595.4# 595.89# 595.9# 597.0# 59800# 59801# 5981# 5982# 5988# 5989# 599.0 6010# 6011# 6012# 6013# 6014# 6018# 6019#
Cellulites	681 6810 68100 68101 68102 6811 68110 68111 6819 682 6820 6821 6822 6823 6824 6825		

McCall group	McCall ICD-9	Kramer group	Kramer ICD-9
	6826 6827 6828 6829		
Chronic Lung	493 4930 49300 49301 49302 4931 49310 49311 49312 4932 49320 49321 49322 4939 49390 49391 49392 491 4910 4911 4912 49120 49121 4918 4919 492 4920 4928 494 4940 4941 496		
Ischemic Stroke	434.0 434.00 434.01 434.1 434.10 434.11 434.9 434.90 434.91 436		
Diabetes acute events*	2501 25010 25011 25012 25013 2502 25020 25021 25022 25023 2503 25030 25031 25032 25033 2508 25080 25081 25082 25083		
Diabetes lower limb PVD*	6811 68110 68111 6826 6827 7854 2507 25070 25071 25072 25073		
		Anemia: iron deficiency, other deficiency, acute post hemorrhagic and other chronic illness	2800 2801 2808 2809 2810 2811 2812 2813 2814 2818 2819 285.1 285.29

[#] Where diagnostic groups overlap between McCall and Kramer, unique codes are highlighted and asterisked.

* To identify care-sensitive hospitalizations related to diabetes, the McCall definition uses codes to identify beneficiaries with a diabetes diagnosis in addition to hospital diagnoses. A beneficiary is to be identified as having diabetes if s/he has at least one acute claim (face-to-face encounter) with a principal or secondary diagnosis of diabetes or at least two non-acute claims seven days apart with a principal or secondary diagnosis of diabetes. These beneficiaries were identified using the following ICD-9, CPT and revenue center codes.

Principal or secondary diagnosis of diabetes, except in pregnancy:

2500 25000 25001 25002 25003 2501 25010 25011 25012 25013 2502 25020 25021 25022 25023 2503 25030 25031 25032 25033 2504 25040 25041 25042 25043 2505 25050 25051 25052 25053 2506 25060 25061 25062 25063 2507 25070 25071 25072 25073 2508 25080 25081 25082 25083 2509 25090 25091 25092 25093 3572 3620 36201 36202 36641 6480

CPT for acute procedures:

99221 99222 99223 99231 99232 99233 99238 99239 99251 99252 99253 99254 99255 99261 99262 99263 99291 99292 99281 99282 99283 99284 99285 99288 99356 99357

Revenue center for acute procedures:

010X 011X 012X 013X 014X 015X 016X 020X 021X 022X 045X 072X 080X 0981 0987

CPT for non-acute procedures:

99201 99202 99203 99204 99205 99211 99212 99213 99214 99215 99217 99218 99219 99220 99241 99242 99243 99244 99245 99271 99272 99273 99274 99275 99354 99355 99381 99382 99383 99384 99385 99386 99387 99391 99392 99393 99394 99395 99396 99397 99401 99402 99403 99404 99411 99412 99420 99429 99341 99342 99343 99347 99348 99349 99350 99351 99352 99353 99499 92002 92004 92012 92014 99301 99302 99303 99311 99312 99313 99321 99322 99323

Revenue center for non-acute procedures:

049X 050x 051x 052x 053x 055x 056x 057x 058x 059x 065x 066x 076x 082x 083x 084x 085x 088x 092x 094x 096x 0972 0973 0974 0975 0976 0977 0978 0979 0982 0983 0984 0985 0986 0988 0989

8. Appendix: Additional Exhibits

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Appendix Exhibit 4: Descriptive Statistics by Outcome, Hospitalization Survival Analysis

	Hospitalized		Died		Survived		Left Censored	
Variable Name	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**
N	**16243**		**8463**		**28767**		**777**	
Nursing Home Characteristics								
Nonprofit ownership‡	0.228	0.420	0.281	0.449	0.268	0.443	0.206	0.405
Government ownership‡	0.053	0.224	0.057	0.232	0.066	0.248	0.049	0.216
For-profit chain ownership‡	0.484	0.500	0.458	0.498	0.448	0.497	0.474	0.500
RN hours per resident day	0.325	0.246	0.366	0.234	0.345	0.243	0.339	0.274
LPN hours per resident day	0.666	0.322	0.654	0.327	0.647	0.319	0.693	0.371
Nursing assistant (NA) hours per resident day	1.956	0.592	2.013	0.588	1.982	0.578	1.962	0.594
Any special care unit	0.267	0.442	0.323	0.468	0.307	0.461	0.238	0.426
NA training program	0.386	0.487	0.417	0.493	0.411	0.492	0.358	0.480
Proportion residents with DNR orders	0.586	0.264	0.648	0.253	0.625	0.262	0.557	0.267
Any physician extender hours	0.224	0.417	0.243	0.429	0.235	0.424	0.219	0.414
Proportion residents paid for by Medicare	0.090	0.089	0.088	0.086	0.083	0.084	0.099	0.100

	Hospitalized		Died		Survived		Left Censored	
County and State Characteristics								
State bed hold policy	0.834	0.372	0.814	0.389	0.830	0.376	0.855	0.353
State average Medicaid rate	108.432	23.256	110.908	21.298	110.525	22.637	109.129	24.238
Hospital beds per person, county	0.029	0.023	0.027	0.019	0.028	0.022	0.030	0.020
Proportion in poverty, population aged 65+, county	0.098	0.044	0.086	0.036	0.092	0.041	0.103	0.046
Resident Characteristics								
Female	0.760	0.427	0.791	0.407	0.821	0.383	0.730	0.444
Age	83.587	7.688	86.775	7.442	83.966	7.748	82.828	7.853
Age squared	7045.890	1272.880	7585.270	1270.390	7110.370	1287.800	6921.990	1287.980
White race	0.852	0.356	0.918	0.275	0.882	0.323	0.826	0.379
Frailty	0.556	0.497	0.470	0.499	0.408	0.491	0.673	0.469
Congestive heart failure	0.449	0.497	0.363	0.481	0.274	0.446	0.611	0.488
Chronic obstructive pulmonary disease	0.281	0.450	0.198	0.398	0.159	0.366	0.450	0.498
Renal failure	0.094	0.292	0.065	0.247	0.040	0.197	0.197	0.398
Depression	0.323	0.468	0.228	0.420	0.241	0.428	0.362	0.481
Diabetes	0.342	0.474	0.219	0.413	0.223	0.416	0.398	0.490
Hypertension	0.649	0.477	0.502	0.500	0.489	0.500	0.746	0.435
Ischemic heart disease	0.441	0.497	0.315	0.464	0.277	0.448	0.583	0.493
Asthma	0.059	0.236	0.034	0.181	0.030	0.170	0.100	0.301
Dementia	0.410	0.492	0.487	0.500	0.421	0.494	0.413	0.493
ADL Index = 4, 5 or 6	0.524	0.499	0.738	0.440	0.506	0.500	0.615	0.487

	Hospitalized		Died		Survived		Left Censored	
Last MDS reported payment by Medicaid	0.594	0.491	0.587	0.492	0.627	0.484	0.553	0.497
Last MDS reported private payment, no Medicaid	0.218	0.413	0.291	0.454	0.260	0.439	0.190	0.393
Additional Nursing Home and County Characteristics								
RN hours as a proportion of licensed nursing hours	0.326	0.193	0.360	0.190	0.348	0.193	0.325	0.191
Total residents	130.416	87.491	129.529	84.931	133.654	92.606	129.205	72.597
Total beds	149.953	93.695	148.488	91.315	152.778	100.242	147.480	78.518
Occupancy rate	0.867	0.125	0.871	0.123	0.874	0.123	0.875	0.119
Nursing home beds per person aged 65+, county	0.055	0.025	0.054	0.021	0.055	0.025	0.052	0.021
Physicians per total population, county	0.002	0.002	0.003	0.002	0.002	0.002	0.002	0.002

‡As noted in the text, the omitted case for the ownership indicator variables is for-profit independent (non chain) ownership.

Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR matched data.

Appendix Exhibit 5: Estimated Models, Time to All-Cause Hospitalization for Long-Stay Nursing Home Residents, Effect of Nursing Home and Individual Characteristics

	All Variables			Nursing Home Variables only			Resident Variables Only		
Variable Name	**Estimate**	**Standard Error**	**Significance**	**Estimate**	**Standard Error**	**Significance**	**Estimate**	**Standard Error**	**Significance**
Intercept	9.6494	1.0652	<.0001	6.8177	0.0916	<.0001	9.7046	1.0632	<.0001
Nursing Home Characteristics									
Nonprofit ownership‡	0.1283	0.0336	0.0001	0.1794	0.0345	<.0001			
Government ownership‡	0.1608	0.0544	0.0031	0.1906	0.056	0.0007			
For-profit chain ownership‡	0.0396	0.0286	0.1665	0.0455	0.0294	0.1212			
RN hours per resident day	0.2134	0.0515	<.0001	0.1797	0.0531	0.0007			
LPN hours per resident day	-0.0994	0.0333	0.0028	-0.149	0.0341	<.0001			
Nursing assistant (NA) hours per resident day	0.013	0.0202	0.5209	0.0447	0.0208	0.0314			
Any special care unit	0.0989	0.0258	0.0001	0.1337	0.0266	<.0001			
NA training program	0.0712	0.023	0.002	0.0919	0.0237	0.0001			
Proportion residents with DNR orders	0.3201	0.045	<.0001	0.47	0.0457	<.0001			
Any physician extender hours	0.0586	0.0268	0.0288	0.05	0.0276	0.0703			
Proportion residents paid for by Medicare	-0.65	0.1256	<.0001	-1.1534	0.1237	<.0001			
County and State Characteristics									
State bed hold policy	-0.1347	0.0305	<.0001	-0.1296	0.0313	<.0001			
State average Medicaid rate	0.0056	0.0005	<.0001	0.004	0.0005	<.0001			

	All Variables			Nursing Home Variables only			Resident Variables Only		
Variable Name	**Estimate**	**Standard Error**	**Significance**	**Estimate**	**Standard Error**	**Significance**	**Estimate**	**Standard Error**	**Significance**
Hospital beds per person, county	-1.0855	0.4621	0.0188	-1.3473	0.4737	0.0045			
Proportion in poverty, population aged 65+, county	-1.948	0.2688	<.0001	-3.0871	0.2733	<.0001			
Resident Characteristics									
Female	0.2764	0.0269	<.0001				0.2768	0.027	<.0001
Age	-0.0681	0.0258	0.0083				-0.06	0.0258	0.0201
Age squared	0.0004	0.0002	0.005				0.0004	0.0002	0.0108
White race	0.1185	0.0332	0.0004				0.2612	0.0321	<.0001
Frailty	-0.406	0.0234	<.0001				-0.4086	0.0234	<.0001
Congestive heart failure	-0.4529	0.0244	<.0001				-0.4692	0.0245	<.0001
Chronic obstructive pulmonary disease	-0.4317	0.0264	<.0001				-0.443	0.0265	<.0001
Renal failure	-0.4483	0.0383	<.0001				-0.4475	0.0384	<.0001
Depression	-0.2133	0.0244	<.0001				-0.2095	0.0244	<.0001
Diabetes	-0.347	0.0245	<.0001				-0.3523	0.0245	<.0001
Hypertension	-0.3467	0.0248	<.0001				-0.3696	0.0249	<.0001
Ischemic heart disease	-0.3841	0.0244	<.0001				-0.3696	0.0244	<.0001
Asthma	-0.2634	0.0478	<.0001				-0.2532	0.0479	<.0001
Dementia	0.0623	0.0228	0.0062				0.0575	0.0228	0.0118
ADL Index = 4, 5 or 6	-0.0562	0.0226	0.0129				-0.0242	0.0225	0.2826

	All Variables			Nursing Home Variables only			Resident Variables Only		
Variable Name	**Estimate**	**Standard Error**	**Significance**	**Estimate**	**Standard Error**	**Significance**	**Estimate**	**Standard Error**	**Significance**
Last MDS reported payment by Medicaid	0.3025	0.0301	<.0001				0.3003	0.03	<.0001
Last MDS reported private payment, no Medicaid	0.3323	0.0361	<.0001				0.3709	0.0358	<.0001
Scale	1.4388	0.0104		1.4848	0.0109		1.4427	0.0104	
Weibull Shape	0.695	0.005		0.6735	0.0049		0.6932	0.005	
-2 Log Likelihood	109363			113909			109890		

‡As noted in the text, the omitted case for the ownership indicator variables is for-profit independent (non chain) ownership.

Note: A positive coefficient indicates a protective effect against hospitalization – longer time to first hospitalization and a negative coefficient indicates an increase in risk – shorter time to first hospitalization.

Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR matched data.

Appendix Exhibit 6: Estimated Model Time to All-Cause Hospitalization: Include Prior Year Hospitalization and State Fixed Effects

Variable Name	Estimated Coefficients	Standard Error	Significance
Intercept	10.241	1.052	0.00
Nursing Home Characteristics			
Nonprofit ownership‡	0.101	0.034	0.00
Government ownership‡	0.160	0.055	0.00
For-profit chain ownership‡	-0.014	0.029	0.63
RN hours per resident day	0.167	0.053	0.00
LPN hours per resident day	-0.045	0.036	0.21
Nursing assistant (NA) hours per resident day	-0.023	0.021	0.27
Any special care unit	0.079	0.026	0.00
NA training program	0.073	0.024	0.00
Proportion residents with DNR orders	0.218	0.047	0.00
Any physician extender hours	0.034	0.027	0.20
Proportion residents paid for by Medicare	-0.390	0.128	0.00
County Characteristics			
Hospital beds per person, county	-0.461	0.475	0.33
Proportion in poverty, population aged 65+, county	-1.241	0.309	0.00
Resident Characteristics			
Female	0.132	0.033	0.00
Age	-0.202	0.024	0.00
Age squared	-0.320	0.024	0.00
White race	-0.281	0.026	0.00
Frailty	-0.292	0.038	0.00
Congestive heart failure	-0.127	0.024	0.00
Chronic obstructive pulmonary disease	-0.296	0.024	0.00
Renal failure	-0.191	0.025	0.00
Depression	-0.213	0.025	0.00
Diabetes	-0.151	0.047	0.00
Hypertension	0.061	0.023	0.01
Ischemic heart disease	-0.011	0.023	0.62

Variable Name	Estimated Coefficients	Standard Error	Significance
Asthma	-0.060	0.032	0.06
Dementia	0.084	0.036	0.02
ADL Index = 4, 5 or 6	-0.627	0.030	0.00
Last MDS reported payment by Medicaid	-0.939	0.038	0.00
Last MDS reported private payment, no Medicaid	-1.057	0.048	0.00
1 hospitalization in 1999	-1.439	0.047	0.00
2 hospitalizations in 1999	-0.939	0.038	0.00
3 hospitalizations in 1999	-1.057	0.048	0.00
4+ hospitalizations in 1999	-1.439	0.047	0.00
Scale	1.421	0.010	
Weibull Shape	0.704	0.005	

-2 log likelihood = 107768

‡As noted in the text, the omitted case for the ownership indicator variables is for-profit independent (non chain) ownership.

Note: A positive coefficient indicates a protective effect against hospitalization – longer time to first hospitalization and a negative coefficient indicates an increase in risk – shorter time to first hospitalization.

Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR matched data.

Appendix Exhibit 7: Significance for Hospitalization Maximum Likelihood Estimates

Model	-2 log likelihood	Number of Parameters	Significance
Null model (intercept only)	114755.6	1	
Beneficiary Variables Only	109890.1	18	<.00001
NH Variables Only	113909.4	16	<.00001
Model 1: All Beneficiary and Nursing Home Variables except prior hospitalization	109363.2	33	<.00001
Model 1 compared to Null	5392.4	32	<.00001
Model 1 compared to Bene Only	526.9	15	<.00001
Model 1 compared to NH Only	4546.2	17	<.00001
Model 2: add Hospitalization Variables	108127	37	<.00001
State fixed effects: Add Hospitalization Variables and State Indicators	107768	83	<.00001
Model 2 compared to Model 1	1236.2	4	<.00001
State fixed effects compared to Model 2*	359	46	<.00001

*State fixed effects model is not exactly nested within Model 2.

Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR matched data using SAS Proc Lifereg.

Appendix Exhibit 8: Estimated Models, Time to ACS Hospitalization for Long-Stay Nursing Home Residents, Effect of Nursing Home and Individual Characteristics

	All Variables			Nursing Home Variables Only			Resident Variables Only		
Variable Name	**Estimate**	**Standard Error**	**Significance**	**Estimate**	**Standard Error**	**Significance**	**Estimate**	**Standard Error**	**Significance**
Intercept	12.9141	1.456	<.0001	7.8366	0.124	<.0001	12.94	1.4539	<.0001
Nursing Home Characteristics									
Nonprofit ownership‡	0.2396	0.046	<.0001		0.0472	<.0001			
Government ownership‡	0.2517	0.075	0.0008	0.2911	0.0772	0.0004			
For-profit chain ownership‡	0.0387	0.0382	0.31	0.2728	0.0392	0.14			
RN hours per resident day	0.2568	0.0697	0.0002	0.0585	0.0715	0.004			
LPN hours per resident day	-0.1331	0.0439	0.002	0.2038	0.0444	<.0001			
Nursing assistant (NA) hours per resident day	0.0212	0.0273	0.44	-0.1973	0.0279	0.09			
Any special care unit	0.1013	0.0352	0.004	0.0475	0.0362	<.0001			
NA training program	0.0897	0.0312	0.004	0.143	0.0321	0.001			
Proportion residents with DNR orders	0.4438	0.0607	<.0001	0.1052	0.0615	<.0001			
Any physician extender hours	0.0647	0.0364	0.07	0.6034	0.0374	0.12			
Proportion residents paid for by Medicare	-0.7823	0.1665	<.0001	0.0578	0.1634	<.0001			
County and State Characteristics									
State bed hold policy	-0.1553	0.0413	0.0002	-1.3219	0.0423	0.0008			
State average Medicaid rate	0.0067	0.0007	<.0001	-0.1419	0.0007	<.0001			

	All Variables			Nursing Home Variables Only			Resident Variables Only		
Hospital beds per person, county	-0.8414	0.6336	0.18	-151543	0.645	0.007			
Proportion in poverty, population aged 65+, county	-2.9706	0.3518	<.0001	-4.4504	0.3566	<.0001			
Resident Characteristics									
Female	0.3967	0.036	<.0001				0.3969	0.036	<.0001
Age	-0.1122	0.0352	0.001				-0.1026	0.0352	0.004
Age squared	0.0007	0.0002	0.002				0.0006	0.0002	0.004
White race	0.1025	0.0441	0.02				0.2999	0.0426	<.0001
Frailty	-0.3893	0.0318	<.0001				-0.3962	0.0318	<.0001
Asthma	-0.3507	0.0617	<.0001				-0.3329	0.0618	<.0001
Congestive heart failure	-0.6044	0.0331	<.0001				-0.6252	0.0332	<.0001
Chronic obstructive pulmonary disease	-0.5594	0.0351	<.0001				-0.578	0.0352	<.0001
Renal failure	-0.402	0.0504	<.0001				-0.4021	0.0505	<.0001
Depression	-0.107	0.0332	0.001				-0.1008	0.0332	0.002
Diabetes	-0.4327	0.0328	<.0001				-0.4417	0.0329	<.0001
Hypertension	-0.3127	0.0338	<.0001				-0.3446	0.0338	<.0001
Ischemic heart disease	-0.3907	0.033	<.0001				-0.3718	0.0329	<.0001
Dementia	0.0088	0.0307	0.8				0.002	0.0308	0.95
ADL index = 4, 5 or 6	-0.4009	0.0311	<.0001				-0.361	0.0309	<.0001
Last MDS reported payment by Medicaid	0.2512	0.0403	<.0001				0.2464	0.04	<.0001

	All Variables			Nursing Home Variables Only			Resident Variables Only		
Last MDS reported private payment, no Medicaid	0.3272	0.049	<.0001				0.3933	0.0486	<.0001
Scale	1.4764	0.0143		1.521	0.0149		1.4802	0.0144	
Weibull Shape	0.6773	0.0066		0.6575	0.0065		0.6756	0.0066	
Log Likelihood	-36957			-38566			-37222		

‡As noted in the text, the omitted case for the ownership indicator variables is for-profit independent (non chain) ownership.

Note: A positive coefficient indicates a protective effect against hospitalization – longer time to first hospitalization and a negative coefficient indicates an increase in risk – shorter time to first hospitalization.

Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR matched data.

Appendix Exhibit 9: Significance for ACS Hospitalization Maximum Likelihood Estimates

Model	-2 log likelihood	Number of Parameters	Significance
Null model (intercept only)	77916	1	
Beneficiary Variables Only	74444	18	<.00001
NH Variables Only	77130	16	<.00001
Model 1: All Beneficiary and Nursing Home Variables except prior hospitalization	73914	33	<.00001
Model 1 compared to Null	4002	32	<.00001
Model 1 compared to Bene Only	530	15	<.00001
Model 1 compared to NH Only	3216	17	<.00001
Model 2: add Hospitalization Variables	73186	37	<.00001
State fixed effects: Add Hospitalization Variables and State Indicators	72906	83	<.00001
Model 2 compared to Model 1	728	4	<.00001
State fixed effects compared to Model 2*	280	46	<.00001

*State fixed effects model is not exactly nested within Model 2.Source: Computed by authors using 1/1/2000 long-stay nursing home cohort based on CCW and OSCAR matched data using SAS Proc Lifereg.

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