# Competition, Information, and Quality: Evidence from Nursing Homes*

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**Abstract**

Economic theory suggests that competition and information disclosure can both be important for quality improvement, yet evidence on how they may interact to affect quality is sparse. This paper estimates the impact of nursing homes competition on their quality and how this impact varies as consumers have better access to quality information. To identify the effect of competition on quality, I exploit exogenous variation in nursing homes' geographical proximity to their potential consumers, using an Instrumental Variable (IV) derived from the estimation of demand as a function of travel distances. The change in information is captured by the recent launch of the Five-Star Quality Rating System, which increased information transparency by adding easy-to-understand star ratings to the multi-dimensional clinical quality measures. I find that while the effect of competition on nursing home quality is generally rather limited, this effect becomes significantly stronger with increased information transparency. The results suggest that regulations regarding quality rating and market structure are policy complements and should be considered jointly to best improve quality.

**JEL Codes**: I10, L10, L22

**Key Words**: Quality of care, competition, information, nursing homes, discrete choice model

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# 1 Introduction

To promote the quality of products and services, policy makers often rely on regulations to enhance competition. Basic microeconomic theory suggests that competition unambiguously leads to better quality when price is administratively set above marginal cost (Gaynor and Town 2011). When price is fixed, firms compete on quality to attract consumers. Additional competitors increase the elasticity of market shares with respect to quality, thus providing more incentives for investment in quality. Despite the clear prediction from economic theory, the empirical evidence is mixed in the literature of fixed-price health care markets. For example, by examining nursing home residents or Medicare patients with heart diseases, some studies establish a positive relationship between competition and quality (Castle et al., 2007; Kessler and McClellan, 2000; Cooper et al., 2011), whereas others draw the opposite conclusion (Grabowski, 2004; Forder and Allan,2014; Gowrisankaran and Town, 2003; Propper et al., 2010).

The effectiveness of competition in promoting quality can be limited by the lack of understandable information on provider quality. Transparent information is essential for raising consumers' sensitivity toward quality and providing firms with incentives to select higher quality in competition. Though promising, this interaction between competition and information to improve quality has not been systematically tested. In this paper, I estimate the effect of competition on nursing home quality, and explore how the effect varies when consumers have better access to quality information.

The first challenge in studying how competition and information may interact to affect quality is to establish the causality between competition and quality. A major concern is the endogeneity arising from the simultaneity between competition and quality: when the market structure drives the choice of quality, the latter shapes the distribution of demand and thus affects the former as well. To address the endogeneity problem, I use an Instrumental Variable (IV) derived from the estimation of demand as a function of travel distances between nursing homes and their potential consumers. Travel distance is valid because it has an impact on individuals' choice of the provider, but depends neither on unobserved characteristics of patients nor on unobserved determinants of facility quality (Kessler and

McClellan, 2000; Mehta, 2007). The idea of this IV strategy is to identify the effect of market competitiveness using exogenous variation in nursing homes' geographical proximity to their potential consumers. In addition to the IV approach, I employ panel estimation with facility fixed effects to control for time-invariant unobservable factors that may affect both the nursing home performance and the market structure.

To study the role of information transparency, I exploit a recent change in quality reporting in nursing homes. Before 2009, the quality of a nursing home was known to the public as 18 distinctive clinical measures that were difficult to interpret. In 2009, Centers for Medicare and Medicaid Services (CMS) launched the Five-Star Quality Rating System to provide easy-to-understand quality information. The new rating system added overall star ratings to the existing multi-dimensional clinical measures, which reduced consumers' learning costs and encouraged the use of CMS's quality reporting.[1] The consistent availability of the clinical measures allows me to estimate the effect of competition on quality both before and after 2009. The pre-post difference in the effects is the primary interest and captures the interaction effect of competition and information on quality.

Analysis of this paper uses panel data from 2006-2010, spanning the introduction of the Five-Star Rating System. The data are pulled together from three main sources: Nursing Home Compare (NHC); the Health Care Information System (HCIS); and the American Community Survey (ACS). The NHC provides nursing home quality (both the clinical measures and the star ratings) and a rich set of nursing home characteristics at the facility level. The HCIS data include information on annual patient flows of nursing homes. From the ACS, I derive demographic and socioeconomics characteristics of potential consumers.

I find that while the effect of competition on nursing home quality is generally rather limited, this effect becomes significantly stronger as consumers have better access to quality information. One possible mechanism is that the information simplification raises consumers' sensitivity to quality and thus fosters effective quality competition. This mechanism has been supported by the following evidence. First, the positive interaction effects

[1] Design for Nursing Home Compare Five-Star Quality Rating System: Technical Users' Guide by CMS, February 2015

disappear once I replace the outcome variables with non-simplified quality measures [2], suggesting an important role played by the information simplification. Second, demand shifts toward the high-quality nursing homes after the release of star ratings, suggesting that consumers are actually aware of the new rating system and are taking advantage of it. I subject the analysis to extensive robustness tests over different covariates and on various subsamples. All results support the hypothesis that the improvement in information delivery is driving a more positive effect of competition on quality.

This paper relates to three strands of literature. The first has investigated the impacts of quality reporting on patient choices and quality itself (Mukamel et al., 2008; Werner et al., 2009, 2012; Grabowski and Town, 2011; Culter et al., 2004; Dafny and Dranove, 2008; Bundorf et al., 2009). Results in this paper echo the recent finding that consumers respond to quality report cards. One unique contribution of this article is a more rigorous design of identification, which allows me to provide direct and solid evidence that public reporting improves quality through inducing informed choices and rewarding high-quality services. The findings also emphasizes that the understandability of the information is important in quality reporting. This confirms the conjecture in the literature that confusing information leads to ineffective public reporting of quality (Marshall et al., 2000), and helps to explain why only minimal consumer response is found to the public reporting of the multi-dimensional nursing home quality in 2002 (Werner et al., 2012; Grabowski and Town, 2011).

Second, this paper adds to the literature on the relationship between market concentration and quality in the health care markets. Previous research has studied how the relationship is influenced by other factors such as managed care penetration (Kessler and McClellan, 2000) and patient valuation (Kessler and Geppert, 2005). This current study brings attention to information transparency. Observing how the positive competition-quality relationship can be recovered by transparent information is desirable, for it provides a possible way to reconcile the inconsistent findings in the literature. Moreover, it suggest that for markets where competition may lead to lower quality, a better solution is to provide understand-

[2] Only a subset of the clinical quality measures are selected to form star ratings. The unselected ones are defined as non-simplified quality measures.

able information rather than to limit competition itself. Knowing this would prevent the states from implementing Certificate of Need (CON) laws that aimed to enhance quality by restricting the entry of facilities. Not surprisingly, CON policies turned out to be unsuccessful and have been removed in some states.[3]

Lastly, this study pertains to demand estimation in the nursing home industry. To my best knowledge, Mehta (2006) is the only work that investigate how nursing home demand is affected by consumer preference over location. While she restricts her study sample to private pay patients in Wisconsin in 2002, I offer an extension by targeting the majority of nursing home residents (the Medicaid/Medicare beneficiaries) nationwide for a longer period of time. Furthermore, the scope of my data allows me to test whether consumer preference differs based on regulatory environment, i.e., the difference across states in Medicaid regulations or the change over time in information regimes.

The paper proceeds as follows. Section 2 provides the background information on the nursing home industry and the reform in quality reporting. Section 3 describes the data and the construction of key variables. Section 4 proposes the estimation methodology. Section 5 presents the results. Section 6 shows the extensions and the robustness checks. Section 7 discusses the limitations and the future work.

# 2 Backgrounds

## 2.1 The Nursing Home Industry

Nursing homes remain the largest and the most expensive component of long-term care in the United States, despite the rapid growth in other long-term care services (Kaye, Harrington, and LaPlante, 2010). In the U.S., more than 16,000 nursing homes are providing services to over 1.5 million residents, with an annual expenditure of over $100 billion (2004 National Nursing Home Survey). The services include skilled nursing and rehabilitation that have a wide impact on populations especially the adults aged 65 years and older. The health, function, and quality life of senior citizens are important and are listed as one of

[3]Improving Health Care: A Dose of Competition, A Report by the Federal Trade Commission and the Department of Justice, July 2004

the major objectives of Healthy People 2020 (Department of Health and Human Services, 2010). Not only because older adults are among the fastest growing age group as "baby boomers" approach 70s, but also because they are at high risk for developing chronic illnesses and related disabilities that are the leading causes of death (Kramarow E, Lubitz J, Lentzner H, et al., 2005).

The industry is characterized by strict price regulations. Most nursing homes receive the majority of their revenues from Medicaid and Medicare enrollees, whose coverage and payment are administrated at the federal or state levels. Medicaid pays for the nursing services of more than 68 percent of all nursing home residents, and Medicare pays for additional 12 percent (Lin 2014). Medicaid beneficiaries are not charged for basic services in nursing homes. Additionally, most states employ the prospective payment system (PPS) so that the reimbursement rate is predetermined and is not based on current services provided.

Given the above background, the nursing home industry is ideal for estimating the interaction effect of competition and information simplification on quality. First, the strict price regulation offers the prerequisite for providers to compete in quality. Second, as the primary users of nursing homes, the elderly are potentially less able to understand complicated information about quality. Therefore, the fact that the quality reporting on nursing homes was initially confusing and later improved makes it meaningful and possible to study the effect of information simplification.

Nursing homes provide a high level of medical care, compared to other senior housing facilities such as retirement communities [4]. They are equipped with registered nurses and nursing aides, who have received training to deal with various medical needs of nursing home residents. Usually 24 hours a day, the staff are supposed to interact with the residents to provide basic care services and to assist people with special needs such as Alzheimer patients. The provision of intensive medical care makes the quality of nursing home care particularly important for the U.S. long-term care.

Persistent poor quality of the industry, despite substantial investment and regulations from the government, has drawn increasing attention from policy makers and researchers. About 1/3 of U.S. nursing facilities are penalized for violations of Federal regulations in

[4]For example, http://www.rlcommunities.com/).

care quality. About 75 percent of the nursing home residents fall at least once in a year, which may cause serious consequences and even death. A large number of nursing home residents suffer from abuse, improper care for activities of daily living, or other adverse events (Harrington et al., 2007).

## 2.2 The Five-star Quality Ratings

Hoping to promote nursing home quality by disclosing it, CMS first introduced numerous quality measures to a web-based report card called Nursing Home Compare (NHC) in 2002. The data are derived from the Minimum Data Set (MDS), a federal mandated process that collects clinical assessment of all residents in Medicare or Medicaid certified nursing homes. [5] These quality measures include pressure ulcers, urinary tract infection, influenza and pneumococcal vaccination, loss of activities of daily livings, and moderate to severe pain.

However, interpreting these quality measures are rather difficult. For some measures that reflect the rate of vaccination, a higher value means better quality while for others, the lower the better. Moreover, certain quality indicators require particular caution to interpret. For example, observing a higher incidence of pain may neither imply better nor worse quality. It is not only because pain is self-reported and hard to verify, but also because an increase in the value can either be driven by deteriorative pain management (lower quality) or a more comprehensive daily examination (higher quality). For the above reasons, consumers' desire for useful and understandable information continued, despite the fact that the quality data had existed for many years.

It was not until 2009 with the release of the Five-Star Quality Rating System that an easy way to understand assessment of nursing home quality became available. The new system has been launched by CMS to simplify the format of quality information and to promote utilization of the website as a guide to nursing home choices. Each nursing facility is given a rating of 1 to 5 stars based on quality of service, with more stars indicating better quality. The stars reflect three domains of quality: staffing, clinical outcomes, and regulatory

[5] In 2011, MDS was upgraded from version 2.0 to 3.0, with adjustment in the assessment of some measures.

inspections. I focus on stars of clinical outcomes, primarily because they are not subject to gaming or manipulation as other quality dimensions. Staffing, for instance, can be easily manipulated within a short periods of time before inspection and data collection (Williams et al., 2010). The stars are formed by collapsing a subset of the initial quality measures. The subset is selected based on "their validity and reliability, the extent to which the measure is under the facility's control, statistical performance, and importance" [6].

The new rating system has lowers consumers' learning costs and improved their searching experience. First, it enables consumers to easily target a few high performance nursing homes. Figure 1 present the cropped snapshot of the new rating system interface on Nursing Home Compare. As shown in Figure 1, consumers are capable of sorting facilities by various variables including the star ratings. With potential choices in mind, the consumers then may add the nursing homes to form a table with detailed provider information for further comparison. Figure 2 illustrates the comparison table, from which one can obtain the detailed information on various aspects of the selected nursing homes including the general profile, health and fire inspections, staffing, quality measures, and penalties. In addition, the new system includes a checklist to guide nursing home search beyond the website. In sum, the Five-Star Quality Rating System has assisted consumers in making informed choice, which would prompt providers to compete on quality.

# 3 Data

## 3.1 Data Source

This paper pulls together information from several datasets. The first is NHC, the official dataset provided by CMS on the website Medicare.com. It contains three main types of content regarding the study periods (2006-2011): (1) quarter-facility level data of 18 clinical quality measures, (2) annual data of facility-level star ratings between 2009 and 2011, and (3) annual data on nursing home characteristics such as the address, the ownership, and the total number of Medicare and/or Medicaid certified beds etc.

The second is the HCIS Data File, from which I obtain patient flow data to construct

[6] Design for Nursing Home Compare Five-Star Quality Rating System: Technical Users' Guide (2012).

the measure of competition[7]. It contains facility-year level data on total patient count and the number of discharge from 2006 to 2011. Data from the HCIS are matched to the NHC data by a unique nursing home identity number.

In addition to the two main data sources, I draw on the ACS to derive demographic and socioeconomics characteristics of census tracts. Census tracts are small geographic subdivisions of a county, which compass a population from 1200 to 8000 with an average of 4000. In this paper, population above age 65 in a census tract is treated as a representative consumer, whose preference over nursing homes is examined to construct an IV for the measure of competition in the first stage.

### 3.2 Competition Measure

The degree of competition is measured by the negative natural logarithm of an Herfindahl-Hirschman Index (HHI). The standard HHI is calculated by summing the squares of the individual market shares over all the participants. It describes the concentration of market by revealing the number of competitors and the market shares possessed by each competitor. Since the intensity of competition decreases with the HHI, I transform the index to make the results more straightforward to interpret.

Geographic markets are defined by county for three reasons. First, this market definition causes less concern about the migration issue. Evidence is found that patients seldom cross county boundaries to seek health services (Bowblis, 2012; Zinn, 1994). If true, any observed difference in quality would be more likely to reflect a real change in care services rather than a shift of patient risk mix due to migration. Second, a county is the unit of long-term care financing and regulation by Medicare. Last, using alternative definitions of geographic markets may not cause much change in the degree of competition. For example, Bowblis and North (2011) use both the county and the 90th percentile variable radius to define a market and find that the two methods generate similar HHIs.

The sample of this study is restricted to rural counties. A county is defined rural if all of its census tracts contain less than 2,500 residents. To identify rural counties nationwide,

[7]I draw patient count from HCIS rather than NHC primarily because the data from the former has more variation (actual patient flows versus number of beds) and is subject to stricter price regulation (Medicare patients versus all residents).

I obtain a list of all urbanized areas and urban clusters from a national 2010 urban area file from U.S. Census Bureau, and subtract them from all counties in the United States.

I restrict my samples to rural areas, primarily because in urban areas the market area is smaller than the county (Zwanziger, Mukamel and Indridason, 2002). Denser population in urban areas often sustain more nursing homes (Caffrey, 2005), thus only a subset of which is actually considered by a rational individual as close substitutes to each other. As a result of this market segmentation, treating a county as a market in urban areas would incorrectly enlarge consumers' choice set and bias the measure of competition. In Section 3.5 and Section 6.1, I discuss the representativeness of the sample and examine how the main findings would be changed by including nursing homes in the urban areas.

### 3.3 Quality Measure

Six quality measures are selected based on importance and data availability. These quality indicators are interpreted as the rate of residents who are free from certain adverse issues including pressure ulcers (PRE), Urinary Tract Infection (UTI), catheter inserted (CAT), loss of Activities of Daily Living (ADL), pain (PAI), and physical restraint (PHY). The raw quality scores reflect the percentage of residents with these adverse health status. I subtract from 100 the original quality scores, so that higher values imply better quality. Table 1 presents the cross-correlation of the quality indicators. The correlations are generally small, ranging from -0.09 to 0.22. It suggests the necessity to study the performance of all six dimensions of the care. A detailed description of the quality measures can be found in Appendix A.1.

### 3.4 Distance and Other Covariates

Travel distance plays a crucial role in predicting demand to construct IV for the competition measure in the first stage. For each county, I first geocoded nursing home addresses and the center of census tracts (the representative consumers), and then calculated the geodetic distances in miles between them. This results in more than 50,000 facility-consumer pairs.

In addition to travel distance, I obtain a series of covariates from both the supply side and the demand side. The supply-side controls are nursing home characteristics that have been

used in the previous literature to assess quality of care. The first is the number of deficiency citations, which is viewed as a proxy of nursing home quality (Grabowski, 2004). Deficiencies indicate failure to meet certain federal requirements during an on-site inspection that examine the health and safety environment of the facilities. Allowing deficiencies to enter the analysis would control for the facilities' management efficiency on nursing home quality and consumer choice.

Other supply-side controls comprise the number of beds, the nonprofit indicator, the chain affiliation, and the rate of Medicaid patients. The total number of certified beds controls for the facility size and rules out the effect of economies of scale. The nonprofit indicator captures the difference in the value of quality caused by ownership status. The chain membership deals with any impact of care standardization on quality. Last, the rate of Medicaid patients is included to ensure that quality is compared among health providers with similar structure of payer-mix. This addresses the concern that quality might be disproportionately low in nursing homes that have high ratio of Medicaid beneficiaries, because Medicaid reimburses at lower rates than Medicare or private insurances.

The demand-side controls are mainly census tract characteristics including average household income, population over age 65, and average travel time to work. These demographic variables are used in the first stage demand estimation. Income controls for the potential influence of wealth on nursing home preferences. Commute time implies consumers' tolerance for long-distance travel. The inclusion of these variable captures consumer heterogeneity and allows more flexibility in demand estimation. To provide additional control, I collect data on market characteristics such as per-capita income, percentage of poverty, state Medicaid rate, and population.

### 3.5 Summary Statistics

Table 2 summaries the descriptive statistics. A total of 2336 nursing homes are studied, with an average HHI around 0.02 [8]. From PRE to PHY are the six quality measures that

[8] It is inappropriate to claim that markets are unconcentrated, even though the HHI is less than the commonly-used cutoff for low concentration (HHI $<$ 0.15). When calculating HHI, I allow no-purchase as the outside option, which differs from the standard formula that assumes market shares sum up to 1. Therefore, HHI in this paper is systematically smaller.

report the percentage of long-stay residents who are free from corresponding adverse health status. The average distance between a nursing home and its potential consumer is 19.2 miles, or approximately a thirty-minute drive. Typically, a nursing home faces consumers from 25 (= 58431/2336) census tracts, is equipped with about 100 beds, and have approximately 60% of its residents paid by Medicaid. About one-fourth of the nursing homes in the sample are non-profit organizations and about half of the nursing homes are affiliated with a chain.

Figure 3 demonstrates the variations in the competition measure between 2006 and 2011. There exists a large cross-sectional variance in the negative log of HHI, as shown in panel a. Panel b plots the longitudinal variation of the competition measure (the lines) and the number of nursing homes (the bars). Grey denotes rural counties alone and black refers to counties nationwide. Even though rural markets in general contain fewer nursing homes and are less competitive, the differences between rural markets and all markets persist steadily and proportionately as time stretches out. It provides evidence that rural markets and urban markets experience similar evolutions regarding nursing home competition. For more discussion about the representativeness of rural counties, see section 6.1.

In addition to show the representativeness of the sample, Panel b of Figure 3 helps to identify the leading driver of the longitudinal variation in competition. Nursing home markets become less competitive after 2009 (the declining lines), which may result from a decrease in the number of nursing homes or a more skewed distribution of demand. However, the bars show a relatively static number of nursing homes. Thus, the evolution in competition is most likely to be driven by a redistribution of market shares.

Figure 4 demonstrates the distribution of demand by nursing home quality, both before and after 2009. It suggests that the redistribution in demand is associated with the improvement in information transparency. As information becomes more obtainable, high-performance nursing homes attract more consumers. Previously, consumption concentrated at nursing homes that lie at the lower end (the left panel). After 2009, top nursing homes start to have a strong appeal to consumers (the right panel). This observation supports the conjecture that the posting of star ratings stimulates informed choice from consumers. However, it also raises the concern about the simultaneity between quality and

competition and calls for an appropriate IV to address the problem.

# 4 Estimation Methodology

## 4.1 Constructing IV in the First Stage

In establishing the causality between competition and quality, I construct an IV in steps to address the endogeneity problem. First, a random utility logit model is used to estimate the demand for nursing home care. The main purpose is to structurally predict market shares from exogenous travel distance and other characteristics of nursing homes and census tracts. The predicted market shares are then transformed to a negative log of HHI for each county, which serves as an IV for the degree of competition.

Figure 5 illustrates the idea of estimating nursing home demand from travel distance. The solid black circle indicates a county or a market, in which nursing homes (the black dots) compete for potential consumers from all census tracts (the dashed red circles). For each census tract, I assume there is a representative consumer locating in the center (the black square). The probability that a representative consumer chooses a certain nursing home depends on the distance between them, nursing home characteristics, and the consumer's taste. I then aggregate the individual choices from each census tract to infer the demand for nursing homes. On the other hand, the actual demand is calculated by dividing the number of nursing home residents by the potential consumers in the market. The coefficients of demand are derived by minimizing the differences between the inferred market shares and the actual market shares.

I follow Berry (1994) and Berry, Levinsohn and Pakes (1995) to estimate demand, primarily because their estimation methodology only requires aggregate data. Assume the utility of a representative consumer $i$ choosing nursing home $j$ at time $t$ is:

$$u_{ijt} = \gamma * dist_{ij} + X_{it} \bullet A + Y_{j(t)} \bullet B + \epsilon_{ijt} \tag{1}$$

where $dist_{ij}$ denotes the distance, the vector $X_{it}$ includes the time-varying census tract controls, and $Y_{j(t)}$ contains the characteristics of providers. This specification allows consumer

heterogeneity to enter the model through demographics variables as well as the random shocks. The benefit is to eliminate the typical problem of unrealistic substitution patterns arising from the multinomial logit model. To facilitate comparisons across predictors, I create z-scores for all of the independent variables.

Based on the utility function, I calculate the probability that representative consumer $i$ chooses nursing home $j$ at time $t$, $s_{ijt}$.

$$s_{ijt} = \frac{exp(\gamma * dist_{ij} + X_{it} \bullet A + Y_{jt} \bullet B)}{1 + \sum_{m \in J_t} exp(\gamma * dist_{im} + X_{it} \bullet A + Y_{mt} \bullet B)} \tag{2}$$

where $J_t$ consists of all nursing homes in the county to which nursing home $j$ belongs. The probability in Equation (2) is derived under a couple of assumptions. First, the error term $\epsilon_{ijt}$ identically and independently follows a generalized extreme-value distribution. Second, consumers are utility maximizing. Consumers choose one facility that generates the highest utility or do no purchase. The utility of the no-purchase state as an outside option is normalized to 0. This process occurs at the beginning of each period, with only new cohorts of consumers making decisions. The above assumption is supported by the extremely low transfer rate amongst nursing home residents (Mehta, 2006).

The probability of individual choices is then aggregated to form the expected market shares of nursing homes. Equation (3) shows that the expected market share of nursing home $j$ at time $t$, $s_{jt}$, is computed as a weighted average of the probability of individual choices, $s_{ijt}$. The weight is the ratio of related population (people over the age of 65) in a particular census tract to that in the entire market, denoted by $\frac{pop65_{it}}{pop65_t}$. Plugging Equation (2) into (3), I express expected market shares as functions of predetermined variables and parameters to be estimated in Equation (4).

$$s_{jt} = \sum_i (\frac{pop65_{it}}{pop65_t} * s_{ijt}) \tag{3}$$

$$= \sum_i (\frac{pop65_{it}}{pop65_t} * \frac{exp(\gamma * dist_{ij} + X_{it} \bullet A + Y_{jt} \bullet B)}{1 + \sum_{m \in J_t} exp(\gamma * dist_{im} + X_{it} \bullet A + Y_{mt} \bullet B)}) \tag{4}$$

where $s_{jt}$ is the expected market share of nursing home $j$ in year $t$.

I search for the coefficients that minimize the difference between expected market shares

(Equation (4)) and actual market shares (the proportion of the admitted patients to the potential population). Equivalently, the estimation of coefficients is completed by maximizing the log likelihood function in Equation (5):

$$\sum_{t=2006}^{2011} \sum_{j \in J_t} ptct_{jt} \, log(s_{jt}) \tag{5}$$

where $ptct_{jt}$ represents the actual patient count, and $s_{jt}$ is the approximated market share defined in Equation (4). With the obtained coefficients, I derive the predicted market share, $\widehat{s_{jt}}$, and calculate the corresponding index of competition, $\widehat{NLHHI}_{jt}$. The validity of using $\widehat{NLHHI}_{jt}$ as an IV in the main regression relies on the fact that it is a function of the market shares, $\widehat{s_{jt}}$, which in turn are predicted from exogenous variables.

### 4.2 Main Specification

Equation (6) specifies the basic estimation.

$$\begin{aligned} QM_{kjt} = \beta_{0k} + \beta_{1k} \, NLHHI_{jt} + \beta_{2k} \, NLHHI_{jt} * after_t + \beta_{3k} t \\ + \beta_{4k} t * after_t + \beta_{5k} MDS_t + \beta_{Xk} X_{jt} + \delta_j + \epsilon_{kjt} \end{aligned} \tag{6}$$

where $k =$ quality measure code, $j =$ nursing home, and $t =$ year.

The dependent variable $QM_{kjt}$ refers to the $kth$ quality measure of nursing home $j$ at time $t$. The competition measure, $NLHHI_{jt}$, is the negative natural log of HHI. $after_t$ takes the value 1 for post-reform periods. $MDS_t$ indicates the upgrade of the MDS from version 2.0 to 3.0 in 2011, when a minor change in quality assessment occurred. $X_{jt}$ includes a vector of control covariates. $\delta_j$ denotes the provider fixed-effects, and the last term $\epsilon_{kjt}$ is the error term.

Coefficients of interest are $\beta_{1k}$ and $\beta_{2k}$. Coefficient $\beta_{1k}$ captures the benchmark effect of competition on quality (the competition effects). Coefficient $\beta_{2k}$ measures the differential effect of competition on quality before and after the reform (the interaction effects). The next two terms add flexibility to the model by allowing for different time trends in quality: coefficient $\beta_{3k}$ reflects the baseline rate of growth in the $k$th quality in low-competition

markets pre-2009, and coefficient $\beta_{4k}$ captures the difference in the growth rate before and after the reform for areas with low competition. Coefficient $\beta_{5k}$ absorbs the abrupt change in quality assessment in 2011.

## 5 Estimation Results

Table 3 column (1) summarizes the estimates of demand in the first stage. Most coefficients have anticipated signs. First, longer travel distance reduces the likelihood of patronage. Second, serving a high proportion of Medicaid residents hurts the attractiveness of a nursing home while being a for-profit facility raises it. These observations are consistent with previous findings that quality of nursing homes is negatively associated with the proportion of Medicaid residents but positively with the for-profit ownership (Harrington and Swan, 2004; Lau et al., 2004). Other nursing home characteristics– the number of deficiencies, the number of certified bed, and chain affiliation– are insignificant in determining consumers' taste. It is surprising, since previous studies found that chain affiliation and smaller bed size often predict higher nursing home quality (Zimmerman et al., 2002; Harrington and Swan, 2003). One possible explanation would be lack of rationality among consumers.

The F-statistics on the instrument is 26.35 (not reported in the table), confirming that the IV is a good predictor of the competition measure. In addition, a Durbin–Wu–Hausman test (Hausman 1978) is performed for the competition measure in each quality estimation (Equation (6)) to determine if exogeneity could be rejected. The null hypothesis is rejected in all cases. Specifically, the p-values of Durbin-Wu-Hausman tests for competition are 0.000, 0.018, 0.000, 0.007, 0.039, and 0.043 of the six quality regressions, respectively. Rejection of the null hypothesis suggests that the IV estimates should be preferred to the OLS estimates.

Table 3 column (2)-(4) and column (5)-(7) exhibit estimation results for two quality indicators–PRE and UTI [9]– using three models (OLS, IV, and IV with nursing home fixed effects). The model specification with both IV and fixed effects (column (4) and (7)) pro-

[9]Pressure ulcers and UTI are considered the most important chronic-care quality indicators by CMS (Morriset et al., 2003; Konetzka et al., 2008).

duces two interesting findings. First, competition has a positive effect on UTI but no effect on PRE. A one standard deviation (1.57) increase in competition would reduce the incidence of UTI by approximately 9%. [10] Second, the simplification of information fosters positive effects of competition on both quality measures. Compared to pre-policy periods, the post-policy periods experience an additional 1% improvement on both PRE and UTI due to a one standard deviation increase in competition.[11]

Coefficient estimates with both IV and facility fixed effects are the most consistent, even though the three model specifications imply slightly different results. OLS generates more negative and insignificant coefficients on the competition effects, which are likely to be biased downward due to the potential simultaneity between quality and competition. Specifically, higher quality facilities will have greater market shares and will appear to be in less competitive markets, thereby underestimating the effect of competition. In the third model, IV addresses the simultaneity problem and the nursing home fixed effects add additional control to time-invariant factors that may affect both competition and quality.

Table 4 summarizes the estimation results for all six quality measures using the most consistent specification only. The three panels vary by different selections of control covariates. Regressions in panel A controls for facility size, ownership status, chain membership, management efficiency, payer-mix, and staffing. Panel B additionally incorporates several market controls, such as county population, income, and state Medicaid reimbursement rate. In panel C, I further include state-year fixed effects to address the concern that some policies change at the state level might affect both market structure and quality provision in nursing homes.

Overall, competition has rather limited influence on quality, with almost no quality indicators expcet UTI in the basic model increasing with competition. However, information transparency significantly boosts the effectiveness of competition on more quality dimensions regardless of the specific model. Some quality measures do not respond much to either competition or information. This may be partially explained by the imperfection of

[10] That is a reduction in the percentage point of UTI residents (1.57*0.54=0.85) divided by the benchmark percentage of UTI patients (100-90.81=9.19)

[11] That is a reduction in the percentage point (1.57*0.06 for PRE and 1.57*0.07 for UTI) divided by the benchmark percentage (10.79 for PRE and 9.19 for UTI )

the quality measure or the data limitation. The failure to find meaningful effects on PAI is attributed to a potential weakness regarding this quality measure. It is clinically ambiguous whether higher value is consistently associated with better or worse quality. PHY has low prevalence compared to other chronic-stay quality measures (more than one fifth of nursing homes report zero percent rates), which may lead to estimates with less accuracy [12].

### 5.1 Mechanism

A possible mechanism is that the information simplification raises consumers' sensitivity to quality and thus provides stronger incentives for nursing homes to compete effectively. To support this argument, I conduct two tests. The first is to show that the positive interaction effects are not spurious. In other words, the observed differential competition effects before and after 2009 are indeed driven by the information simplification. The second is to investigate if the information simplification has contributed to consumers' understanding of nursing home quality and lead consumers to make informed choices. These two tests together prove the existence of the interaction effects and strengthens the steps through which the mechanism occur.

To confirm that the effect of information simplification is not spurious, I re-estimate equation (6) using the quality measures that are not part of the quality star ratings. These quality measures are exposed less, if any, to the reform of information simplification compared to their counterparts in the main regressions. If the decision of quality is made regardless of how efficiently the information is conveyed to consumers, we would expect similar behavior of these non-simplified quality measures.

Table 5 presents the key estimation results for 9 non-simplified quality measures. For these quality measures, the simplification of information either exerts no influence on the competition effects or leads to negative competition effects. Given the different patterns found for simplified and non-simplified quality measures, it is unlikely that the differential pre- and post- competition effects are entirely attributable to factors other than the information itself. In other words, an improvement in the delivery of provider information plays a key role in nursing homes' decision of quality given comparable market structures.

[12] Design for Nursing Home Compare Five-Star Quality Rating System: Technical Users' Guide

In the second test, I explore how demand varies with quality star ratings before and after 2009. An immediate challenge is that star ratings did not exist before 2009. To overcome this data limitation, I first predict pre-2009 star ratings from an array of clinical quality measures using a non-parametric estimation called the kth-nearest-neighbor (KNN) discriminant analysis. The main idea of KNN is to find the k closest examples of a particular object in the multidimensional feature space, list the categories to which each of the k examples belongs, and assign the object to the category that encompass most of the k neighbor examples. In the current nursing home case, the multidimensional feature space consist of 9 quality measures and the categories are the five-star ratings. It is known that the five star ratings are generated from which quality measures, but the specific formula remains unclear to researchers. Therefore it is more appropriate and convenient to use KNN than a simple linear regression, for KNN can recover the mapping without a specific functional form.

Overall, the KNN model does a good job of predicting in sample. Figure 6 compares the distribution of actual star ratings and that of the predicted star ratings after 2009 as an evaluation of the non-parametric fitting. Panel A illustrates the kernel density of both the actual and the predicted star ratings. The KNN model successfully classifies most nursing homes to their actual quality bins, with a slight over-assignment to the middle level and under-assignment to the two extreme levels. Figure 6 panel B provides the confusion matrix. Numbers on the diagonal reveal the percentage of correct predictions at each star levels. For example, nursing homes that are predicted as a 5-star facility turn out to be an actual 5-star facility with probability $61\%$. The stars are predicted correctly at least $45\%$ of the time and are neither systematically overestimated nor underestimated. Together, the two panels in Figure 6 reveal the validity and the accuracy of the methodology to recover quality star ratings.

Table 6 demonstrates the estimation results of consumers' responses to star ratings. Three measures of demand (log of the patient count, log of the market share, and log of the total number of patients discharged) are regressed against star ratings, the post-reform dummy, and their interactions. The coefficients on star2 to star5 reveal consumer's attitude to better nursing homes pre-2009. The coefficients on the interaction terms capture the pre-post differences in consumers' preference for higher-quality nursing homes relative to 1-star

nursing homes. Before 2009, consumes strictly prefer 1-star nursing homes to 5-star nursing homes and cannot tell the differences between 1-star facilities from 4-star facilities. After 2009, consumers tend to react more strongly and positively to quality. These observations lend support to the hypothesis that neater presentation of quality induces more informed choices from consumers.

# 6 Extensions

## 6.1 Sample Representativeness

The main analysis has focused on rural counties. In this subsection, I explore how far the results can be generalized to urban areas. The base specifications are re-estimated in all markets and in rural markets alone for 12 states. The effects of competition and information are similar regardless of the type of markets. As shown in Table 7, competition has limited impact on quality, and improvement in information tends to facilitate positive effects of competition on quality. With the observation that more quality measures respond to enhanced information accessibility in all markets as opposed to in rural markets only, we expect larger information effects if current study is extended to cover all counties in the U.S.

Due to data limitation, we are unable to complete the rural-versus-all analysis for all 50 states. Instead, we compare all rural nursing homes with non-rural nursing homes nationwide and observe no significant differences in several key aspects. As shown in Figure 7, nursing homes in rural counties display similar distribution of size, management efficiency, and resident payment source as their counterparts. This provides suggestive evidence that our main findings, which are obtained for rural nursing homes, may potentially be extended to the whole market.

## 6.2 Heterogeneous Effects of Competition

The effects of competition and information may be heterogeneous in capacity constraint faced by nursing homes, which is an important characteristic of the industry. We expect less effects in nursing homes with higher occupancy rate (more capacity constraint), because

they are less able to increase sale by raising quality even if the market is sensitive to quality. To test the above "ceiling effect" hypothesis, I run the main specification separately for nursing homes with occupancy rates above and below the sample mean. Table 8 exhibits the estimation results, with the top panel reporting highly occupied nursing homes and the bottom panel the less occupied. Consistent with the hypothesis, the effects of competition and information are larger for nursing homes with less concern about reaching capacity limit.

# 7 Discussions

In the health care industry all over the world, policy makers rely heavily on competition or public quality reporting to promote quality and efficiency (Cooper et al. 2011). This paper assesses the impact of competition on care quality, and more interestingly how quality is affected by the interaction between competition and information transparency. Using the nursing home industry as a case study, I find that competition has a limited effect on clinical quality measures, but the effect becomes significantly stronger as consumers have better access to quality information. One policy implication is that public reporting and competition regulation should be considered jointly to beset promote quality. The result that the information simplification further improves quality suggests the limitation of quality rating in certain markets and prompts necessary supplementary initiatives to mitigate market imperfections.

Several observations are noteworthy. First, results in this paper suggest a multi-task-agency effect. In other words, measuring and rewarding quality in some areas may harm quality in other areas. In this study, I find evidence that health providers are substituting resources away from non-simplified quality measures (e.g. vaccinations) to simplified ones (e.g. pressure ulcers). The reallocation of resources parallels the previous finding that unreported components of quality were adversely affected by quality reporting (Lu 2012). However, the effect should not raise too much concern in this paper. First, non-simplified quality measures are still collected and reported. Their continuous availability to the public puts a cap on the transfer of resources. What is more, the switching of resources itself may

be beneficial. After all, the simplified quality measures are selected for a reason: more reliable, more manageable, and more important. For example, treating pressure ulcers costs the U.S. $11 billion annually (Institute for Healthcare Improvement, 2007), suggesting a $100 million savings from better management of pressure ulcers found in this paper. While on the other hand, influenza vaccination has been proved not cost effective for healthy people between ages 65 and 74 years (Allsup et al., 2004). On balance, the savings would outweigh the costs due to the switching of focus.

Second, the positive yet small effect of information simplification on quality calls for a further optimization in public reporting of provider quality. One important direction is to incorporate consumer satisfaction information into the rating system. In the U.S., quality information of long-term care is gathered only through provider self-assessments and inspections, although perspective of users are often used as a supplement in European counties including Sweden and Finland (Rodrigues et al. 2014). It might be beneficial to collect and post quality measures that are from the residents' point of view. Adding consumer evaluation helps to align the health providers' objective with consumer welfare. It also has the potential to suppress the inflation in current self-reported quality measures, which has already aroused suspicion from the public. Consumer-reported outcomes and reviews, through either public reporting or online feedback mechanism, can potentially complement provider-reported quality indicators regarding clinical care.

This study has some limitations, despite the high number of robustness/specification checks performed. First, due to the data limitation, I treat census tracts as representative consumers to study choice of nursing homes. The underlying assumption is that all individuals over the age of 65 within a census tract are identical. Lacking data on the distribution of socioeconomic characteristics within a census tract, it is difficult to evaluate the credibility of this assumption. However, the fact that the study sample is restricted to rural areas helps to alleviate the concern, because population in rural communities are found more homogeneous than their urban counterpart in social, racial and psychological traits [13].

Another limitation pertains to the test of over-identification. The test is often performed

[13] http://www.yourarticlelibrary.com/difference/rural-urban-differences-demographic-and-socio-cultural-characteristics/39322/

to assess whether the IV affects the outcome variable only via its impact on the instrumented variables. In this study, over-identification cannot be tested because the equation estimated is exactly identified, i.e., the number of instruments and the number of the instrumented variables are the same. However, the main results are unlikely to be undermined, for there is no evidence suggesting that the competition predicted from travel distance (the IV) would affect the quality (the outcome) through channels other than driving the actual competition (the instrumented variable). Future work is required to find more instruments to complete the test.

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# Appendix

## A1: Detailed Descriptions of Quality Measures

This section describes the exact meanings of the quality measures, methods to improve them, and how they may interact with each other.

1) Activities of Daily Living (ADL)

This measure reflects the percentage of long-term care residents who were not losing any of the following four activities of daily living (ADL): the ability to change positions while in bed, to move from one chair to another, to eat independently and to go to the bathroom alone. To improve resident function in ADL, nursing home staff may try to encourage independence, adjust medication, or give a physical and occupational therapy. Among these, encouraging residents to keep doing daily activities with little help is most effective, even though it may take more staff time.

2) Pain (PAI)

This quality measure reflects the percent of residents who were not reported to have moderate to severe pain during the 7-day assessment period. Unlike other quality measures, lower percentage do not necessarily mean a better service provided. It is because a higher score can be a result of a worse pain management or a better job for checking residents with pain. For this reason, improvement in the quality of service provided might not be precisely translated into a better measure score.

3) Pressures Ulcers (PRE)

This quality measure shows the percent of residents without getting a pressure sore in the nursing home. It takes a long time to heal pressure ulcers and complications such as skin and bone infections may follow. Typical ways to help to prevent or treat pressure ulcers include changing the resident's position frequently, providing proper nutrition and using pads on bony parts such as the heel and tailbone since these are the places where pressure ulcers usually develop.

4) Physical Restraint (PHY)

This quality measure reflects the percent of residents in the nursing home who were not physically restrained daily during the 7-day assessment period. There are various types of physical restraints. For example, chairs with lap trays, lap belts, and special types of vests. Physical restraints are supposed to only be used as a part of a resident's medical condition, not for punishing a resident or for making a staff's life easier.

5) Indwelling Catheter (CAT)

This quality measure reports the percent of residents who did not have a catheter inserted and left in their bladder for a period of time during the 14-day assessment period. Inserted catheters may cause urinary tract infections, physical injury, or skin problems. Thus a catheter should only be used when medically necessary, not for the staff's convenience.

6) Urinary Tract Infection (UTI)

This quality measures reflects the percent of residents who did not have an infection in their urinary tract anytime during the 30 days before their most recent assessment. An untreated UTI can spread to other parts such as the bladder and kidney and cause more infections. The most effective way to prevent UTI is to make sure the residents are having good hygiene. It requires nursing home staff to keep the area clean, empty residents' bladder regularly, and provide sufficient drinking fluid.

**A2: Number of Nursing Homes by State and Year**

**Figure A1:** Number of Nursing Homes by State and Year

| State \ Year | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | Total by States |
|---|---|---|---|---|---|---|---|
| AK | 3 | 2 | 1 | 0 | 0 | 2 | 8 |
| AL | 14 | 13 | 22 | 22 | 22 | 21 | 114 |
| AR | 41 | 42 | 42 | 41 | 39 | 38 | 243 |
| AZ | 4 | 4 | 4 | 4 | 3 | 2 | 21 |
| CA | 35 | 40 | 41 | 37 | 41 | 35 | 229 |
| CO | 50 | 55 | 47 | 52 | 50 | 38 | 292 |
| DE | 18 | 18 | 18 | 17 | 12 | 16 | 99 |
| FL | 141 | 137 | 139 | 144 | 143 | 144 | 848 |
| GA | 85 | 82 | 81 | 76 | 66 | 64 | 454 |
| GU | 0 | 1 | 1 | 1 | 1 | 0 | 4 |
| IA | 62 | 59 | 64 | 64 | 57 | 58 | 364 |
| ID | 15 | 16 | 13 | 17 | 15 | 18 | 94 |
| IL | 59 | 55 | 58 | 58 | 60 | 57 | 347 |
| IN | 59 | 61 | 63 | 63 | 64 | 65 | 375 |
| KS | 22 | 21 | 23 | 21 | 23 | 21 | 131 |
| KY | 96 | 94 | 91 | 82 | 95 | 84 | 542 |
| LA | 33 | 36 | 34 | 36 | 36 | 37 | 212 |
| MA | 7 | 6 | 7 | 6 | 7 | 6 | 39 |
| MD | 26 | 24 | 23 | 24 | 23 | 24 | 144 |
| ME | 4 | 3 | 4 | 3 | 4 | 2 | 20 |
| MI | 44 | 45 | 50 | 49 | 47 | 47 | 282 |
| MN | 52 | 55 | 50 | 51 | 53 | 52 | 313 |
| MO | 86 | 89 | 92 | 93 | 90 | 95 | 545 |
| MS | 28 | 28 | 30 | 27 | 27 | 30 | 170 |
| MT | 22 | 23 | 19 | 18 | 16 | 18 | 116 |
| NC | 107 | 104 | 104 | 93 | 100 | 94 | 602 |
| ND | 47 | 44 | 46 | 47 | 49 | 46 | 279 |
| NE | 59 | 55 | 61 | 59 | 61 | 53 | 348 |
| NH | 12 | 12 | 12 | 12 | 11 | 10 | 69 |
| NJ | 135 | 137 | 140 | 132 | 141 | 140 | 825 |
| NM | 6 | 6 | 6 | 4 | 6 | 5 | 33 |
| NV | 1 | 1 | 1 | 1 | 1 | 1 | 6 |
| NY | 50 | 48 | 50 | 45 | 46 | 49 | 288 |
| OH | 68 | 67 | 66 | 69 | 70 | 69 | 409 |
| OK | 21 | 19 | 18 | 18 | 18 | 20 | 114 |
| OR | 12 | 10 | 10 | 11 | 9 | 8 | 60 |
| PA | 96 | 98 | 99 | 100 | 95 | 99 | 587 |
| PR | 5 | 4 | 6 | 6 | 6 | 5 | 32 |
| RI | 30 | 31 | 30 | 31 | 32 | 32 | 186 |
| SC | 37 | 36 | 36 | 39 | 42 | 42 | 232 |
| SD | 41 | 42 | 44 | 42 | 42 | 42 | 253 |
| TN | 47 | 48 | 47 | 40 | 45 | 38 | 265 |
| TX | 63 | 61 | 62 | 65 | 66 | 67 | 384 |
| UT | 32 | 25 | 23 | 23 | 26 | 14 | 143 |
| VA | 116 | 114 | 117 | 117 | 121 | 123 | 708 |
| VI | 0 | 1 | 1 | 1 | 1 | 0 | 4 |
| VT | 2 | 3 | 4 | 3 | 4 | 4 | 20 |
| WA | 25 | 27 | 26 | 26 | 25 | 27 | 156 |
| WI | 29 | 29 | 32 | 30 | 30 | 31 | 181 |
| WV | 20 | 22 | 23 | 19 | 8 | 8 | 100 |
| WY | 1 | 4 | 4 | 4 | 4 | 1 | 18 |
| Total by year | 2068 | 2057 | 2085 | 2043 | 2053 | 2002 | 12308 |

**Figure** 1: Cropped Snapshot of the Five-Star Quality Rating System—-Sorting Nursing Homes

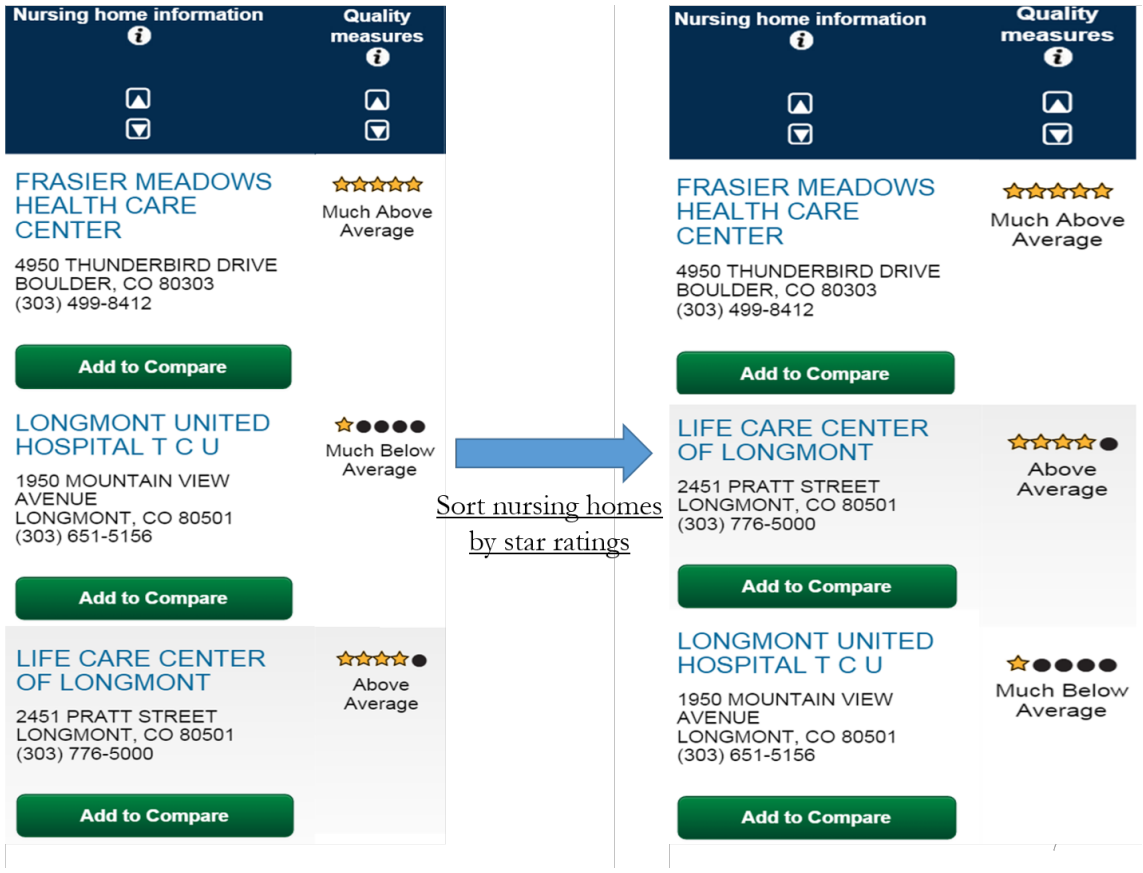
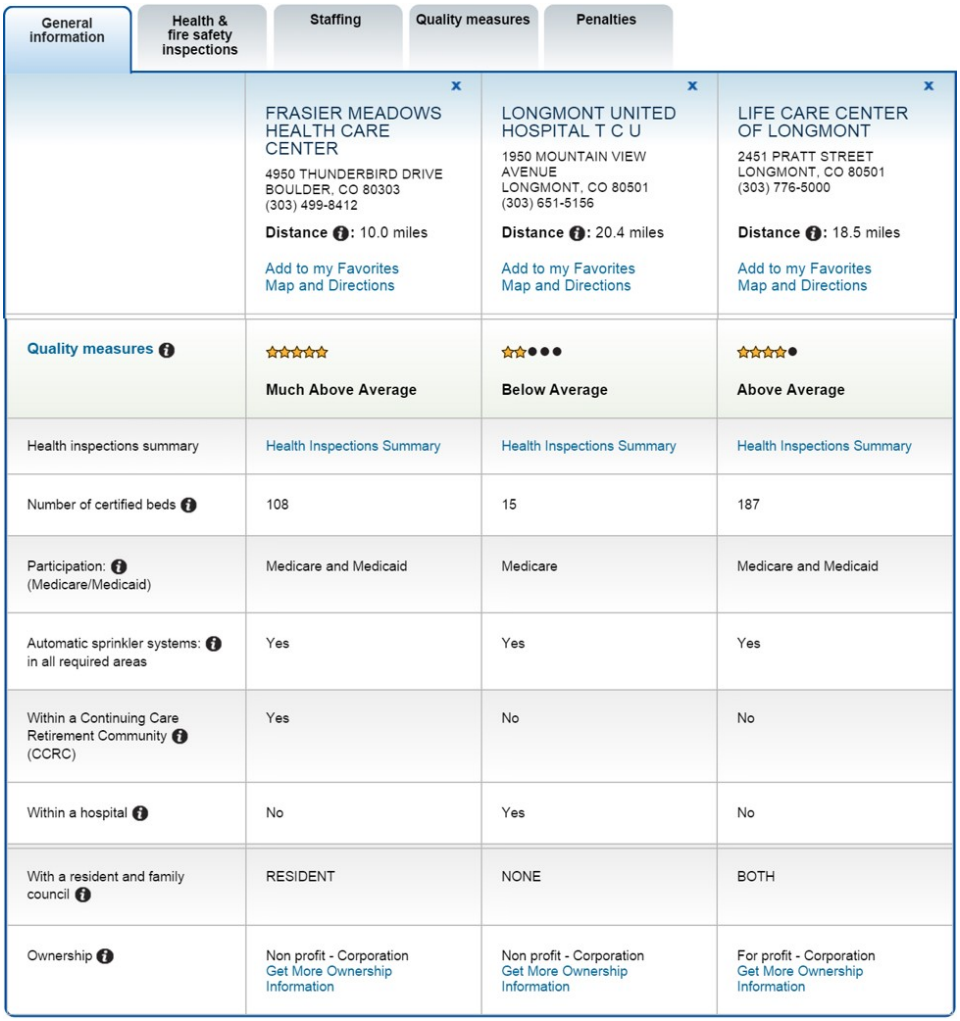


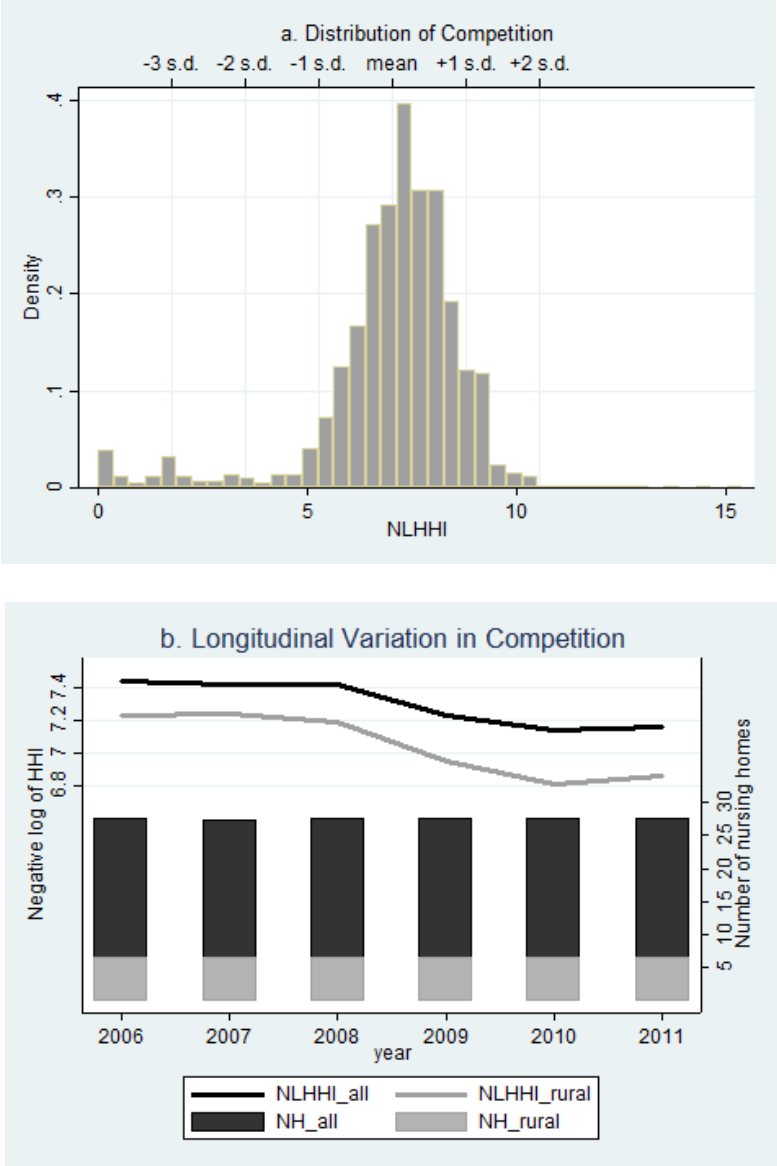
**Figure 2**: Cropped Snapshot of the Five-Star Quality Rating System—-Comparing Nursing Homes



General information | Health & fire safety inspections | Staffing | Quality measures | Penalties

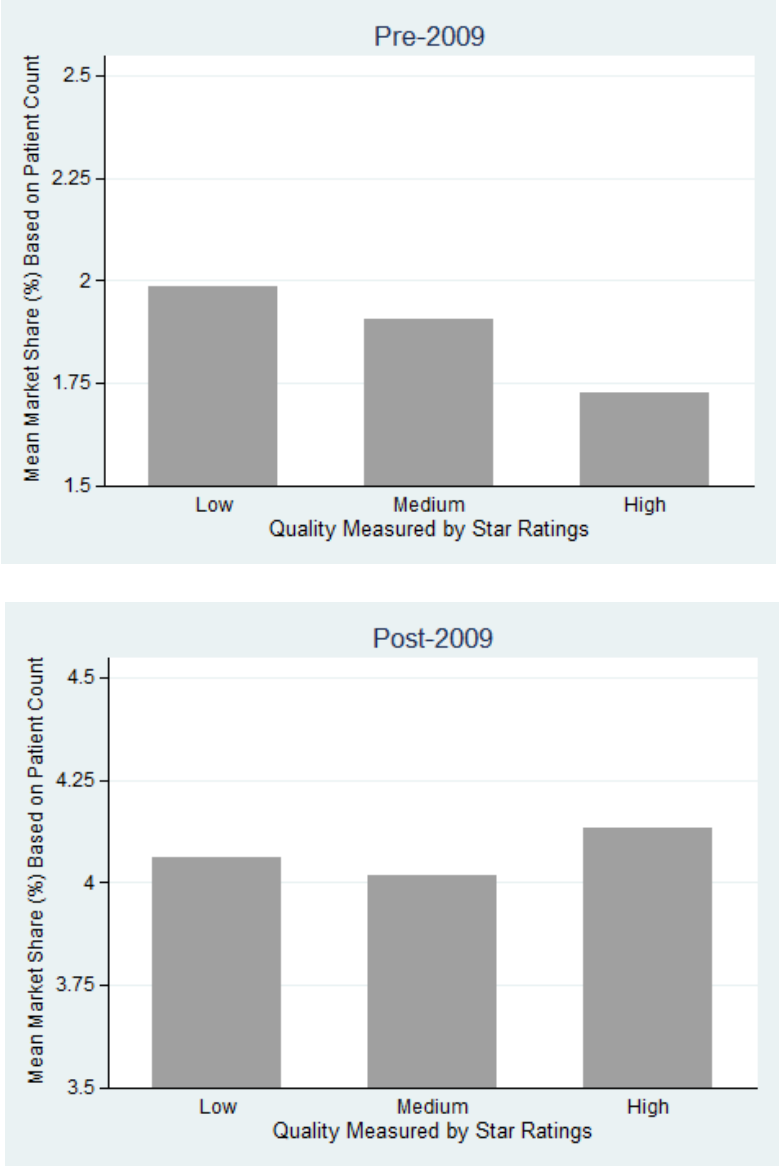
| | FRASIER MEADOWS HEALTH CARE CENTER<br>4950 THUNDERBIRD DRIVE<br>BOULDER, CO 80303<br>(303) 499-8412<br>**Distance**: 10.0 miles<br>Add to my Favorites<br>Map and Directions | LONGMONT UNITED HOSPITAL T C U<br>1950 MOUNTAIN VIEW AVENUE<br>LONGMONT, CO 80501<br>(303) 651-5156<br>**Distance**: 20.4 miles<br>Add to my Favorites<br>Map and Directions | LIFE CARE CENTER OF LONGMONT<br>2451 PRATT STREET<br>LONGMONT, CO 80501<br>(303) 776-5000<br>**Distance**: 18.5 miles<br>Add to my Favorites<br>Map and Directions |
|---|---|---|---|
| **Quality measures** | ★★★★★<br>**Much Above Average** | ★★●●●<br>**Below Average** | ★★★★●<br>**Above Average** |
| Health inspections summary | Health Inspections Summary | Health Inspections Summary | Health Inspections Summary |
| Number of certified beds | 108 | 15 | 187 |
| Participation: (Medicare/Medicaid) | Medicare and Medicaid | Medicare | Medicare and Medicaid |
| Automatic sprinkler systems: in all required areas | Yes | Yes | Yes |
| Within a Continuing Care Retirement Community (CCRC) | Yes | No | No |
| Within a hospital | No | Yes | No |
| With a resident and family council | RESIDENT | NONE | BOTH |
| Ownership | Non profit - Corporation<br>Get More Ownership Information | Non profit - Corporation<br>Get More Ownership Information | For profit - Corporation<br>Get More Ownership Information |

**Figure 3**: Variation in Nursing Home Competition




Source: the Health Care Information System (HCIS) Data File.
NLHHI = NLHHI_rual = average negative log of HHI in rural markets; NLHHI_all = average negative log of HHI in all markets; NH_rural = average number of nursing homes in rural markets; NH_all = average number of nursing homes in all markets.

**Figure 4**: Distribution of Market Shares by Star Quality Ratings: Pre- and Post-2009




Low = 1-2 stars Medium = 3 stars High = 4-5 stars
All observations are from rural markets. The pre-2009 star ratings are predicted from percentage quality measures using a non-parametric estimation. See Section 5.1 for details.

**Figure 5**: Stage 1—Estimating Nursing Home Demand from Travel Distances

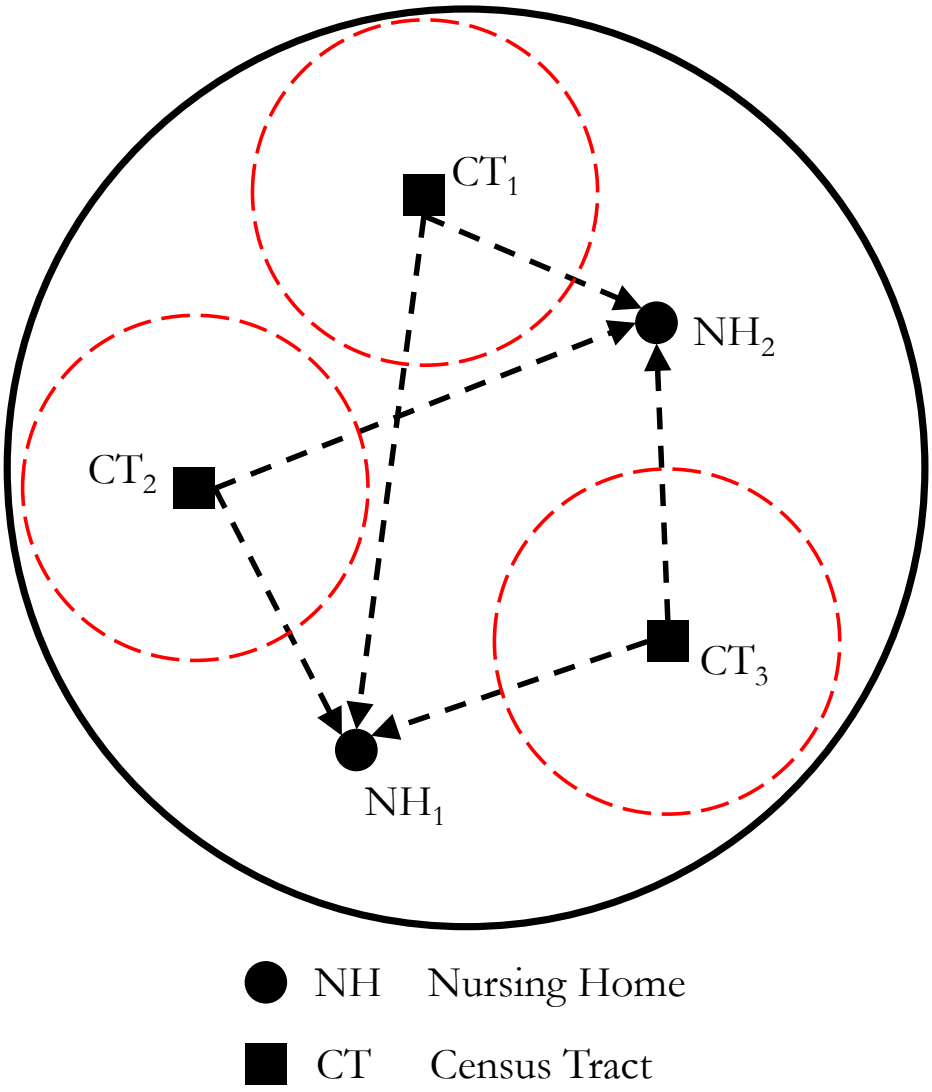
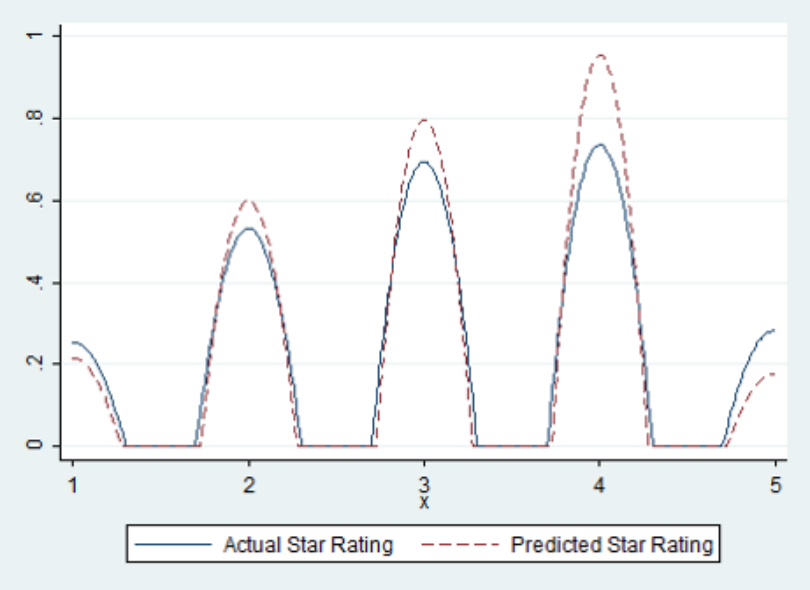


**Figure 6**: Actual Quality Star Ratings Versus Predicted Star Ratings Post-2009

a. Kernel Density




b. Confusion Matrix

| | Actual Star Rating | | | | | |
|---|---|---|---|---|---|---|
| **Predicted Star Rating** | 1 ☆ | 2 ☆ | 3 ☆ | 4 ☆ | 5 ☆ | Total |
| 1 ☆ | **53.34** | 25.43 | 13.09 | 6.81 | 1.33 | 100.00 |
| 2 ☆ | 13.36 | **45.86** | 24.04 | 13.75 | 2.99 | 100.00 |
| 3 ☆ | 6.67 | 17.71 | **46.09** | 23.39 | 6.14 | 100.00 |
| 4 ☆ | 3.19 | 11.15 | 21.38 | **50.48** | 13.80 | 100.00 |
| 5 ☆ | 0.64 | 3.85 | 10.48 | 23.64 | **61.39** | 100.00 |
| Total | 10.17 | 21.27 | 27.79 | 29.45 | 11.32 | 100.00 |

The top panel presents the kernel density of actual star ratings and predicted star ratings. The bottom panel summarizes the confusion matrix. The fitted star ratings are derived from 9 long-stay quality measures using KNN discriminant analysis.

**Figure 7**: Histogram of Nursing Home Characteristics – Rural Versus Non-rural Markets

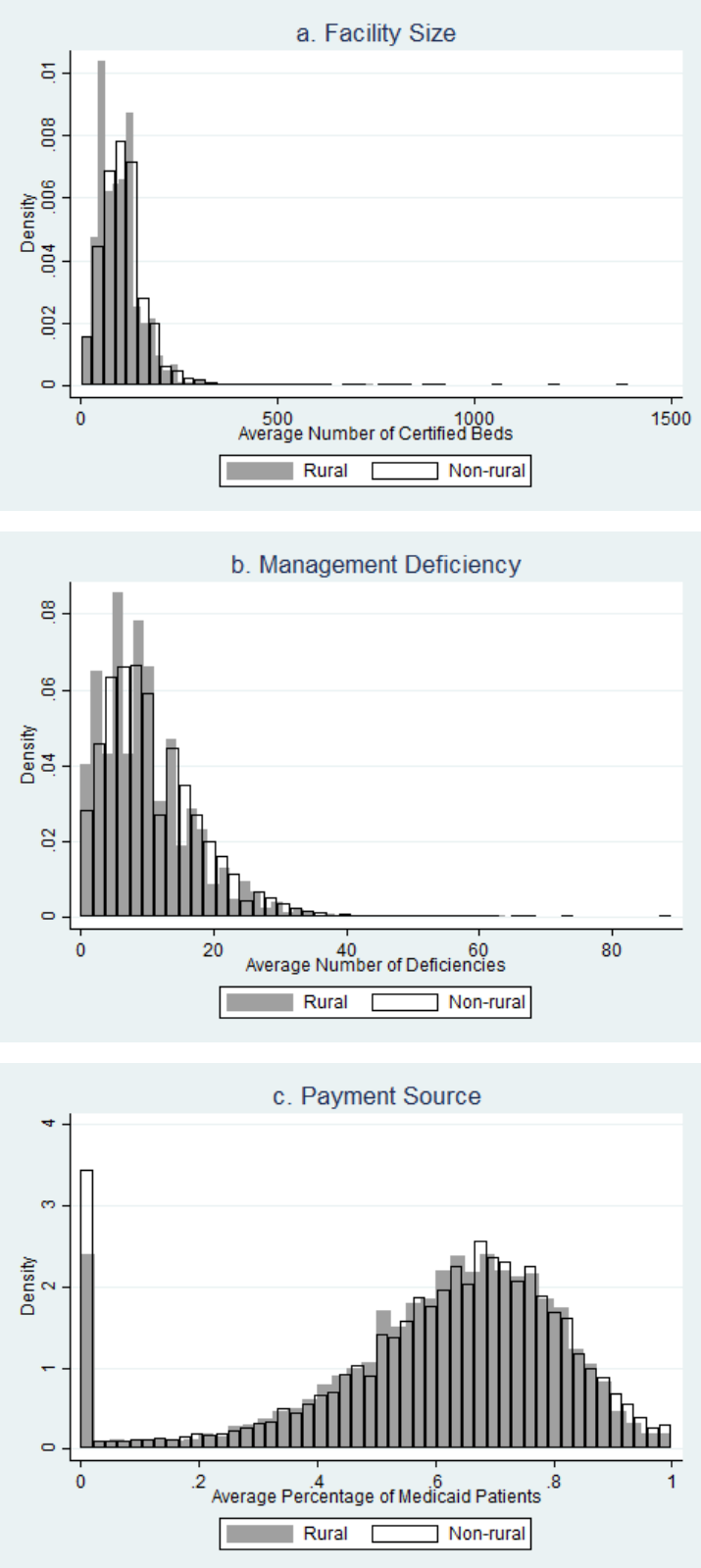


**Table 1:** Cross-correlations of the Quality Measures

| Quality | PRE | UTI | CAT | ADL | PAI | PHY |
|---|---|---|---|---|---|---|
| PRE | 1.00 | | | | | |
| UTI | 0.20 | 1.00 | | | | |
| CAT | 0.20 | 0.22 | 1.00 | | | |
| ADL | 0.01 | 0.08 | -0.01 | 1.00 | | |
| PAI | -0.09 | 0.03 | 0.02 | 0.08 | 1.00 | |
| PHY | 0.09 | 0.05 | -0.01 | 0.04 | -0.01 | 1.00 |

**Table 2:** Summary Statistics of Key Variables and Other Controls

| Variable | Mean | Std. Dev. | N |
|---|---|---|---|
| **Key Variables** | | | |
| *HHI* | 0.02 | 0.12 | 2336 |
| *NLHHI* | 7.03 | 1.57 | 2336 |
| *PRE* | 89.21 | 4.56 | 1736 |
| *UTI* | 90.81 | 3.87 | 2120 |
| *CAT* | 94.60 | 3.23 | 2110 |
| *ADL* | 83.89 | 5.40 | 2045 |
| *PAI* | 94.62 | 3.61 | 2097 |
| *PHY* | 96.19 | 4.41 | 2126 |
| *Distance* | 19.20 | 74.53 | 58431 |
| **Nursing Home Characteristics** | | | |
| *Deficiencies* | 9.70 | 5.21 | 2336 |
| *Beds* | 97.03 | 57.86 | 2336 |
| *Medicaid* | 0.59 | 0.22 | 2336 |
| *Nonprofit* | 0.26 | 0.41 | 2336 |
| *Chain* | 0.51 | 0.43 | 2336 |
| *Nurse hours* | 4.58 | 5.62 | 2336 |
| *Charges* | 314.29 | 69.28 | 2307 |
| *Government-owned* | 0.07 | 0.25 | 2336 |
| **Census Tract Characteristics** | | | |
| *Time2work* | 25.56 | 6.15 | 6967 |
| *Income* | 73409.51 | 35897.44 | 6935 |
| *Population65* | 607.77 | 399.35 | 6967 |
| **Market Controls** | | | |
| *Pop65_county* | 127361.61 | 305511.58 | 812 |
| *Income_county* | 58353.57 | 13996.43 | 812 |
| *Poverty* | 15.59 | 6.39 | 812 |
| *Medicaid payment* | 5291.99 | 1180.92 | 859 |

**Table 3:** Effects of Market Structure on Nursing Home Quality: PRE and UTI

| | Demand | PRE | | | UTI | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) OLS | (3) IV | (4) IV-FE | (5) OLS | (6) IV | (7) IV-FE |
| NLHHI | | -0.05 | -0.37 | 1.10 | -0.07 | 0.06 | 0.54* |
| | | (0.10) | (0.28) | (0.73) | (0.06) | (0.12) | (0.30) |
| NLHHI*after | | 0.01 | 0.02 | 0.06* | 0.04** | 0.04** | 0.07*** |
| | | (0.03) | (0.02) | (0.03) | (0.02) | (0.02) | (0.02) |
| ***Time trends*** | | | | | | | |
| Pre-2009 | | 0.61*** | 0.56*** | 0.33*** | -0.09 | -0.09 | -0.10* |
| | | (0.11) | (0.11) | (0.08) | (0.06) | (0.06) | (0.06) |
| Post-2009 | | 0.63*** | 0.55*** | 0.31** | 0.12 | 0.12 | 0.13 |
| | | (0.14) | (0.15) | (0.15) | (0.11) | (0.11) | (0.11) |
| ***Controls*** | | | | | | | |
| MDS | | 3.07*** | 3.10*** | 3.01*** | 1.10*** | 1.12*** | 1.16*** |
| | | (0.24) | (0.24) | (0.26) | (0.20) | (0.20) | (0.20) |
| Nurse hours | | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 |
| | | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| Charges | | -0.01** | -0.01* | 0.01*** | -0.00 | -0.00 | -0.00 |
| | | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| Government-owned | | 1.81*** | 1.79*** | 0.60 | 0.99*** | 1.01*** | 1.04** |
| | | (0.49) | (0.50) | (0.67) | (0.31) | (0.31) | (0.51) |
| Deficiencies | 0.41 | -0.00 | -0.00 | -0.02*** | -0.00 | -0.01 | -0.02*** |
| | (0.60) | (0.02) | (0.02) | (0.01) | (0.01) | (0.01) | (0.01) |
| Beds | 0.01 | -0.01*** | -0.01*** | 0.00 | 0.00 | 0.00 | 0.00 |
| | (0.41) | (0.00) | (0.00) | (0.01) | (0.00) | (0.00) | (0.01) |
| Medicaid | -2.38 *** | -1.64** | -1.68** | 2.62*** | 3.52*** | 3.53*** | 2.12*** |
| | (0.30) | (0.72) | (0.73) | (0.65) | (0.57) | (0.57) | (0.49) |
| Nonprofit | -1.90 *** | 1.18*** | 1.21*** | -0.73** | 0.79*** | 0.79*** | 0.16 |
| | (0.32) | (0.25) | (0.26) | (0.37) | (0.21) | (0.21) | (0.29) |
| Chain | -0.33 | 0.13 | 0.16 | 0.10 | -0.10 | -0.10 | 0.22 |
| | (0.37) | (0.24) | (0.24) | (0.20) | (0.18) | (0.18) | (0.16) |
| Distance | -1.14 *** | | | | | | |
| | (0.33) | | | | | | |
| $N$ | 210562 | 8378 | 8373 | 8373 | 11002 | 10985 | 10985 |

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
PRE = pressure ulcers, UTI = urinary tract infection
Three model specifications are applied to each of the two quality measures: OLS, IV, and IV with nursing home fixed effects.

**Table 4:** Effects of Market Structure on Nursing Home Quality: All Measures

| **A.Basic Specification** | | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | PRE | UTI | CAT | ADL | PAI | PHY |
| NLHHI | 1.10 | 0.54* | -0.05 | 0.73 | -0.11 | 0.20 |
| | (0.73) | (0.30) | (0.20) | (0.46) | (0.32) | (0.27) |
| NLHHI*after | 0.06* | 0.07*** | 0.03* | -0.00 | 0.01 | -0.03 |
| | (0.03) | (0.02) | (0.01) | (0.04) | (0.03) | (0.02) |
| $N$ | 8373 | 10985 | 10892 | 10473 | 10731 | 10998 |
| **B.Market Controls** | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | PRE | UTI | CAT | ADL | PAI | PHY |
| NLHHI | 1.01 | 0.33 | 0.01 | 0.82 | -0.09 | 0.20 |
| | (0.74) | (0.30) | (0.19) | (0.50) | (0.34) | (0.29) |
| NLHHI∗after | 0.05 | 0.05** | 0.02 | 0.03 | 0.00 | -0.03 |
| | (0.03) | (0.02) | (0.01) | (0.04) | (0.03) | (0.02) |
| $N$ | 8164 | 10580 | 10501 | 10128 | 10353 | 10590 |
| **C.Market Controls and State-year FE** | | | | | | |
| NLHHI | 0.82 | 0.07 | 0.02 | 0.17 | 0.20 | 0.19 |
| | (0.63) | (0.26) | (0.17) | (0.44) | (0.30) | (0.25) |
| NLHHI∗after | 0.30* | -0.01 | 0.04 | -0.21 | -0.18 | -0.05 |
| | (0.17) | (0.12) | (0.08) | (0.20) | (0.14) | (0.12) |
| $N$ | 8164 | 10580 | 10501 | 10128 | 10353 | 10590 |

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
All regressions use IV and nursing home fixed effects. The basic specification is the same as in Table 3.
Market controls consist of county population, median household income, percentage below poverty line, and state Medicaid reimbursement rate. Complete estimation results are available upon requests.

**Table 5:** Effect of Market Structure on Non-simplified Quality Measures

| | (1) INC | (2) BED | (3) LOC | (4) DEP | (5) DEL | (6) INF | (7) PNE | (8) SIN | (9) SPN |
|---|---|---|---|---|---|---|---|---|---|
| NLHHI | -1.17 | -0.01 | -0.01 | 0.96** | 0.23 | -0.34 | 0.21 | 0.54 | 1.06 |
| | (0.76) | (0.22) | (0.38) | (0.48) | (0.47) | (0.61) | (0.78) | (2.73) | (3.24) |
| NLHHI∗after | 0.02 | 0.01 | 0.04 | -0.05 | 0.01 | 0.00 | -0.33*** | -0.17* | -0.30*** |
| | (0.06) | (0.02) | (0.03) | (0.04) | (0.02) | (0.06) | (0.08) | (0.09) | (0.11) |
| $N$ | 8951 | 9210 | 8021 | 10910 | 7635 | 11286 | 11334 | 9713 | 10108 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The dependent variables are seven quality measures that are not selected to form star ratings. Measure (1) to measure (5) reflect the percentage of residents free from certain adverse health status: incontinence, bedfast, worse locomotion, depression, and delirium. The next four reveal the percentage of residents with certain vaccination provided: INF = influenza vaccination, PNE = pneumococcal vaccination, SIN = short-stay influenza vaccination, SPN = short-stay pneumococcal vaccination. Each regression is estimated using IV with facility fixed effects, time trend, and other controls.

**Table 6:** Consumer Response to Quality Star Ratings: Pre- and Post-2009

| | (1) log patient count | (2) log market share | (3) log patient discharged |
|---|---|---|---|
| star2 | -0.01 | -0.01 | -0.02 |
| | (0.01) | (0.01) | (0.01) |
| star3 | -0.03** | -0.03*** | -0.04** |
| | (0.01) | (0.01) | (0.02) |
| star4 | -0.02 | -0.02* | -0.04** |
| | (0.01) | (0.01) | (0.02) |
| star5 | -0.07** | -0.07*** | -0.10** |
| | (0.03) | (0.03) | (0.04) |
| after | -0.01 | -0.04*** | -0.01 |
| | (0.01) | (0.01) | (0.02) |
| star2*after | 0.02 | 0.02 | 0.05* |
| | (0.02) | (0.02) | (0.02) |
| star3*after | 0.05*** | 0.05*** | 0.07*** |
| | (0.02) | (0.02) | (0.02) |
| star4*after | 0.04** | 0.05*** | 0.07*** |
| | (0.02) | (0.02) | (0.02) |
| star5*after | 0.14*** | 0.14*** | 0.19*** |
| | (0.03) | (0.03) | (0.04) |
| $N$ | 7100 | 7100 | 7095 |

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
star2-star5 are indicators of 2-star nursing homes to 5-star nursing homes. The omitted group is the 1-star nursing homes. after = 1 if year$\geq$2009. Star2*after to star5*after are the interactions between the after dummy and star rating categories. Star ratings before 2009 are obtained using a nonparametric estimation from percentage quality ratings, see Section 5.1 for details.

**Table 7:** Effect of Market Structure on Nursing Home Quality: All Markets Versus Rural Markets in 12 States

| **All Markets** | | | | | | |
|---|---|---|---|---|---|---|
| | (1) PRE | (2) UTI | (3) CAT | (4) ADL | (5) PAI | (6) PHY |
| NLHHI | -1.41 | 0.17 | 0.13 | -1.43 | 0.23 | -0.11 |
| | (0.92) | (0.44) | (0.45) | (1.13) | (0.33) | (0.43) |
| NLHHI*after | 0.25** | -0.04 | 0.08* | 0.15 | 0.03 | -0.01 |
| | (0.10) | (0.04) | (0.04) | (0.11) | (0.04) | (0.04) |
| $N$ | 5753 | 7512 | 7457 | 7151 | 7326 | 7517 |
| **Rural Market** | | | | | | |
| NLHHI | -0.36 | -0.25 | 0.75* | 0.25 | -0.05 | -0.09 |
| | (0.67) | (0.38) | (0.39) | (0.48) | (0.24) | (0.26) |
| NLHHI*after | 0.10 | 0.07 | 0.24*** | 0.00 | 0.07 | -0.04 |
| | (0.11) | (0.09) | (0.08) | (0.10) | (0.07) | (0.05) |
| $N$ | 889 | 1415 | 1396 | 1312 | 1372 | 1415 |

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
The 12 states include Alaska, Alabama, Delaware, Iowa, Idaho, Louisiana, Maine, Montana, North Dakota, New Hampshire, New Mexico, and South Carolina. The primary selection criterion lies in the calculation burden.

**Table 8:** Effect of Market Structure on Nursing Home Quality – High-occupancy Versus Low-occupancy

| **High Occupancy** | | | | | | |
|---|---|---|---|---|---|---|
| | (1) PRE | (2) UTI | (3) CAT | (4) ADL | (5) PAI | (6) PHY |
| NLHHI | 0.32 | 0.65 | 0.27 | 0.64 | -0.86 | 0.60 |
| | (0.65) | (0.44) | (0.28) | (0.70) | (0.53) | (0.44) |
| NLHHI∗after | 0.01 | 0.05* | 0.02 | -0.01 | 0.01 | -0.01 |
| | (0.04) | (0.03) | (0.02) | (0.05) | (0.04) | (0.03) |
| $N$ | 4923 | 5829 | 5802 | 5687 | 5751 | 5834 |
| **Low Occupancy** | | | | | | |
| NLHHI | 3.64 | 0.79* | -0.30 | 0.44 | 0.49 | -0.18 |
| | (2.82) | (0.47) | (0.32) | (0.74) | (0.49) | (0.41) |
| NLHHI∗after | 0.19* | 0.08** | 0.05** | 0.01 | 0.01 | -0.07** |
| | (0.10) | (0.04) | (0.02) | (0.06) | (0.04) | (0.03) |
| $N$ | 3450 | 5156 | 5090 | 4786 | 4980 | 5164 |

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Each regression is estimated using IV with facility fixed effects, time trend, and other controls as in Table 3.