UNTANGLING THE RELATIONSHIP BETWEEN NEIGHBORHOOD DISADVANTAGE, QUALITY, AND COVID-19 OUTCOMES IN OHIO NURSING HOMES: A SPATIAL ANALYSIS APPROACH

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ABSTRACT

The COVID-19 pandemic has exposed vulnerabilities within the healthcare system, with nursing homes in under-resourced communities particularly impacted. Numerous studies have linked community socioeconomic status to both care quality and COVID-19 outcomes in these settings, suggesting that nursing homes in disadvantaged neighborhoods provide lower quality care, resulting in poorer health outcomes for residents. However, whether high-quality nursing homes can effectively reduce these health disparities remains unclear. Additionally, conventional long-term care research often overlooks spatial relationships, which can introduce bias into findings. Understanding these dynamics is essential for building resilience against future health emergencies.

This study explores the relationships among neighborhood disadvantage, care quality, and COVID-19 outcomes in Ohio nursing homes, examining the potential influence of spatial relationships. While nursing homes in more disadvantaged areas generally exhibit lower quality performance, these quality metrics do not show significant associations with neighborhood socioeconomic status after adjusting for organizational factors and resident characteristics. Instead, quality performance is associated with factors like financial health (e.g., Medicaid payor mix, occupancy rates), stable in-house staffing, consistent leadership, and resident demographics.

The study also reveals consistently high mortality risks among residents in nursing homes located in disadvantaged neighborhoods, which are unaffected by quality performance indicators. While COVID-19 incidence rates among residents and staff show no significant associations with neighborhood socioeconomic status, higher CMS Five-Star Staffing ratings and resident satisfaction scores significantly reduce resident COVID-19 incidence rates over the two-year pandemic period. Conversely, higher CMS Five-Star Overall, Health Inspection, and Staffing ratings are linked to increased staff COVID-19 incidence rates, with community incidence rates and organizational factors also influencing outcomes.

Significant spatial effects are identified across quality measures, including CMS Five-Star ratings and resident and family satisfaction scores, providing nuanced insights into rurality and other nursing home characteristics. Modest spatial effects are also observed in resident COVID-19 cases during the pre-vaccination period, highlighting the importance of spatial dynamics in public health responses.

These findings underscore the complex interplay between neighborhood disadvantage, quality performance, and COVID-19 outcomes in nursing homes. Addressing these disparities requires targeted interventions that account for the intricate interdependencies within nursing home settings. Policymakers and researchers should consider spatial analyses when developing interventions, as overlooking spatial dynamics could lead to ineffective solutions.

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DEDICATION

This dissertation is dedicated to my parents, Ruihua Qin and Yuguang Qiu, and to my husband, Justin Singree.

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Untangling the Relationship Between Neighborhood Disadvantage, Quality, and COVID-19 Outcomes in Ohio Nursing Homes: A Spatial Analysis Approach

Chapter 1: Introduction

Despite the recent expansion of in-home care and assisted living, nursing homes remain a critical component of the long-term care system, often serving as the final stop for individuals across various long-term care settings. The ongoing coronavirus disease 2019 (COVID-19) pandemic has put providers under enormous strain, from protecting vulnerable residents and frontline workers from the virus to surviving under extreme COVID-era staffing shortages and higher operation costs. It was even more challenging for nursing homes located in socioeconomically disadvantaged neighborhoods that already struggled to take care of a more vulnerable population with limited resources even before the pandemic. A good understanding of how nursing homes in neighborhoods with different levels of socioeconomic resources deliver quality care and manage the virus during the pandemic is needed. Findings from current nursing home literature are limited due to the absence of taking into account the characteristics of neighboring providers when studying nursing home quality and COVID outcomes, thus findings might be misleading. Moreover, it is unknown whether nursing home quality would buffer the adverse consequences of neighborhood socioeconomic disadvantage on nursing home residents and employees. Investigation of this specific mechanism is needed to prepare policymakers and providers for future damaging disasters like the COVID pandemic.

To address the above gaps, using a disadvantage metric at the census block group level, this dissertation project begins with examining whether socioeconomic resources available in neighborhoods explain the differences in Ohio nursing home performance of quality and managing COVID, using a spatial analysis approach to account for potential impacts from other nursing homes. This study then also examines whether good quality could help providers overcome challenges that restrained community resources brought in protecting their residents and staff from the COVID-19 virus. This chapter introduces the background and significance of the problem, specifically, how socioeconomic resources available in communities might shape providers' performance during COVID. In addition, it briefly describes the rationale for using the geospatial method to approach such research questions. This chapter also demonstrates this study’s contributions and its potential implications for research, practice, and policy.

Nursing Home Industry Under the Pandemic

Since the initial outbreak in December 2019, the coronavirus (COVID-19) is still an ongoing pandemic. This contagious respiratory virus spread vastly and quickly often via asymptomatic carriers and has taken away over one million Americans' lives over the past two years (Centers for Disease Control and Prevention, 2022a). The COVID-19 disease also has disproportionately affected populations that are older age, minority, lower socioeconomic status, and with compromised health (Jordan et al., 2020; Nayak et al., 2020). Congregate settings like nursing homes that primarily serve the older population with multiple underlying health conditions are a particularly worrisome location during this pandemic. Nursing home residents and staff have accounted for over fifteen percent of COVID-19 deaths in the U.S. (Centers for Disease Control and Prevention, 2022b, 2022a).

About 15,600 U.S. nursing homes are currently providing services for over 1.3 million individuals with physical and/or cognitive care needs (Harris-Kojetin et al., 2019), and are projected to host a population to be even less healthy than the current cohort because of high obesity and smoking rates (Hooyman et al., 2016). Nursing home residents are extremely vulnerable to COVID-19. The COVID-19 death rate is much higher among older residents who are 65 or above than their counterparts outside of nursing homes (Cronin & Evans, 2022). Residents are susceptible to COVID-19 not only because of their compromised health but often they have to share a small room with another resident with a very small space between beds. In addition, many residents need assistance with daily activities (e.g., eating, dressing) and thus often have close contact with care workers. Nursing aides provide care from room to room and can asymptomatically carry the virus. Due to these factors, maintaining physical distancing was nearly impossible, making nursing homes one of the highest-risk settings for COVID-19 transmission.

Nursing home staff is also of concern during this pandemic. Positions of nursing home staff include but are not limited to direct care staff (e.g., certified nursing assistants [CNAs]), clinical care staff (e.g. physicians, registered nurses [RNs], etc.), and ancillary staff (e.g., activity director, cook, etc). At the beginning of the pandemic, nursing homes experienced a severe shortage of personal protection equipment (PPE) (e.g., masks, gloves, etc.), which put staff at high risk of contracting the disease. Even before the pandemic, nursing home jobs were not considered desirable compared to alternatives because they are poorly paid and physically and

emotionally demanding. This pandemic has only put the nursing home workforce in a more challenging situation. Many infection and control protocols have drastically increased the workloads of nursing home staff. For example, visitors were banned for about half a year in nursing homes, reducing the availability of informal care from family and friends. All these factors have contributed to the extreme COVID-19 nursing home staffing shortage with more than 400,000 care workers departing from the nursing homes for better healthcare jobs or positions in other industries over the past two years of the pandemic (U.S. Bureau of Labor Statistics, 2022).

Staffing is the largest cost for operating a nursing home, this severe pandemic staffing shortage has only made the situation even more challenging (Xu et al., 2020). To keep up with staffing, providers have to offer higher pay to retain staff and/or hire temporary staff, which often costs more. The majority of providers heavily rely on government payment programs such as Medicaid which can hardly cover the actual costs, let alone increase pay. With the staffing issue exacerbated, operating a nursing home is continuously getting more expensive. Many providers eventually had to limit their admissions and might be forced to close (AHCA & NCAL, 2022). Adequate staffing is one of the key factors for providing good quality care (Castle, 2008). With the baby boomer generation passing the age of 65 and experiencing significantly improved life expectancies, we are facing an unprecedented rise in the older population. We cannot afford to lose more nursing home staff; knowledge of protecting residents and staff from a disastrous event like COVID is much needed for the U.S..

The early stages of the COVID-19 pandemic also highlighted failures in the nursing home industry, including racial and ethnic disparities, which can be attributed to long-standing systemic inequalities (e.g., Li et al., 2020; Lord et al., 2021). These disparities reflect deep-rooted issues in access to quality care, staffing resources, and funding, all of which disproportionately impact minority communities and exacerbate health outcomes for vulnerable populations within nursing homes (Carlson & Selassie, 2022). Approaches to address COVID-19 disparities in these settings are urgently needed. One approach is using small-area socioeconomic metrics, also known as neighborhood disadvantages, to detect, react to, and ultimately enable equitable resource allocation with a larger goal of mitigating health disparities in nursing home settings.

Neighborhood Disadvantage, Nursing Homes, and COVID-19

Neighborhood disadvantage is an overall proxy of social and economic conditions for communities that describes critical aspects of social organizations, structure, stratification, and environments. Racial/ethnic minority and socioeconomically disadvantaged individuals in the United States often reside in impoverished neighborhoods that have limited access to food and health care, ongoing safety issues, risky environmental exposures, and adverse health-related outcomes (Kind et al., 2014; Richardson et al., 2014; Steenland, 2004). The individual-level socioeconomic risk factors of health can be amplified due to residential segregation. More importantly, literature has suggested that neighborhood disadvantage affects health independently of individual-level socioeconomic status (Hu et al., 2018; Ludwig et al., 2011). Of importance are the limited living options of these community members who cannot afford to live or access care in affluent areas; they are more likely to have worse health over the life course (Surachman et al., 2019). Nursing homes in disadvantaged neighborhoods primarily serve minority and socioeconomically disadvantaged populations who might have more underlying health conditions, and therefore, may be more susceptible to higher COVID-19 infection and mortality.

Some recent findings have highlighted associations between community-level socioeconomic factors and nursing home COVID-19 outcomes. Looking at socioeconomic resources at the ZIP-code level, Lord and his colleagues (2021) found that a lack of community socioeconomic resources is associated with higher infection rates in nursing homes. Just like other health conditions, COVID outcomes can be significantly affected by socioeconomic resources available in communities. Communities with lower socioeconomic resources are facing greater challenges to apply COVID prevention and control strategies. For example, poor housing conditions are associated with worse sanitation, overcrowding, and decreased ability to physically distance, which all increase risk for COVID-19 transmission. As the pandemic evolves, evidence has suggested that the COVID-19 disease does not evenly distribute across locations and groups. Studies have shown that individuals with socioeconomic disadvantages and/or who are from communities with limited socioeconomic resources are disproportionately affected by this ongoing global COVID pandemic regardless of incidence, mortality, and severity of symptoms (Clouston et al., 2021; Tipirneni et al., 2022).

The nursing staff has been considered a source of transmission of COVID-19 in nursing homes (McGarry et al., 2021; Shen, 2022). Nursing homes in disadvantaged communities employ a majority of their care workers from the same or neighboring communities where that transmission risk is already high due to the limited employment opportunities in those areas. As mentioned earlier, nursing home care workers are underpaid, which means that they often have to either work at multiple facilities or seek work in other fields to make ends meet. Along with the extended pressure from taking care of vulnerable populations during the COVID, nursing homes in disadvantaged neighborhoods might even experience more severe staffing shortages than their counterparts in well-off neighborhoods. They might face more difficulties in retaining and recruiting staff and either have to rely on temporary or contract nurses who are more costly or sacrifice adequate staffing for care. All these factors could make staff and residents in providers that are in disadvantaged communities more vulnerable to COVID.

The levels of socioeconomic resources that are available in communities have also been recognized as an important factor for the quality and financial performance of healthcare organizations (Park & Martin, 2018; Weech-Maldonado et al., 2019). A weaker community economy and a less vibrant civic life deplete physical or social resources from communities that could help them to attract health providers or skilled health workers (Fiscella & Williams, 2004). Limited community assets also constrain the development of local institutions (i.e., schools, clinics, churches, etc.), which are part of the social networks where information about social services and healthcare is obtained (Browning & Cagney, 2002). Additionally, nursing homes located in more impoverished communities are more likely to be occupied by residents that are paid for by Medicaid. Financial strain can be a challenge for these facilities and further inhibits them from improving quality.

One way to better understand COVID or more general health disparity is to incorporate socioeconomic status in quality measures, which is an ongoing debate in the hospital industry. Concerns are between hospitals caring for more poor patients being unfairly penalized and the possibility of creating substandard quality of care for socioeconomically disadvantaged individuals. This mirrors the reality and challenges for nursing home providers in disadvantaged neighborhoods. Nursing homes in communities with limited socioeconomic resources may face challenges beyond their control in performing well as rated by current quality indicators for several reasons. First, individuals residing in limited-resources communities are more likely to

have low socioeconomic status themselves, which may prevent them from choosing nursing homes farther away. They also are more likely to have to rely on Medicaid to pay for their care. Lower Medicaid reimbursement rates can put resource constraints on providers and lead to the inability to attract effective management or staff to provide quality care.

Second, nursing homes highly dependent on Medicaid funding are often located in disadvantaged communities, which face challenges in attracting healthcare professionals and have a higher risk of adverse health outcomes. During the pandemic, these communities experienced significantly higher COVID-19 transmission rates than more affluent areas, making infection prevention within nursing homes even more challenging (Noppert et al., 2023). Medicaid residents are primarily the disadvantaged population living in deprived communities. Both individual-level and community-level socioeconomic disadvantages are significant risk factors for adverse health outcomes and less social support, which are characteristics associated with outcomes residents received in nursing homes (Bosma et al., 2001; Robinette et al., 2016; Stringhini et al., 2017; Thompson et al., 2016; Weyers et al., 2008). More importantly, the current system primarily addresses issues with existing conditions among older adults, only a very small proportion of public funding is allocated to preventive care services (R. Applebaum & Kunkel, 2018). Conditions or disabilities are already severe when elders receive assistance from Medicare or Medicaid. Also, elders with care needs cannot be eligible for Medicaid until the service depletes their assets. In other words, those who use Medicaid as their payment source might have lived under severe conditions for an extended time, and those conditions are much more likely exacerbated when they are qualified for the Medicaid payment. These nursing homes may falsely be given the tag of low-quality, even if they deliver similar care as those who perform well in quality indicators used.

Neighborhood disadvantage or small-area socioeconomic metrics might be a useful tool to address health disparities, especially in the nursing home system where the primary consumer population is older adults. Although significant associations between income and health outcomes are suggested in existing literature, measuring individual-level economic variables is difficult in a large population as it is often not documented well in electronic records. For example, Medicare claims data does not update much on economic information for individuals, which makes it not valid and reliable for the older population. Therefore, such information is practically challenging for public reporting or incorporation into health policy. More

importantly, solely individual-level income-based measures ignore the independent influence of neighborhood contexts, which might not sufficiently capture social risk factors and social determinants that describe social processes and social relationships such as a socioeconomic position that may influence individuals' health (Singh, 2003). An appropriate metric for capturing social risk for the older population's health is needed to be considered in long-term care research. This study will use the Area Deprivation Index (ADI), a measure that incorporates various perspectives of disadvantage, to investigate the quality and COVID-19 issues in nursing homes.

When good quality is in place, improved health outcomes are expected. Nursing home quality itself might be a determinant of COVID-19 cases and deaths in nursing homes. Existing evidence on nursing quality and COVID outcomes are mixed and most are based on the Centers for Medicare & Medicaid Services (CMS) Five-Star Rating as quality measures (Abrams et al., 2020; J. Bowblis & Applebaum, 2021; He et al., 2020; Kitchen et al., 2021; Y. Li et al., 2020). The CMS Five-Star Rating evaluates performance from statewide health inspection surveys, staffing levels, and resident outcomes and generates four ratings including an overall rating summarizing all other three domains for each provider. While the CMS Five-Star Rating is widely used in nursing home literature, it fails to include perspectives of quality from customers who are the ultimate experts about the care they or their family members receive. More importantly, consumers' perspectives of quality have a subjective nature, which is likely to be influenced by consumers' impressions of the communities in which nursing homes are located. Currently, only one study conducted in Maryland has included consumer perspective of quality and found no association between family satisfaction and resident COVID-19 cases (Mattingly et al., 2021). Additionally, these studies were conducted in the early stage of the pandemic, therefore it is unknown if relationships persist in Ohio and over the whole course of the pandemic after some immediate crises were addressed (e.g., vaccination rates, PPE availability). This study will extend existing work on the impact of neighborhood disadvantage on nursing home performance by incorporating both perspectives of quality from consumers and the CMS in the context of COVID-19.

Given potential relationships between neighborhood disadvantages, quality, and nursing home COVID-19 outcomes, what remains unknown is what role nursing home quality plays in the relationship between neighborhood socioeconomic resources and nursing home COVID-19

outcomes. In other words, are failures in protecting nursing home residents and staff from the COVID-19 pandemic merely a result of constrained community resources or are they a result of substandard quality of care stemming from a lack of critical resources? If good quality in nursing homes successfully protects residents and staff from the harm of COVID-19 despite constrained community resources putting some facilities in disadvantageous positions, research and policy attention could be paid to quality improvement among providers in disadvantaged neighborhoods. If quality does not buffer the risk of severe diseases like COVID-19 in nursing homes within disadvantaged communities, policymakers and researchers might want to focus efforts on strengthening control and prevention strategies to protect elders and workers in these neighborhoods.

Geospatial Analyses for COVID-19

To make correct interpretations and provide appropriate recommendations to research and policy, the impact of neighborhoods on nursing home quality and COVID-19 outcomes and whether quality in a nursing home mediates the negative impact of COVID-19 in nursing homes need to be carefully examined.

Conventional nursing home literature largely ignores the spatial effects and processes underlying data by using aggregate information from larger or geopolitical boundaries. It is widely believed by geographers, spatial statisticians, and spatial economists that "everything is related to everything else, but near things are more related than distant things." (Tobler, 1970). Failures of recognizing such effects would lead to bias in findings and ultimately a misleading interpretation. For a disease like COVID-19 that could spread through asymptomatic carriers, effectively protecting residents and staff in one nursing home would reduce the risk of further transmission to communities therefore spatial spillover effects might occur. Worse COVID-19 outcomes in one nursing home could potentially increase the risk to neighboring providers. In addition to spillovers of the disease, quality in one’s own nursing home might also be affected by the quality of neighboring providers through competition and knowledge spillovers. All these potential spatial effects likely do not conform to specific geographic boundaries. This study will use a fixed distance to define the influence of other nursing homes' characteristics on a facility's own quality and COVID-19 outcomes, as well as spatially correlated factors that may be difficult to access. This approach aligns with the concept that entities are more influenced by closer objects and less by those further away, allowing for a more precise analysis of proximity-based

impacts. Unlike traditional nursing home literature that examines contextual level factors of provider performance only by including aggregate information from predefined geographic boundaries, I will account for spatial interaction between nursing homes by using different specifications of spatial models. Justifying the existence of these potential spatial patterns among nursing homes will be a necessary precursor to power more robust research designs including the experimental, quasi-experimental, and longitudinal design which allows a better understanding of how contextual factors can influence COVID-19 outbreaks as well as care service in long-term care settings. Resource planning and policy development could also potentially benefit from the understanding of these spatial interactions between nursing homes.

For example, current policies strictly control healthcare costs, with many states, including Ohio, operating under Certificate of Need (CON) laws that limit the supply of long-term care services. Insufficient provider concentration in a market may drive up prices for private payers, which could lead some consumers to qualify for Medicaid more quickly. The CON program operates at the county level, which may not be the most cost-effective approach, as nursing homes often compete with other providers in smaller geographic areas, such as neighborhoods or census block groups, especially for facilities near county borders. Planning at different geographic levels should be guided by evidence-based research. For quality performance influenced by market competition—which doesn't necessarily follow administrative boundaries—it is essential to account for spatial relationships to yield more accurate and reliable insights. In this context, state planning agencies can make more informed decisions about permitting new nursing homes, ensuring an optimal market concentration that encourages quality improvements.

The primary inquiry of this study is to assess whether good care in nursing homes can combat the challenges of resource constraints in the community to protect residents and staff from COVID-19. To complete the inquiry, this study will use census block group level of disadvantage and the spatial models explicitly accounting for spatial effects among all nursing homes with the following three specific aims

Aim 1: to examine the association between neighborhood disadvantage and nursing home quality of CMS Five-Star Rating and resident and family satisfaction among Ohio nursing homes.

Aim 2: to investigate associations between neighborhood disadvantage and COVID-19 outcomes in nursing homes,

Aim 3: to explore the role of nursing home quality in the relationship between neighborhood disadvantage and COVID-19 outcomes

Aim 4: to determine whether spatial effects should be accounted for when evaluating the relationships between neighborhood disadvantage, nursing home quality, and COVID-19 outcomes as explored in the previous aims.

Chapter 2: Literature Review

Neighborhood Disadvantage Metrics ADI

Neighborhood disadvantage is a modifiable and actionable factor that can be addressed at the policy level in long-term care settings for reducing health disparity as well as improving the economic well-being of disadvantaged communities. Low-income and minority populations often aggregately reside in more deprived communities that collectively affect their access to food, safety, education, positive health behaviors, as well as better physical and mental health outcomes (Kind et al., 2014; Ludwig et al., 2011; Sheets et al., 2017; Thornton et al., 2016). More importantly, evidence suggests neighborhood disadvantage is associated with health independently of individuals' socioeconomic positions (Hu et al., 2018; Ludwig et al., 2011).

Addressing neighborhood disadvantages in long-term care settings is especially critical for communities that are socioeconomically deprived. In a two-tiered system, Mor and his colleagues (2004) found that lower-tiered nursing homes that serve mainly Medicaid residents are more likely to locate in disadvantaged communities and are more vulnerable to close voluntarily due to financial difficulty or even, involuntarily due to severe health deficiencies. Closures of these lower-tiered nursing homes not only affect current residents, but also these disadvantaged communities where they live as a whole. Many of the current residents in lower-tiered nursing homes are race/ethnic minorities and/or have a history of mental health issues; failures of these providers might lead to the loss of institutional long-term care options for these historically underserved populations (Mor et al., 2004). For socioeconomically disadvantaged communities where opportunities are limited, closures of these Medicaid-dependent nursing homes would result in losing employment as nursing assistants, a stable source of income for members of these communities.

With the significance of health disparity and aging issues in the US, it's worthwhile investigating the benefits of incorporating neighborhood disadvantages into resource planning and policy development in the context of long-term care. Many countries such as the UK have accounted for neighborhood disadvantage in policy development through payment adjustment and quality metric adjustments to protect providers in disadvantaged communities from being penalized for housing more underserved populations, however, they are rarely employed in the US (Smith & Witter, 2004). One of the major reasons for this dilemma is the lack of evidence of how neighborhood disadvantages guide quality metrics and payment adjustments as well as

health interventions. Addressing neighborhood disadvantages to policy, research design, and practice for healthcare requires a metric that could appropriately be characterizing U.S. communities.

Previous nursing home literature measured community disadvantaged at different geographic levels (C. Reed & Andes, 2001; Mor et al., 2004; Park & Martin, 2018; Reed et al., 2001; Weech-Maldonado et al., 2021; Yuan et al., 2018), but each of these is distinct from each other and might not necessarily align to characterize US communities. Some nursing home literature assumes the county is a proxy for a community when studying the influence of neighborhood disadvantage (Mor et al., 2004; Yuan et al., 2018). The rationale behind this decision is that county is the administrative division of a state and is used in legislation and policymaking for resource planning and allocation. Although these measures are helpful in terms of decisions that rely on county-level infrastructure or funding, they became too large for characterizing a community in terms of environment and population. It is very common for a county to have some neighborhoods relatively wealthy but others that are extremely disadvantaged, and thus, members not only have different socioeconomic statuses but also might share different health exposures, behaviors, and outcomes. For studying nursing homes, a county-level disadvantage might not be able to accurately capture characteristics of the specific populations served, labor pool of qualified staff and management team, and inherent bias in the quality assessment process due to neighborhood infrastructure.

Disadvantage measurements using ZIP code-based measures such as ZIP-code tabulation area (ZCTA) level have also been applied in existing nursing home literature (Park & Martin, 2018; Weech-Maldonado et al., 2021). There are some issues with using ZCTA level disadvantage measurements for analyzing nursing home providers. First, the ZCTA is a geographic entity that was created by the US Census Bureau representing United States Postal Service (USPS) areas. The Census Bureau assigned ZIP codes that were shared by the majority of household addresses in the Census 2010 block to a ZCTA. Because ZCTA derived data from the census that only occurred in populated areas, some ZIP codes do not necessarily have an associated ZCTA. Some nursing homes use PO boxes as their addresses and would not appear in ZCTA if their ZIP code only serves PO boxes. Thus, they might be unintentionally excluded from analyses. More importantly, postal campus locations might be drastically different from nursing home physical addresses, even if they are located in populated areas. Thus, data

aggregated from these areas might not represent the true population and environments where nursing homes are located.

Therefore, disadvantage measurements on geographic entities with better spatial resolution and sociodemographic homogeneity may present better opportunities in health disparity research. Census tracts, blocks, and block groups are useful geographies for characterizing neighborhood demographic and economic characteristics. All three of these geographic units conform with county and state boundaries and are nested together, covering the entire US. They are developed for the decennial census and rarely changed. The Census block is the smallest unit among all these three and has around an average of 100 people. A census block group is composed of a set of adjacent census blocks and is the smallest geographic unit (containing between 600 and 3000 population) for which the US census bureau tabulates and publishes sample data. Thus, disadvantage measurements on the census block group level would be ideal to characterize the socio-economic positions of US communities.

The Area Deprivation Index (ADI) is one of the potentially useful metrics to describe community disadvantage, originally developed based on a measure from the Health Resources & Services Administration (HRSA) (Singh, 2003). ADI is a composite measure that combines 17 indicators that are calculated from the US census data, capturing four theoretical factors including poverty, education, employment, and housing quality. These material and social conditions are more likely to depict the multi-dimension nature of community socioeconomic positions than a surrogate measure, as they are often interconnecting with each other affecting members' experiences, and ultimately, well-being over time. More importantly, Kind later refined, tested, and adopted this measure, and now it is regularly updated and publicly available on the census block group level, the closest area to the neighborhood that is publicly available (Kind & Buckingham, 2018). Empirical evidence has shown census block group level ADI is associated with a wide range of health conditions and care quality measures such as Alzheimer's disease, cancer, and 30-days hospital readmission (Hu et al., 2021; Zuelsdorff et al., 2020). However, no studies appear to have examined the census block group ADI in the context of long-term care settings. With ADI's great potential of informing health policy, this dissertation project incorporates ADI of neighborhood socioeconomic status on the census block group level among Ohio nursing homes.

Five-Star Ratings

The vast majority of nursing homes in the U.S. receive payments from Medicaid and/or Medicare, which require regular inspections as well as certifications. This procedure allows CMS to monitor the performance of providers; meanwhile, it provides information to consumers intending to enable them to identify facilities that meet their needs. CMS's quality information primarily comes from state-wide surveys, facility-reported staffing hours, and health-related outcomes among residents. CMS initiated a five-star scale system summarizing the information from the data and being assigned to three quality of care domains and overall performance (detailed descriptions of each are provided later). Such an attempt has effectively changed the consumer's purchasing behavior, with the consumer expecting and demanding less from lower-rated facilities. According to Werner and his colleagues (2016), since the introduction of the star rating system, 5-star graded facilities gained market share by 6.4%; alternatively, the market share for facilities with the lowest rating (1-star) decreased by 8.1%. Besides consumers, The CMS Five-Star rating system has also received attention from insures. Nursing homes are required to have a 3-star or better overall quality rating to be qualified as CMS Bundle Payments for Care Improvements Awardees. With such prominence, it is crucial that this system be fair. Below provides a review of quality indicators and how they constructed CMS Nursing Home Compare (NHC) five-star ratings.

Quality indicators are methods in which the performance of nursing homes can be compared. The CMS Five-Star System focuses on clinical care, ignoring some other quality of life data that often is just as important to the consumer (Castle & Ferguson, 2010). While clinical data is vital to analyzing the effectiveness of a nursing home, quality of life measures are also of importance for residents who spend an extended period in their care. The CMS Five-Star Rating System composed providers' performance in three domains, they are health inspection, quality measures, and staffing.

The health inspection domain measures providers' practices and policies meeting federal standards. The health inspection score is determined by provider performance on 1) deficiencies from the most recent three cycles of state health inspection surveys, taking into account their quantity, severity, and scope, and 2) substantiated findings from the most recent three years of complaint surveys (CMS, 2024). Providers' ratings in this domain are based on their relevant health inspection performance in each state. Around ten percent of nursing homes in each state

receive 5-star in this domain. The bottom twenty percent of providers score a 1-star rating. Among the remaining providers, approximately equal proportions receive a rating of 2-star, 3-star, and 4-star. However, many faults the health inspections for significant variance in the quality between different inspection citation practices across states and even different survey districts within states (Office of the Inspector General, 2004).

The staffing domain assesses providers' staffing level, which is a function of the number of Registered Nurse (RN) hours per resident per day and the total nurse hours per resident per day for RN, licensed practical nurse (LPN), and certified nurse aide (CNA). The information that determines this rating is facility-reported data derived from the Payroll-Based Journal (PBJ) in CMS Certification and Survey Provider Enhanced Reports (CASPER) systems. Staffing level performance for both RN and nurses overall is adjusted for case mix and given equal weight for determining the staffing domain rating. For example, a 5-star in the staffing domain requires providers to have 5-stars in both RN and total nurses. The information that determines this rating is gathered and reported by the facilities. Self-reporting allows variations in data collection and reporting between nursing homes to cause discrepancy and bias in this score (Mukamel & Spector, 2003).

The 2019 Provider performance in the quality measures domain in this study is determined by 16 out of 24 quality measures posted on NHC, which indicate resident health and function levels. These quality measures are based on Minimum Data Set version 3.0 (MDS 3.0) as well as Medicare claims data. Performance on these quality measures is risk-adjusted based on the resident level of factors (e.g., care needs). Different from the health inspection domain, the distribution of the quality measures domain is set nationally. Among all nursing homes, providers in the top quantile (25%) of quality measures scores receive 5-star ratings. Every 20% of nursing homes subsequently receive 4-star, 3-star, and 2-star ratings. The remaining providers (around 15%) receive 1-star ratings (CMS, 2015). Similar to the staffing information, this is self-reported data where variations in the collection methods, reporting, and programming can result in variations of results where the same underlying data is collected (Rahman & Applebaum, 2009).

The overall rating is a composite outcome that incorporates performance from the three domains described above. Since the health inspection performance heavily emphasizes the most recent findings provided by trained surveyors, the provider's overall rating is largely determined

by this domain. The result of providers' overall ratings is their health inspection ratings with up to 2 stars of difference depending on their performance in staffing and quality measures domains. Providers without health inspection ratings do not receive the overall ratings.

Risks for residents and providers are largely ignored in the CMS star-rating system. No risk adjustments are included in health inspection results, which are weighted heavily in overall performance. Domains of staffing and quality measures are only to some extent adjusted for the health status of residents. Strategies that CMS uses to account for risk for resident and nursing homes differences include exclusions for calculation (e.g., comatose residents are waived from assessments in most measures); adjusting for resident-level covariates in some quality measures (e.g., percentage of residents with moderate to severe pain is adjusted based on whether the individual is independent in decision-making on the previous assessment); and using resident admission profile to adjust some measures. None of the measures used by CMS have been adjusted for the socioeconomic characteristics of residents and the communities where the providers are located.

Consumer Input Quality

Consumer input is not only a quality indicator of interest for consumers themselves, but for providers and policymakers (Williams et al., 2016). Consumer-determined quality indicators measure how the quality of care meet or surpass consumer expectation. A study conducted in Minnesota found that the overall perceived quality of care was positively associated with residents' and family satisfaction with the facilities (Ryden et al., 2000). Improved satisfaction among cognitively impaired residents from Hong Kong was explained by higher satisfaction with social support and improved mental component of health-related quality of life (L. Y. K. Lee et al., 2005). For families of residents with dementia, dissatisfaction was correlated with negative interactions with staff and nursing aides' insensitive manners (Ejaz et al., 2002). Additionally, a higher level of residents' satisfaction was correlated with improved overall service quality, including tangibles, reliability, responsiveness, assurance, and empathy (Duffy & Ketchand, 1998). In conclusion, empirical evidence has supported that consumer satisfaction is integral to the quality of care.

The provider's perspective about quality of care is not always aligned with the consumer's view and expectation. Researchers from Ohio find that providers' rankings obtained from CMS Five-Star rating do not always reflect findings from the resident and family

satisfaction surveys (Williams et al., 2016). On a national level, Mukamel and her colleagues (2020) compare the quality component and overall quality from CMS Five-Star Ratings with a simulated ranking based on consumers' values and only find moderate agreement on the two measures.

Expectations about the quality of care from providers tend to focus on regulatory outcomes, which are more objective and result in more financial returns. The essence of consumer-determined quality indicators is that they reveal perceptions of care quality from consumers, who are ultimately the experts about the care they or their family members receive. In other words, consumer-determined quality measurements have a subjective nature and must be obtained from consumers' perspectives. Given the differences, it is not surprising that the inconsistency of quality performance across the spectrums of providers and consumers was found (Williams et al., 2016). As the population of older adults and those with Alzheimer's disease grows, nursing homes will increasingly serve individuals who are less healthy and require more complex care. Therefore, gaining insights directly from those receiving care is essential to improve overall well-being and better address the evolving needs of this population.

Currently, two types of consumer-determined quality measures for nursing homes are used in practice. The first one is resident and family complaints. Depending on whom to file with, the complaints could be investigated either by the Long-Term Care Ombudsman Program or the state certification agency. Research (Stevenson, 2006) suggests that results from resident and family complaint investigations represent consumers' concerns of quality in a more timely manner and could be a supplemental tool to nursing home quality. Another viable tool to include consumers' voices in quality is resident and family satisfaction scores. Several states such as Ohio and Minnesota have taken the initiative of including results from this instrument in their quality report cards (Ejaz et al., 2002; Shippee et al., 2017a). Reasons that this practice has not been applied nationwide are often associated with high expenses of developing instruments and implementing the surveys with individuals (Ejaz et al., 2003; Sangl et al., 2007).

Ohio is one of the states that has created and implemented satisfaction surveys in nursing homes. Ohio is the first state that started obtaining consumer input on quality back in 2001. In 2005, Ohio further required its Department of Aging to include consumer satisfaction in the public report card, the Ohio-Long Term Care Consumer Guide (OLTCCG) (Wheatley et al., 2007). The consumer satisfaction in the OLTCCG reflects both the views of residents and their

families where they are collected in alternating years. To incorporate the recent shift to person-centered care in the nursing home industry, Scripps Gerontology Center was contracted by the ODA to revise the surveys for nursing home families and residents in 2015 (Straker et al., 2019). The updated surveys were first implemented in 2016 continuing through the present day.

The biggest concern about the satisfaction measures are the positively skewed responses due to the social desirability pressures and worries about the consequence on services received that negative response might cause (Applebaum et al., 1999; Uman et al., 2000). Overall, responses in the two satisfaction surveys used in this study are positive but do exhibit a reasonable range. For example, the overall nursing home resident satisfaction score for 2017 ranged from 54.1 to 97.5 with a mean of 77.8 and a standard deviation of 6.6.

Potential Spatial Effects in the Study

As Tobler's First Law of Geography suggests, "everything is related to everything else, but near things are more related than distant things." Similarly, nursing home quality performance and COVID-19 outcomes are likely to be more similar among facilities located close to one another. These similarities could directly arise from spatial spillover effects in quality standards and COVID-19 outcomes which occurs when changes in one location affect another location.

Spatial spillover effects in quality performance could happen through market competition. Nursing homes like other healthcare organizations function in a market, it is not wise to ignore the externalities this market generates and its impacts on nursing home performances. The healthcare market is based on the interactions between nursing homes and customers. Customers are on the demand side of the market and are likely to choose healthcare with good standing and better quality. For example, patients have reported their choices based on better hospital health outcomes or neighbors' opinions (Moscone et al., 2012; Porell & Adams, 1995). Although the CMS Five-Star Rating quality report is playing a more and more important role in consumers choosing nursing home placement, consumers have also expressed their concerns about the reliability of data reporting and that they hoped to include measures of other resident experiences such as satisfaction (Konetzka & Perraillon, 2016). Thus, both the CMS Five-Star Rating and consumer satisfaction might create competition among providers, as consumers might have a trade-off between quality, reputation, and distance to their homes. Competition between nursing homes might be affected by distances between nursing homes as

providers might improve quality for attracting consumers in the same market. Conventional nursing home literature often uses aggregate measures like Herfindahl-Hirschman Index (HHI) to describe competition level in a marketplace (normally a county) (e.g., (Weech-Maldonado et al., 2021). These measures assume a market is defined by established boundaries, which is not often the case, especially for providers near state and county borders where nearby competitors may exist on opposite boundary lines. In addition, distances between providers are ignored in these measures, three nursing homes geographically close are considered in a market with the same competition as three nursing homes spread out but within the border geographical unit. In addition to the competition, knowledge or productivity spillover might also create externalities to care quality. Healthcare literature has highlighted the important role of social networks in doctors' practices in care innovation such as the prescription of a new drug or technology adoption (Coleman et al., 1957). In other words, knowledge from externalities or colleagues could power quality improvement in the healthcare setting. Health professionals can also transfer knowledge to other care organizations through job movements or multiple job employment. The agglomeration economy study also suggests companies (nursing homes) have stronger technology (quality improvement activities) spillovers in an area with a high density of providers. Simply put, knowledge of care is likely to be exchanged between one provider and its neighboring providers in a form of high nursing home quality or health outcomes. Potential competition in addition to knowledge spillovers creates spatial correlation in quality and needs to be considered.

Similar to spatial spillover in quality, knowledge spillover might exist in nursing home COVID outcomes. Exchange of COVID prevention and control knowledge might occur among health professionals especially with the guidelines, new knowledge, and resources for COVID-19 infection and prevention becoming available. Additionally, the Health Resources and Services Administration (HRSA) has distributed two billion dollars in COVID-19 Provider Relief Funds and added metrics rewarding improvements in infection and mortality performance (HRSA, 2021). Providers, as a result, are well motivated to tackle this pandemic and learn effective practices for managing COVID-19, especially when there are successful examples from high-performing neighbors. Additionally, spillover effects could also occur through decreased transmission risk. The COVID-19 infected person can vary from symptom-free to suffering from many symptoms within 2-14 days after infection. Therefore, infected individuals can still appear

to be asymptomatic and spread the virus through droplets. Effective COVID-19 management in nursing homes would decrease infectiousness among residents, health workers, and visitors, which further decreases the risk for individuals with whom they might interact outside nursing homes. In turn, the risk of these parties becoming ill in neighboring nursing homes might also be reduced. COVID-19 cases and deaths in one nursing home are likely to be associated with COVID-19 performance in neighboring providers, and such spatial correlations are not restricted to any existing political boundaries.

In addition to direct impacts from spatial spillovers on quality performance and COVID-19 outcomes, proximity-related factors among neighboring nursing homes can also significantly influence these outcomes, often transcending predefined geographic boundaries. For instance, staff members—particularly CNAs and agency workers—frequently work at multiple nearby nursing homes, facilitating virus transmission and impacting care quality. This movement is driven by ease of access rather than strict administrative boundaries.

Shared supply chains, maintenance, and support services can similarly affect quality standards and COVID-19 management. Nursing homes in close proximity often rely on the same suppliers for PPE, medical equipment, and testing materials. When resources are strained in one facility, this shortage can ripple out, impacting nearby homes regardless of jurisdiction. Additionally, neighboring nursing homes often depend on shared providers for essential maintenance and support services (e.g., HVAC, sanitation), where service interruptions or delays can affect infection control and overall quality across facilities.

Environmental factors like air quality, pollution, and local climate conditions also impact nursing homes within the same environmental zone, influencing residents' health outcomes. These factors, although critical to quality and COVID-19 outcomes, do not necessarily align with specific geographic boundaries and are not always consistently captured in accessible data.

Regardless of the mechanisms driving spatial clustering in quality and COVID-19 outcomes among nursing homes, these patterns are unlikely to align with predefined geographic boundaries. Failing to account for potential influences from neighboring facilities can introduce biases in findings, ultimately resulting in ineffective solutions. This dissertation employs Spatial Autoregressive (SAR) models to capture the potential impacts of quality and COVID-19 cases and deaths from neighboring nursing homes. Additionally, Spatial Error Models (SEM) and Spatial Moving Average (SMA) models are used to address spatial relationships in factors not

included in this study. By incorporating these spatial models, the effects of neighborhood disadvantage and other factors on nursing home quality and COVID-19 outcomes can be estimated with greater precision.

Conceptual Framework

This study incorporates components from Resource Dependence Theory (RDT) and the Anderson Behavioral Model to construct the overall conceptual framework for the study. The two models are incorporated together to explain the relationships between how external environments affect the nursing home quality and COVID outcomes and how the quality performance acts in the relationship between neighborhood disadvantage and COVID-19 in nursing homes. RDT emphasizes the importance for organizations to foster a relationship with environments to obtain resources that are critical for functioning. This theory is applied to guided hypotheses that explain the influence of neighborhood disadvantages on nursing home quality and performance of managing COVID-19 as well as the need to account for characteristics of neighboring providers. Anderson's Behavioral model uses a systematic approach to account for factors that affect health care access and outcomes. This model is used to highlight the potential role of nursing home quality in the relationship between neighborhood disadvantage and nursing home COVID-19 outcomes as well as additional organization-, resident-, and community-level characteristics controlled for in this study.

The RDT describes an exchange relationship between organizations and their environments. Organizations need to rely on resources to function, which is ultimately from the environment. Thus, engagement and accommodation need to be made by organizations to secure and maintain resources with external groups and organizations for survival (Salancik & Pfeffer, 1978). While having various dependency relationships, organizations continuously seek opportunities and threats in the environments and then select or change partners. RDT also suggests that numerous stakeholders could exist in environments that might have different preferences and goals, which might influence organizations' behaviors (Salancik & Pfeffer, 1978). For nursing homes, these stakeholders could be federal governments, consumers, and other providers sharing the same markets. The framework provided by the RDT has been used in studying nursing home performance, quality, and competition (Decker, 2008; Zinn et al., 2010). Using the RDT framework, this study specifically investigates how socioeconomic resources available in communities affect CMS Five-Star ratings, family and resident satisfaction, and

COVID-19 cases and deaths while accounting for characteristics of neighboring providers, organizational structure, and residents that might affect their ability and willingness to carry good performance in quality and managing COVID-19.

The disparity in nursing home quality and management in COVID-19 can be explained by the limited availability of resources in socioeconomically disadvantaged communities that could enable providers to carry out functions. Disadvantaged neighborhoods have more racial/ethnic minorities due to historical housing segregation. Institutional racism creates the uneven distribution of resources in the U.S., which might affect the availability of resources for nursing homes. Nursing homes in disadvantaged neighborhoods might face more difficulty recruiting qualified nursing staff and effective management teams, which inhibits them from having positive financial performance, delivering high-quality care, and protecting residents and staff from COVID-19. On the demand side, nursing homes might also face consumers that mainly are paid for by Medicaid, which limits their financial ability for quality innovations. Guided by Resource Dependence Theory (RDT), providers located in more disadvantaged neighborhoods may be less likely to achieve high-quality performance, such as CMS Five-Star Ratings and Consumer Satisfaction scores and may experience worse COVID-19 outcomes—such as higher rates of resident and staff COVID-19 cases and COVID-19 resident deaths—compared to providers in more advantaged neighborhoods.

Similar to RDT, Anderson's behavioral model also highlights the important role of community resource availability in health care utilization and outcomes. Anderson's behavioral model originally was developed to understand factors in family's use of health services and has gone through continuous development since its initial model in the 1960s (Andersen, 1995). New outcomes of interest such as consumer satisfaction and health status have been added to the model in the 70s (Aday & Andersen, 1974; Andersen & Newman, 1973). Anderson's models comprise three core components including predisposing, enabling, and need factors (Andersen, 1995). Predisposing factors are population characteristics (e.g., age, race/ethnicity) that suggest the likelihood of needing health services and having certain health outcomes. Enabling factors are structural characteristics that may impede or facilitate one's chance of receiving health care resources. Finally, need factors are the population's need for health care. The need could be clinical or perceived symptoms. According to Anderson's model, all these factors can be characteristics of individuals or environments that independently or interactively affect health

service's use and care outcomes. In other words, Anderson's model could provide a systematic framework showing how resident, provider, and community factors account for COVID-19 performance. Anderson's behavioral model is also used to explain the relationship between the role of nursing home quality in the relationship between neighborhood disadvantage and nursing home COVID-19 outcomes, where nursing home quality is conceptualized as an enabling factor. Adequate community resources lead to good nursing home quality, which ultimately protects residents and staff from the COVID-19 virus. High-quality performance may help alleviate the negative impact of limited community resources on nursing homes' COVID-19 outcomes, resulting in lower rates of staff and resident COVID-19 infections and reduced resident COVID-19 mortality.

Integrating RDT and Anderson's behavioral model, the overall conceptual framework includes arrays of resident, provider, and community characteristics in addition to neighborhood disadvantage (see **Figure 1**). The next section is a brief overview of additional nursing home characteristics that are included in this study guided by the two theories. According to RDT, an organization's decision to adapt or not depends on its ability and willingness. Organizational characteristics including financial condition, nurse staffing, management, and structure could reflect providers' power and inclinations of acquiring resources in an environment that influences their behaviors, and thus could also be perceived as enabling factors for nursing home COIVD-19 outcomes.

Financial conditions such as ***payor mix*** could affect nursing home quality as well as performance in managing COVID-19. Today, Medicaid is the largest payment source for nursing home care but is known for its lower and decreasing reimbursement rates which could put significant resource strain on nursing homes (Grabowski et al., 2017). Nursing homes that are highly dependent on Medicaid have the least power of securing resources that enable them to provide good-quality care or manage COVID-19, as they have less potential for cross-subsidization from other payers. The Medicare payment is about twice the Medicaid rate in most states making it a more attractive funder for facilities, even though providers do need to cover medications and therapies as part of their payment. Besides payor-mix, ***occupancy rate*** can also be considered an important indicator for nursing home financial condition. The COVID-19 pandemic has exacerbated the declining occupancy rate issue in US nursing homes (National Investment Center, 2021). Providers with low occupancy rates may encounter financial strain

due to fewer filled beds. Thus, low occupancy nursing homes have less extra revenues that could be invested in quality improvement. Nursing homes with low occupancy have been found to be more likely to have staffing cuts, receive more complaints, and announce consolidation (Paulin, 2021).

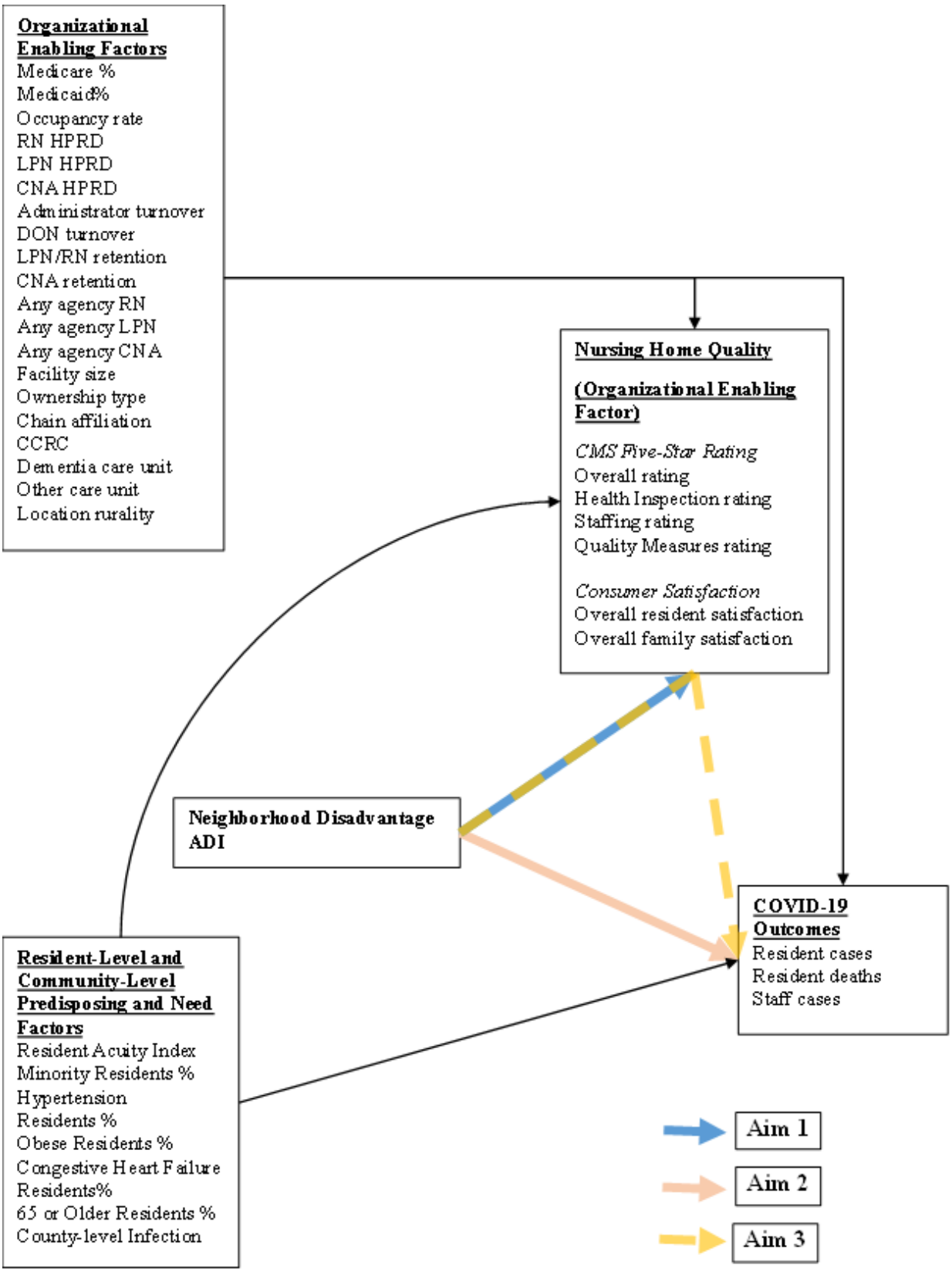
Workforce characteristics in a nursing home are crucial to effective care delivery. Nurse staffing is the direct input that nursing homes have for providing care services. Both the nurse staffing level and stability are essential for nursing home performance. ***Nurse staffing level*** describes the amount of care nursing homes deliver. Inadequate nurse staffing level has been found to be associated with worse nursing home process and outcome quality such as increased infections, moderate to severe pain, inappropriate antipsychotic medication usage, and higher restraint use (Bostick et al., 2006; Castle, 2008; Dellefield et al., 2015). ***Staffing stability*** is also important for nursing home performance as it allows care workers to get familiar with residents, the care team, and practices that are all critical to the quality of care and that ultimately bring in physical, mental, and psychological benefits to residents (Bowers, Nolet, 2011; Gandhi & Grabowski, 2021). Turnover and retention are two separate concepts and distinct indicators of workforce stability. Turnover describes how many people fill in one position over a given period of time including departing employees and new hires. The retention of nursing staff indicates the proportion of staff that stay in their position in a specific period. This study focuses on nursing staff retention since it is a measure relatively less studied and a more attainable management goal than managing turnover (Donoghue, 2010). ***Agency nurse staff*** is a strategy to bolster staffing levels, however, it might disrupt care quality due to discontinuity of care and weakened teamwork. In the context of COVID-19, it might also increase the risk of transmission. Agency nurse staff use has been found to be associated with worse clinical outcomes (J. Bowblis & Applebaum, 2021; Castle, 2009). **Management** makes a difference in organizations' success or failure. Administrator and director of nursing represent the ability of a nursing home to obtain and maintain resources that are critical for providing good care for example quality staffing. Both ***administrator and director of nursing turnover*** are found to be related to nursing home quality (Castle & Lin, 2010).

Structure characteristics such as ***facility size*** are also factors indicating a provider's power in an environment. More beds in a nursing home might allow additional resources, however, it might also create more challenges to manage and contribute to pooer resident's

health outcomes. Larger nursing homes generally have lower quality than their smaller counterparts (Lord et al., 2021; Park & Martin, 2018). Larger providers are found to have higher risk of COVID-19 infection rate. Other typical nursing homes structural characteristics include ***ownership type***, ***chain affiliation***, ***continuing care retirement community membership (CCRC)***, and ***location***. In general, providers that are not-for-profit, non-chain affiliated, part of a CCRC, and located in urban areas perform better in quality indicators (Bowblis et al., 2013; Hermer et al., 2018). All these are characteristics that describe provider-level of resource availability. For-profit nursing homes are found to provide lower quality of care and may be less attractive for private-pay residents, which might contribute to higher dependency on Medicaid payment compared to their not-for-profit counterparts (Christensen & Arnould, 2005). For better economic efficiency, chain-affiliated providers might have shared resources such as staffing and practice and administrative standards, but it might sacrifice resources that are critical to quality of care (Anderson et al., 2003). For example, they might have less full-time nursing staff that are familiar with residents, and thus, care may not address their needs. Additionally, an entry fee and monthly payment is normally required from CCRC providers, and residents often pay out-of-pocket and rarely can be paid for by Medicaid. Thus, CCRC nursing homes are relatively selective to their consumers and have more financial resources. Finally, similar to neighborhood disadvantage, location rurality can be an indicator of resource availability in the environment, which contributes to performance differences.

To align with Anderson's behavioral model, resident- and community- characteristics are also included in the framework and conceptualized as predisposing and need factors. Underlying conditions have been widely documented as risk factors for COVID-19 progression and mortality such as congestive heart failure (X. Li et al., 2020). In addition to the comorbidity, different degrees of disability may also contribute to the risk of infection due to difficulties in performing preventive health measures as well as increased physical contact with care workers for care needs. These resident characteristics also contribute to nursing home quality, because providers are required to have more resources to meet residents' care needs. For example, high-needs residents increase the workload for staff, and so providers have to either increase compensation to retain their employees or sacrifice care quality as a result of high turnover. County-level infection is also included as it highlights the risk of transmission and the potential need for COVID-19 related care.

Figure 1. Conceptual Framework for This Study



Chapter 3: Method

Data Source and Data Management.

Data from several sources are used for this study. Key data elements on nursing home COVID-19 infection and mortality came from the CMS Nursing Home COVID-19 Public File. Each nursing home reported COVID-19 related information through the CDC's National Healthcare Safety Network system (COVID-19 LTC Facility Module). CDC and CMS regularly perform quality assurance checks to identify erroneous data entries (Centers for Medicare & Medicaid Services, 2021). This study utilized reports ending the week of May 24th, 2020, when the CDC began requiring providers to report COVID-19 data. It also included data from January 31st, 2021, and January 30th, 2022, capturing periods right before COVID-19 vaccinations became available to older adults and two years after the pandemic outbreak.

This file is linked with two other CMS publicly available data products. One of the datasets is the December of 2019 monthly Nursing Home Compare archive provider data. This dataset reports summary information about each Medicare and/or Medicaid-certified nursing home in the U.S. including selected measures CMS quality of Five-star ratings (e.g. health inspection rating, quality measures rating), facility structure (e.g., ownership type, CCRC membership), and nurse staffing level (e.g., RN HPRD, LPN HPRD). CMS updates this data regularly and makes it publicly available on the Nursing Home Compare website. The other CMS data used in this study is the fourth quarter of 2019 Payroll-Based Journal (PBJ) data, which is the last complete recorded data available for pre-pandemic. The PBJ data includes daily nursing home staffing information and is being utilized to capture the agency nurse staffing in each nursing home.

These CMS datasets were merged with the Ohio Biennial Survey of Long-Term Care Facilities (hereafter referred to as the Biennial Survey) to capture measures related to staff stability (e.g., RN retention) and management characteristics (e.g., NHA turnover). The Biennial Survey is designed and administered by Miami University's Scripps Gerontology Center and is supported by the Ohio Revised Code. Due to the pandemic-related delay in the launch of the 2019 wave of the Biennial Survey, which had a response rate of only 74%, this study relies on the 2017 wave of the survey, which achieved a higher response rate of 91% (R. Applebaum et al., 2022; Kennedy et al., 2020b).The 2017 Ohio Nursing Home Resident Satisfaction Survey and 2018 Ohio Nursing Home Family Satisfaction Survey were used to derive the consumer

perspective of quality (e.g., overall family satisfaction). The information about the implementation of the two surveys is provided below.

The 2017 Ohio Nursing Home Resident Satisfaction Survey was administered to residents in a private location through face-to-face interviews. Residents were randomly selected from a census list provided by providers two weeks before the interview. Long-term and short-term stay residents were proportionally sampled to meet the 10 percent statewide and provider-level margin of error required by the ODA. Interviewers were trained to approach nursing home residents. After training, Cohen's Kappa values for all survey items are above 0.8 which indicates the high agreement on selecting response categories among interviewers (Vital Research, 2018). In 2017, Ohio conducted 23,154 Resident Satisfaction interviews with nursing home residents and had a participation rate of 69% (Vital Research, 2018).

The 2018 Ohio Nursing Home Family Satisfaction Survey was a self-administered questionnaire with options of a mailed written survey packet and an online survey. Each provider followed the guidance provided by ODA, selecting the most engaged family members or friends of current residents as potential participants for the survey. Scripps Gerontology Center managed to verify names and addresses to ensure each provider had more than 85% of the resident census listed. In 2018, among 52,696 families or friends of residents that were reached, 39.4% (N = 20,716) responded to the Family Satisfaction Survey (Straker et al., 2019).

This study also uses the 2019 LTCFocus facility data to incorporate provider's payor-mix (e.g., Medicare percentage, Medicaid percentage), facility structure (e.g., dementia care unit, chain affiliation), and resident characteristics (e.g., racial composition, Average Acuity Index) that are not covered by the CMS public data. The LTCFocus project from the Brown University Center for Gerontology and Healthcare Research incorporates data from multiple sources (e.g., OSCAR, MDS) and contains a wide range of information providers.

To capture the rurality of a nursing home's location, each provider was also linked with the rural-urban commuting area (RUCA) data via ZIP code (WWAMI Rural Health Research Center, 2020**).** County-level community COVID-19 infection rates are retrieved from the USA Facts data.

Nursing homes with P.O. box addresses were manually replaced with their physical locations. All Ohio nursing homes are then geocoded with exact street-level addresses using the Google API service. With the geolocations, the neighborhood disadvantage measure of ADI at

the block group level is then spatially linked to each nursing home. This study uses the 2019 ADI which is retried from the Neighborhood Altas.

Measures

Nursing home COVID-19 outcomes and Neighborhood Disadvantage

The initial reporting date for the CMS Nursing Home COVID-19 Public File is May 24th, 2020. However, providers may report the new COVID-19 incidences of the initial reporting week or cumulative cases since Jan 1st, 2020 due to the retrospective reporting. Providers only report weekly new counts for subsequent weeks and the cumulative counts are calculated by CMS. From this, three measures are constructed for the timeframes of pre-vaccination (Jan. 31st, 2021) and the two-year pandemic (Jan 30th, 2022), since May 24th, 2020, the number of COVID-19 1) resident cases, 2) resident deaths, and 3) staff cases. Providers who did not submit data or passed quality assurance check on May 24th, 2020, Jan 31st, 2021, or Jan 30th, 2022 are assigned as missing. In this study, all three COVID-19 measures are adjusted per 100 beds per month to account for varying provider sizes, including differences in the number of residents and staff exposed to the virus. Using the number of licensed beds as a denominator has several advantages. First, staff and resident numbers may fluctuate over time. Second, staff count data is unavailable, making a per-person metric impractical for staff cases. Third, sample size issues can arise when the resident count is zero. Finally, the number of unique COVID-19 cases among residents or staff is unknown, which could introduce substantial measurement error.

Neighborhood Disadvantage

Neighborhood disadvantage is measured by the ADI nation percentile ranking at the block-group level ranging from 1 (least disadvantaged) to 100 (most disadvantaged). The 2019 Ohio Area Deprivation Index is based on the 2015-2019 U.S. Census American Community Survey.

Workforce Characteristics

Nursing home workforce characteristics are included in this study including staffing levels, staffing stability, and agency/contract staffing. Nurse staffing levels are measured by hours per resident day (HPRD) of registered nurses (RNs), licensed practical nurses (LPNs), and certified nurse aides (CNAs). The HPRD represents the number of hours that nurse staff is available for performing care and administrative duties for each resident. Staffing stability is

captured by retention, which is defined as the percentage of people remaining in that same position between the first and last payroll periods in 2017. Retention measures for RN/LPN, and CNA are all included in this study. I also include measures for agency nurse staff as temporary staff might contribute to the spread of COVID-19 by providing care to residents at multiple providers. Temporary staff, also referred to as contracted or agency staff, have only become more common in nursing homes recently due to the exacerbated nursing staff shortage caused by the pandemic. Therefore, temporary nurse staff is measured by three indicators respectively noting whether the nursing home uses any agency staff for RN, LPN, and CNA. To capture management characteristics, nursing home administrator (NHA) turnover and director of nursing (DON) turnover are included. Providers that have more than one NHA are categorized as having NHA turnover and having only one NHA is categorized as having no NHA turnover. A similar coding scheme is applied to DON turnover.

Nursing Home Quality

A total of six measures are used to respectively capture perspectives of nursing home quality from the CMS and consumers. The CMS's view of quality is measured by the four CMS Five-Star Ratings. The four ratings are five-point scales where a 1-star and a 5-star respectively represent the lowest and the highest quality in the domains of Health Inspections, Quality Measures, Staffing, in addition to an overall performance on the former three. The Health Inspection domain assesses nursing homes' performance in statewide health inspection surveys. The domain of Quality Measures evaluates providers performance on quality measures from MDS and Medicare claims data. Staffing domain performance is based on providers' staffing levels of RN, LPN, and CNA. Finally, as described in the literature section, the overall performance of five-star rating is a composite measure that incorporates providers' performance from the state recertification and complaint inspection surveys, facility-reported nurse staffing levels, and quality indicators retrieved from administrative datasets (CMS, 2019). To avoid collinearity, measures of nurse staffing levels (details are provided later) are not included as covariates when the overall rating of quality or staffing rating are included in models.

Consumers' perspective of quality is the overall satisfaction scores providers received from residents and their families. The Ohio Nursing Home Resident and Family Satisfaction Surveys respectively consist of 47 and 32 items from 7 domains of residents' daily life and care. These domains are moving in, spending time, care & services, caregivers, meals & dining,

environment, and facility culture. Detailed items of the two surveys are listed in Appendix **A**. In the resident satisfaction survey, an item score of 100 indicates the resident provides a positive response ("generally, yes"), and a 0 grade represents a negative response ("generally, no"). For the family satisfaction survey, all question item scores are assigned as 1) 0 ("definitely no"); 2) 33 ("probably no"); 3) 67 ("probably yes"); 4) 100 ("definitely yes"). The overall satisfaction score for each facility is the average score of all the question items for all residents or their family in its corresponding survey. Residents who respond to more than 10% of the survey are included in calculating the overall resident satisfaction score (Vital Research, 2018). The overall family satisfaction score represents families that responded to more than 20% of the survey (Straker et al., 2019).

Additional Control Covariates.

Additional sets of measures are also included for all regression analyses as they are potential risk factors for lower quality or worse COVID-19 outcomes in nursing homes and roughly capture other enabling as well as predisposing and need components in Anderson's behavioral model. The first set are measures of provider structure characteristics including facility size (number of beds), ownership type (for-profit versus not-for-profit/government-owned), chain affiliation (yes/no), being part of a CCRC (yes/no) and having dementia (yes/no) or any other special care unit (yes/no).

The second set of additional measures controlled in this research captures the financial resources available to providers. They are occupancy rate (%) and payor mix of Medicare (%) and Medicaid (%). Risk factors of resident characteristics for COVID-19 infection and mortality as well as worse nursing home quality are also accounted for in analyses. These characteristics include resident case-mix and composition of age and race. Measures of resident case-mix include the average acuity index, which describes levels of care residents need as well as residents with hypertension (%), obesity (%), or congestive heart failure (%). Resident age composition is measured by the percentage of residents aged 65 or older. The racial composition of residents is indicated by the percentage of residents who are non-white. Besides resident characteristics, analyses also control the rurality of providers' locations. Categorization B from the WWAMI Rural Health Research Center (2020) guides the measure of rurality in this study (metropolitan area/ micropolitan/ small or isolated small rural town).

Finally, all models are adjusted for the community infection rate due to the transmissible nature of COVID-19. The community infection rate is calculated as the total number of COVID-19 cases per 100,000 people in a county.

Study Sample

Due to very different characteristics of residents, case mix, practices, locations, and reimbursement patterns, this dissertation project focuses on non-hospital-based nursing homes in Ohio. Nursing homes that failed CMS data quality check, did not submit COVID-19 data on weeks of May 24th, 2020, Jan. 31st, 2021, and Jan. 30th, 2022, or located in hospitals are excluded from this study. After the exclusions, a total of 859 nursing homes in Ohio are eligible for this study.

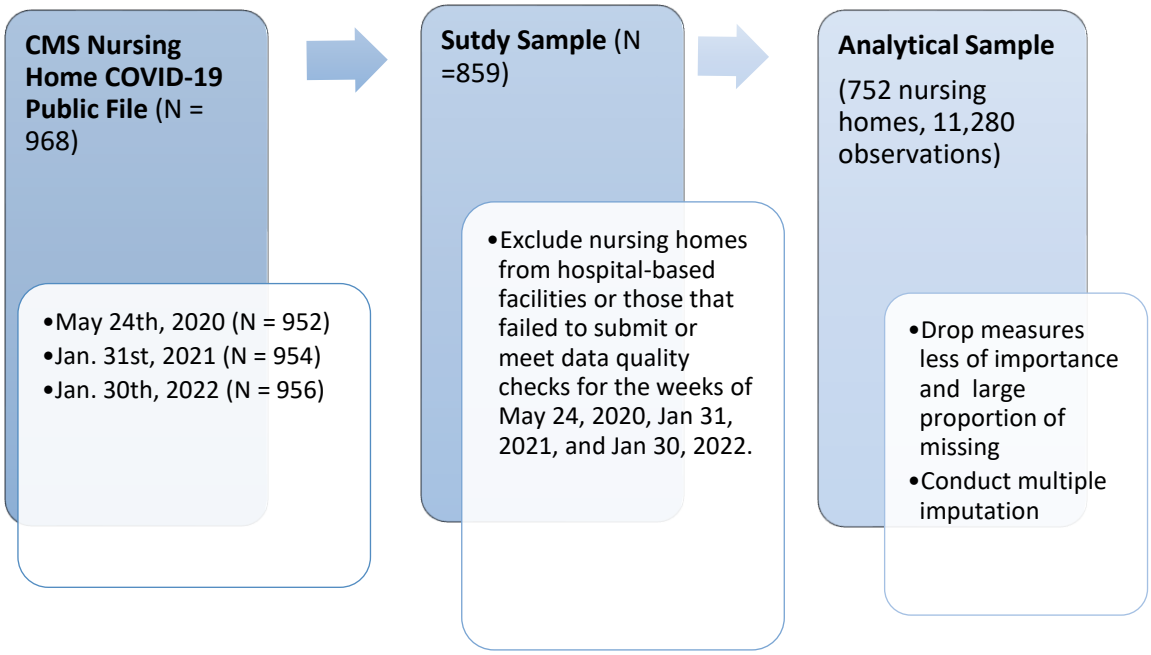
Because this study incorporates information from multiple sources, missing data is an inevitable issue in this study. Missing data on prevalences of obese (16.76%), congestive heart failure (30.73%), and 65 or older (23.75%) residents from the LTCFocus facility data are especially concerning, with over 10% of nursing homes having missing data on at least one measure (Details on missingness for each measure by data source are provided in **Table B.1** from **Appendix B**). Bias is likely to be introduced in subsequent analyses when over 10% of data is missing (Bennett, 2001). The measures of congestive heart failure and obese prevalence among residents is dropped from analyses due to a large proportion of missing data and less importance of the focus in this study. Hypertension is a very common health condition among nursing home residents, prevalence measure of this condition is also dropped from this study to best restore the sample size as well as reduce the complexity of the models (Simonson et al., 2011)**.** Older age is widely recognized as an important risk factor for illness and deaths from COVID-19 infection and mortality therefore, the measure of age 65 or older resident prevalence needs to be retained (Freed et al., 2022; Wolff et al., 2021)**.**

Simple logistic regressions are performed to investigate whether the missingness of 65 or older resident prevalence as well as measures that have missing over 10% of the sample from other data sources occur completely at random or is dependent on other variables in this study (The full results are detailed in **Table B.2** of **Appendix B**.). Missingness of data is rarely arbitrary in social and economic studies, including this one. For instance, nursing homes that are located in more socioeconomically disadvantaged neighborhoods and have a higher proportion of Medicaid residents, reduced staffing hours for RNs and CNAs, turnovers of NHAs, low

retention rates for LPNs/RNs, usage of agency CNAs, non-profit or government ownership, no affiliation with a chain, membership in CCRC, lower CMS Five Star Ratings and Consumer Satisfaction scores, reduced COVID-19 mortality rates for residents and lower case rates for staff members are more likely to have incomplete data on the prevalence of residents aged 65 and above. All evidence confirms that the data are not missing completely at random (MCAR).

Multiple imputation is used to address potential biases generated by missing data. Measures that account for more than 10% of the study sample are included in the imputation models and are being imputed. This study uses full conditional specification logistic, discriminant, and regression methods with fifteen imputations. As a result, a total of 752 nursing homes are included in the final analytical sample.

Figure 2. Flowchart of Sample Selection of This Study



Analyses

Separate analyses are performed for the COVID-19 cases incidence rates for residents and staff members as well as mortality rates for residents during the pre-vaccination (May 24th, 2020 to Jan 31st, 2021) and two-year pandemic (May 24th, 2020 to Jan 30th, 2022) periods. All analyses are conducted using multiple imputed data under SAS 9.4. The primary goal of this study is to untangle the relationships between neighborhood disadvantage, quality, and COVID-

19 outcomes in Ohio nursing homes specifically accounting for underlying spatial relationships highlighted in Tobler's first law of geography that closer objects are more similar. Specifically, this study answers four questions:

1) Are nursing homes in more disadvantaged neighborhoods more likely to have lower quality performance including CMS Five-Star Ratings (Health Inspections, Quality Measures, Staffing, and overall ratings) and /or Consumers Satisfaction (Overall Resident Satisfaction and Overall Family Satisfaction scores)?

2) Are providers in neighborhoods that are more disadvantaged more likely to have more staff or resident COVID-19 cases and deaths?

3) Are providers with better quality performance (Health Inspections rating, Quality Measures rating, Staffing rating, Overall rating, Overall Resident Satisfaction score, Overall Family Satisfaction score) more likely to protect their residents and staff from COVID-19 infection and mortality regardless of neighborhood disadvantages?

4) Whether spatial effects should be considered when evaluating the complex relationships between neighborhood disadvantage, quality, and COVID-19 outcomes, specifically:

a) the relationships between neighborhood disadvantage levels and various quality performance measures (including Health Inspections rating, Quality Measures rating, Staffing rating, Overall rating, Overall Resident Satisfaction score, and Overall Family Satisfaction score);

b) the relationships between neighborhood disadvantage levels and COVID-19 outcomes (such as resident cases, resident deaths, and staff cases per 100 residents per month) in nursing homes; and

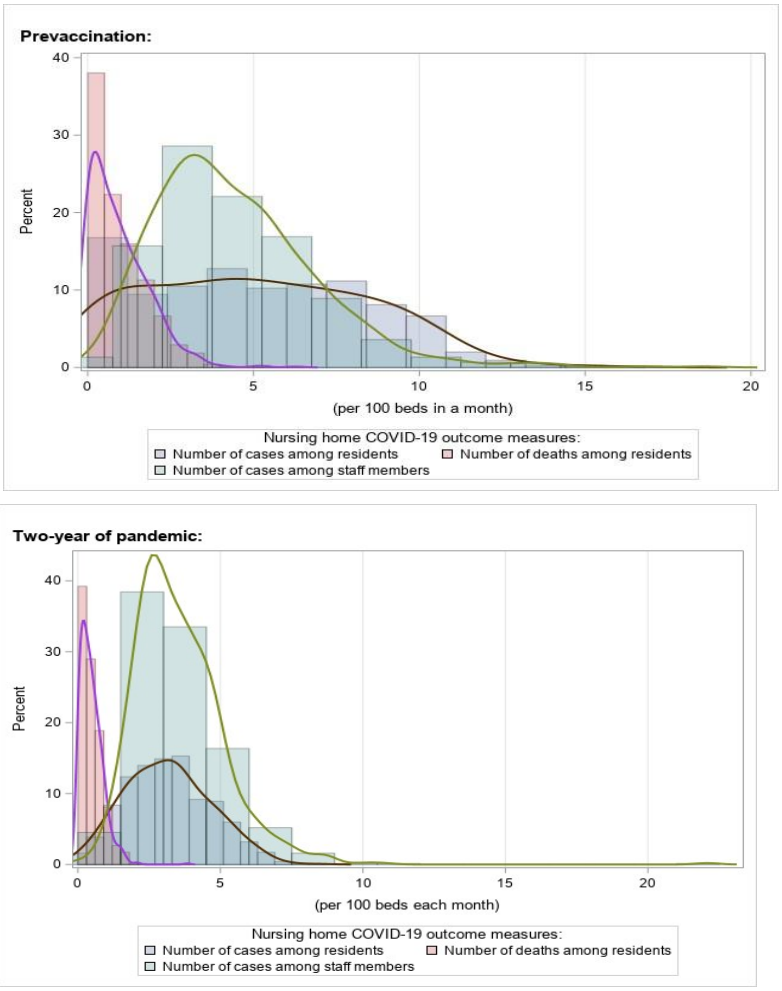
c) the role of quality performance measures in mediating the relationship between neighborhood disadvantages and COVID-19 outcomes.

Univariate statistics are used to summarize the characteristics of the analytical sample. Means are calculated for continuous measures such as neighborhood SES disadvantage, Medicare payor mix, and facility size. Percentages are calculated for categorical measures including ownership type, chain-affiliation, and location rurality.

Bivariate statistics are applied to detect relationships among measures. Pearson correlation tests are conducted to detect relationships between continuous measures that are not COVID-19 related outcome measures. Simple linear regressions are performed to investigate relationships between categorical measures and continuous measures that are not COVID-19

outcome measures. COVID-19 related outcome measures including average resident cases, resident deaths, and staff cases per 100 beds in a month are all non-negative values and have positive skewed distributions (as in **Figure 3**). Simple Poisson regressions with offsets are performed to investigate associations between nursing home COVID-19 outcomes and other measures. Relationships between categorical measures are investigated with simple binary or multinomial regressions.

Figure 3. Distributions of COVID-19 Outcome Measures

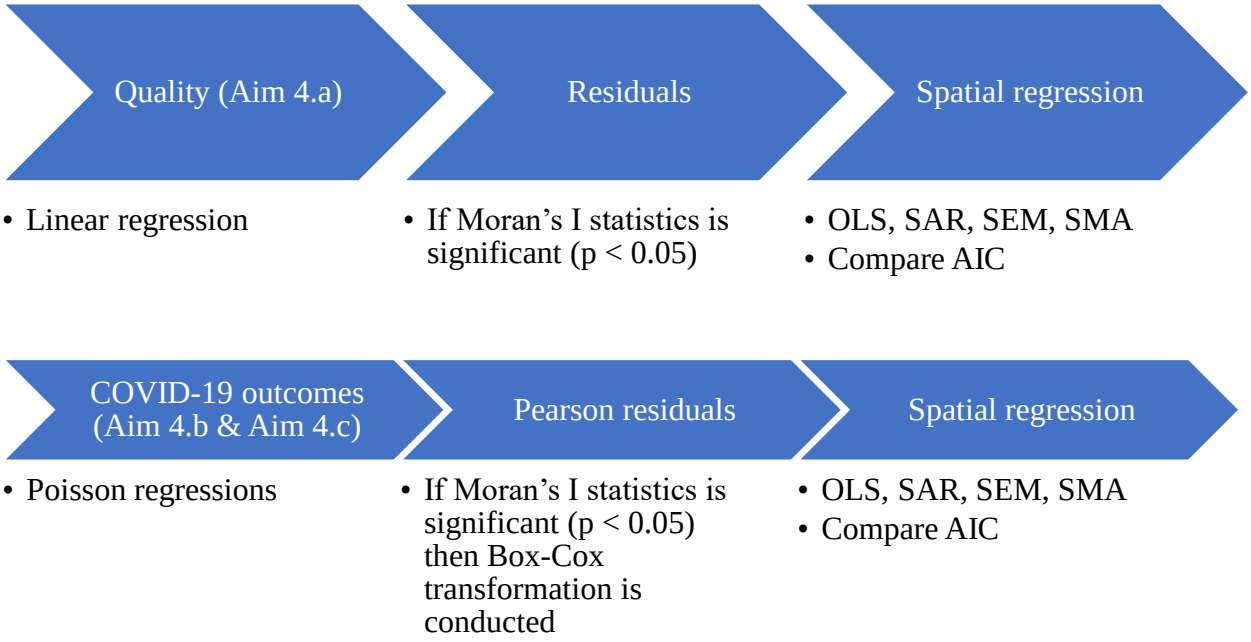


Multiple regression analyses are applied to answer the **four** research questions in this study. Specifications of each regression model are determined by the functional form of outcome measures, and when appropriate, spatial specifications of regression models are further conducted. To investigate if neighborhood disadvantage affects various aspects of nursing home

quality such as Overall, Health Inspection, Quality Measures, and Staffing of CMS Five-Star Ratings, and Consumer Satisfaction scores of Overall Resident Satisfaction (**Aim 1**), six separate linear regression models are used. These models account for all relevant factors that could influence the results, except in those estimating CMS Five-Star Overall and Staffing ratings. Since staffing level measures (RN HPRD, LPN HPRD, and CNA HPRD) are components of the Overall and Staffing ratings calculations, they are excluded from these two models. As described earlier, nursing home COVID-19 outcome data are non-negative values that are right skewed, Poisson regressions with offset terms are estimated to investigate **Aim 2 and Aim 3** of this study. To understand whether neighborhood SES disadvantage predicts COVID-19 incidence and mortality rates for residents as well as incidence rates for staff members (**Aim 2**), models will include neighborhood SES disadvantage along with organizational enabling factors as well as resident- and community level predisposing and need factors. Each nursing home quality measure (Overall rating, Health Inspection rating, Quality Measures rating, Staffing rating, Overall Resident Satisfaction score, Overall Family Satisfaction score) is separately added to the models to further investigate how quality impacts the relationship between neighborhood disadvantage and nursing home COVID-19 outcome measures (**Aim 3**). To avoid multicollinearity, staffing level measures are excluded when evaluating the role of the CMS Five-Star Overall or Staffing ratings in the relationship between neighborhood disadvantage and COVID-19 outcomes.

The approach to multiple regression analyses for **Aim 4** in this study is illustrated in **Figure 4**. To verify whether above non-spatial models are adequately and accurately representing relationships between neighborhood disadvantage, quality, and COVID-19 outcomes (Aim 4), Moran's I statistics (as defined in Equation 1) are first applied on raw residuals from linear models and Pearson residuals from Poisson models. Moran's I statistics are widely used for examining the first law of geography that closer objects are more similar. Specifically, Moran's I investigates if geographic patterns across map is clustered (similarity), dispersed (dissimilarity), or random.

Figure 4. Flowchart of Multiple Regression Analyses Process for Aim 4



$$I = \frac{n\sum_{i=1}^{n}\sum_{i=1}^{n} W_{ij}(x_i-\bar{x})(x_j-\bar{x})}{\sum_{i=1}^{n}\sum_{i=1}^{n} W_{ij}(x_i-\bar{x})^2} \quad \text{(Equation 1)}$$

The n is 752 nursing homes that are included in this study. x_i and x_j are raw or Pearson residual values from earlier non-spatial models at nursing home i and nursing home j. W_{ij} is a fixed distance[1] binary spatial weight matrix representing spatial relationships between nursing home i and nursing home j. ([1] if nursing home j is within a Euclidean distance of 0.5 to nursing home i, [0] for those outside of this range). Deviations from the mean residual for all nursing home locations are examined and summed up. Moran's I is a measure that can vary between -1 and 1. A value of 1 shows that neighboring nursing homes have similar residual values (either high-high or low-low), while a value of -1 indicates that neighboring nursing homes have dissimilar residual values (either high-low or low-high). On the other hand, a value of 0 indicates that residual values between nursing homes are randomly distributed. To test statistical significance, Moran's I statistics can calculate a z-score and p-value by comparing the expected Moran's I values based on spatial random distribution to the observed value given the number of locations and variance of the data. Statistically significant Moran's I statistics ($p <$

[1] Weight matrix in this study based on Euclidean distance following the method proposed by Alan Ricardo da Silva (2018).

.05) suggesting further spatial specification regression models should be explored to account for spatial relationships under the data.

Spatial specifications of regressions are conducted using SPATIALREG procedure from SAS 9.4. As SPATIALREG procedure calculates spatial regression using a linear functional form of the dependent variable, nursing home COVID-19 outcome measures for nursing homes must be transformed to enable comparable linear regressions. A widely used technique to transform measures and make them resemble a normal distribution is the Box-Cox transformation (Box & Cox, 1964). The core idea of Box-Cox transformation is to create a replacement dependent variable $y(\lambda)$, that maintains the same regression model while producing normally distribute residuals. Box-Cox transformation is defined as in Equation 2 and is indexed by a parameter λ. Statistical programs such as SAS search through a specified range of λ values and choose an optimal value based on maximum likelihood criterion (Draper & Smith, 1981). Because the dependent variable has changed, interpretations of regression coefficients must be based on transformed dependent variable $y(\lambda)$. For example, λ of 0.5 is corresponding to the square root transformation, thus, the interpretation for regression coefficient β is that every one-unit change in an independent variable (x) is equal to β change in square root of original dependent measure $(\sqrt{y})$.

$$y(\lambda) = \begin{cases} \frac{y^{\lambda}-1}{\lambda}, & if\ \lambda \neq 0; \\ \log y, & if\ \lambda = 0. \end{cases} \qquad \text{(Equation 2)}$$

Three different spatial specifications of regression models that account for spatial effects in the data differently are explored in this study, including Spatial Autoregressive (SAR) model, Spatial Error Model (SEM), and Spatial Moving Average (SMA) model. Let y_i denotes the observation of dependent measures at nursing home i = (1, 2, 3, …, n). n is 752 nursing home locations included in this study. For these 752 nursing homes, W_{ij} represent an nxn (752x752) fixed distance binary spatial weight matrix (same as ones used in Moran's I statistics). x_i is a vector indicating values of p independent variables at the nursing home $i(nxp)$, Below describes equations and interpretations of the three spatial model techniques.

The Equation 3.1 defines the SAR model which conceives spatial effects among locations are among neighboring observations of dependent variables. β is a parameter vector $(px1)$ for p independent measures and ρ is a spatial autoregressive coefficient, ϵ_i is residual values (error

term) at nursing home i. Observation of the dependent measure at nursing home i not only rely on its values of independent measures (x_i') scaled by β, but also neighboring nursing homes observations of dependent measures ($w_{ij}y_j$) scaled by ρ. The average magnitude of the correlation between values of a dependent measure at a location and its neighbors is represented by ρ. One unit change in average y values in neighbors of j is associated with ρ change in y in i. SAR model implies a feedback effect between locations, that changes in one location can impact the levels of neighboring locations. This impact is then passed on to the neighbors of those neighbors, and so on, until eventually all locations are affected. For example, lower COVID-19 incidence rates for residents in neighboring nursing homes are associated with a decrease in incidence rates in each nursing home through reduced transmission risk. Such phenomenon follows a global pattern that changes in COIVD-19 incidence rates for residents in one location could potentially impact all Ohio nursing homes.

$$y_i = \rho \sum_{j=1}^{n} W_{ij}y_j + x_i'\beta + \epsilon_i \quad \text{(Equation 3.1)}$$

Different from SAR model, SEM and SMA model account for spatial effects among random omitted measures. Let n be 752 nursing homes included in this study and $y = (y_1, y_2, y_3, \dots, y_n)$ be observation of dependent measure. The basic form of the SEM and SMA model is defined as in Equation 3.2 and spatial relationships are embedded in the error term (u). The Error term (u) in SEM follows an autoregressive (AR) as defined in equation 3.2.1, while following a moving average (MA) process (Equation 3.2.2) in SMA model. ϵ represents the random error, while λ is the spatial autoregressive parameter that captures the spatial process of the error term (u) in SEM and SMA, ensuring accurate estimation of β. W is a (752x752) spatial weight matrix (same as W_{ij} described earlier). AR process is used for modeling spatial autocorrelation that has global effects that change in one location can potentially cause changes in all locations. Whereas the MA process is used for local spatial relationships that change in one location can only have impact on their neighbors.

$$y = x\beta + u \quad \text{(Equation 3.2)}$$

$$u = \lambda W u + \epsilon \quad \text{(Equation 3.2.1)}$$

$$u = \epsilon - \lambda W \epsilon \quad \text{(Equation 3.2.2)}$$

To compare model fits, Akaike Information Criteria (AIC) are respectively calculated for the three spatial specifications of regression models (SAR, SEM, and SMA) as well as its

original non-spatial counterparts (linear regression). A lower value of AIC indicates that a model loses less information and is of higher quality.

Variance inflation factors (VIF) are conducted to evaluate the degree of multicollinearity among the independent variables for all multiple regressions. All VIF values are below 10, suggesting no significant multicollinearity issues were present in the models (Curto & Pinto, 2011).

Chapter 4: Results

Introduction

This study aims to examine the impact of neighborhood socioeconomic resources on nursing homes in Ohio during the COVID-19 pandemic. The study addresses four research aims, focusing on the relationships between neighborhood disadvantage, quality, and COVID-19 outcomes. Specifically, the research investigates: 1) how the level of neighborhood disadvantage impacts nursing home quality from different perspectives, 2) how neighborhood disadvantage affects various COVID-19 outcomes, 3) how different levels of nursing home quality influence the relationship between neighborhood disadvantage and COVID-19 outcomes, and 4) whether spatial effects should be considered when evaluating these complex relationships. The study considers both the CMS and consumer perspectives of quality. The CMS perspective includes Health Inspection, Quality Measures, Staffing, and Overall ratings from the CMS Five-Star Rating system, while the consumer perspective includes resident and family satisfaction scores from the Ohio Department of Aging's Long-term Care Consumer Guide. To capture different stages of the pandemic, COVID-19 data reported as of pre-vaccination (January 31, 2021) and at the two-year mark of the pandemic (January 30, 2022) are utilized.

This chapter presents the results of this study. Descriptive statistics are first provided for the multiple-imputed data. The results of bivariate relationships and non-spatial multiple regressions are organized by research aims 1 through 3. Finally, the results for research aim 4 are presented.

Characteristics of the Analytical Sample

Table 1 presents descriptive statistics of the 752 nursing homes included in the analytical sample. Ohio nursing homes are in neighborhoods that are moderately socioeconomically disadvantaged with a mean national ADI ranking of 65th percentile (mean [M] = 65.013, standard error [SE] = .780). Most Ohio nursing homes are for-profit (77.926%), located in metropolitan areas (71.277%), chain affiliated (70.612%), not a CCRC member (83.777%), do not have dementia (72.606%) or other special care units (69.282%), and report an average of 94 beds (M= 94.455, SE = 1.479). Ohio nursing homes reported an occupancy rate of 81.132 (M = 81.132; SE = 0.458) and rely heavily on Medicaid to support their residents. On average, more than three-

fifths (M = 61.26, SE = .322) of residents are primarily supported by Medicaid, while less than ten percent (M = 9.106, SE = 0.322) are supported by Medicare.

Table 1. Descriptive Statistics of Analytical Sample

N=752	Mean or %	Standard Error
Neighborhood Disadvantage (National ADI rank), mean	65.013	.780
Organizational Enabling Factors		
Medicare %, mean	9.106	.322
Medicaid %, mean	61.256	.715
Occupancy rate, mean	81.132	.458
RN HPRD, mean	0.587	.011
LPN HPRD, mean	0.929	.010
CNA HPRD, mean	2.052	.016
NHA turnover, %		
Has turnover	64.840	.018
No turnover	35.140	.018
DON turnover, %		
Has turnover	67.429	.018
No turnover	32.571	.018
LPN/RN retention, mean	69.464	.854
CNA retention, mean	61.344	.752
Any agency RN, %		
Yes	35.505	.017
No	64.495	.017
Any agency LPN, %		
Yes	30.718	.017
No	69.282	.017
Any agency CNA, %		
Yes	33.378	.017
No	66.622	.017
Facility size, mean	94.455	1.479
Ownership type, %		
For profit	77.926	1.513
Not for profit/government owned	22.075	1.513
Chain affiliated, %		
Yes	70.612	1.662
No	29.388	1.662
CCRC membership, %		
A member	16.223	1.345
Not a member	83.777	1.345
Dementia special care unit, %		
Has	27.394	1.627
Has not	72.606	1.627

Other special care unit, %		
Has	30.718	1.683
Has not	69.282	1.683
Location rurality, %		
Metropolitan	71.277	1.651
Micropolitan	18.351	1.413
Rural	10.372	1.113
Resident- and Community Level		
Predisposing and Need factors		
Resident Acuity Index, mean	12.207	.041
Minority Residents %, mean	17.820	.713
65 or Older Residents %, mean	75.131	.652
County-level Infection (pre-vaccination), mean	920.433	4.446
County-level Infection (two-year pandemic), mean	1087.989	3.462
Nursing Home Quality		
Overall, mean	2.963	.053
Health Inspection, mean	2.737	.045
Quality Measures, mean	3.779	.041
Staffing, mean	2.375	.036
Overall Resident Satisfaction, mean	75.871	.216
Overall Family Satisfaction, mean	75.177	.315
COVID-19 Outcomes		
Pre-vaccination		
Monthly Resident COVID-19 Cases per 100 Beds, mean	5.074	.123
Monthly Resident COVID-19 Related Deaths per 100 Beds, mean	0.933	.032
Monthly Staff COVID-19 Cases per 100 Beds, mean	4.430	.089
Two-year pandemic		
Monthly Resident COVID-19 Cases per 100 Beds, mean	3.160	.055
Monthly Resident COVID-19 Related Deaths per 100 Beds, mean	0.475	.014
Monthly Staff COVID-19 Cases per 100 Beds, mean	3.566	.060

Note. SES = Socioeconomic status; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.

Average CNA staffing among Ohio providers is around 2 hours per resident day (M = 2.052, SE = 0.016). Average staffing for licensed nurses such as LPN (M = 0.929, SE = 0.010)

and RN (M = 0.587, SE = 0.011) are both less than 1 hour per resident day. Staffing stability is relatively low in Ohio providers. Turnovers over three years of both NHA (M = 64.840, SE = 0.018) and DON (M = 67.429, SE = 0.018) are around sixty-five percent and average annual retention rates for LPN/RN (M = 69.464, SE = 0.854) and CNA are between sixty and seventy percent (M= 61.344, SE = 0.752). Temporary staff utilization is not prevalent in Ohio nursing homes, only about a third ever used agency RN (35.505%), LPN (30.718%), or CNA (33.378%).

Ohio providers primarily serve residents that are 65 or older (75.131%), white (minority: M= 17.820%), and having around 12 care needs (M= 12.207, SE = .041). As the course of the pandemic progressed, COVID-19 cases became more prevalent in communities, county-level incidence rates increased from 920 cases per 100,000 people each month in pre-vaccination to 1088 cases per 100,000 people each month at two years of the pandemic at the county level. Yet monthly COVID-19 cases (5 cases per 100 beds vs. 3 cases per 100 beds) and deaths (0.91 deaths per 100 beds vs. 0.46 deaths per 100 beds) for residents decline after vaccination becomes available, as do staff cases (4.46 cases per 100 beds vs. 3.61 cases per 100 beds).

Bivariate and Multiple Regression Results

Using multiple imputed data, this section organizes results of bivariate statistics and multiple regressions without/with accounting for spatial effects by research aims. Bivariate relationships between study measures are examined and a full display of bivariate results can be found in **Appendix C**. Pearson correlation tests are conducted to examine relationships between continuous measures. The relationships between the categorical measures and continuous are examined using simple linear regressions. Simple Poisson regressions are estimated to examine relationships between count measures (e.g., resident death count) and all other measures. Bivariate relationships between categorical measures are assessed with simple binary or multinomial logistics regressions.

Following bivariate analyses, multiple regressions without controlling for spatial effects (nonspatial models) are first estimated. Multiple linear regressions are estimated for continuous dependent measures – Overall rating, Health Inspection Rating, Quality Measures rating, Staffing rating, Overall Resident Satisfaction, and Overall Family Satisfaction. Count measures including resident cases, resident deaths, and staff cases in pre-vaccination as well as in two-year pandemic are estimated by multiple Poisson regressions. Residuals from multiple linear regressions and Pearson residuals from adjusted Poisson models are tested with Moran's I to

determine whether spatial effects could be considered in these models. Finally, linear regression models along with spatial models including SAR, SEM, and SMA are fitted. Count measures are Box-Cox transformed to make non-spatial models and spatial models comparable. AIC values are used to compare which model specification best describes the data.

Research Aim 1. *How does the level of neighborhood disadvantage impact nursing home quality from different perspectives?*

Table 2 presents bivariate test results of nursing home characteristics from different perspectives of quality. Nursing homes located in more socio-economically disadvantaged neighborhoods are more likely to receive lower ratings across all domains as well as the overall performance in the CMS Five Star Rating system. Payor mix and occupancy rate are significantly associated with CMS Five Star Rating system performance. Except for the Quality Measures domain, nursing homes that host a greater percentage of residents using Medicare as the primary payor source receive higher ratings in the CMS Five Star Rating system. Conversely, nursing homes that have a greater proportion of residents that are primarily supported by Medicaid are more likely to receive lower ratings across all domains in addition to the Overall rating. Nursing homes with increased occupancy rates tend to receive higher ratings in Health Inspection, Quality Measures, and Overall.

Table 2. Nursing Home Characteristics from Various Perspectives of Quality

	CMS Five Star Rating								Consumer Satisfaction			
	Overall		Health Inspection		Quality Measure		Staffing		Overall Resident Satisfaction		Overall Family Satisfaction	
	r or *β*	*p*	*r* or *β*	*p*	*r* or *β*	*p*	*r* or *β*	*p*	*r* or *β*	*p*	*r* or *β*	*p*
Neighborhood disadvantage (National ADI rank), r	-.143	<.001	.431	<.001	-.104	.004	-.198	<.001	-.072	.050	-.050	.178
Organizational Enabling Factors												
Medicare %, *r*	.191	<.001	.162	<.001	.051	.159	.312	<.001	.230	<.001	.139	<.001
Medicaid %, *r*	-.279	<.001	-.224	<.001	-.157	<.001	-.394	<.001	-.278	<.001	-.194	<.001
Occupancy rate, *r*	.203	<.001	.215	<.001	.152	<.001	.047	.198	.092	.011	.143	<.001
RN HPRD, *r*	.400	<.001	.283	<.001	.162	<.001	.722	<.001	.266	<.001	.237	<.001
LPN HPRD, *r*	-.035	.337	-.016	.667	-.053	.146	-.027	.464	.003	.934	-.047	.207
CNA HPRD, *r*	.364	<.001	.258	<.001	.198	<.001	.583	<.001	.314	<.001	.328	<.001
NHA turnover (ref=no turnover), *β*												
Has turnover	-.851	<.001	-.713	<.001	-.277	.003	-.387	<.001	-1.423	.003	-3.947	<.001
DON turnover (ref=no turnover), *β*												
Has turnover	-.780	<.001	-.686	<.001	-.303	<.001	-.223	.006	-1.678	<.001	-3.265	<.001
LPN/RN retention, *r*	.113	.006	.127	.002	.044	.280	.023	.572	.049	.247	.168	<.001
CNA retention, *r*	.048	.282	.070	.098	.001	.986	.045	.295	.018	.654	.134	.001
Any agency RN (ref=No), *β*												
Yes	-.331	.003	-.364	<.001	-.157	.068	.168	.025	-.494	.274	-1.377	.036
Any agency LPN (ref= No), *β*												
Yes	-.227	.046	-.320	.001	-.088	.327	.196	.011	.010	.982	-.010	.988
Any agency CNA (ref= No, *β*												
Yes	.002	.985	-.071	.457	-.039	.652	.244	.001	.260	.571	.647	.332
Facility size, *r*	-.129	<.001	-.134	<.001	-.007	.857	-.112	.002	-.167	<.001	-5.182	<.001
Ownership type (ref= non-profit/government owned), *β*												
Profit, %	-.744	<.001	-.407	<.001	-.306	.002	-.964	<.001	-3.478	<.001	-5.182	<.001
Chain affiliation (ref=Not affiliated), *β*												
Affiliated	-.258	.026	-.155	.118	.027	.765	-.411	<.001	-.972	.040	-3.805	<.001
CCRC membership (ref=not a member), *β*												
Yes	.680	<.001	.314	.010	.342	.002	.824	<.001	2.271	<.001	2.881	<.001
Dementia care unit (ref=no), *β*												
Yes	.038	.748	.002	.987	-.037	.689	-.015	.851	.121	.803	1.005	.158
Other care unit (ref=no), *β*												
Yes	-.046	.686	-.064	.516	-.113	.207	-.066	.392	-.162	.730	.741	.281
Location rurality (ref= Metropolitan), *β*												
Micropolitan	-.050	.717	.028	.814	-.387	<.001	.060	.525	1.951	<.001	1.894	.021
Rural	-.055	.756	.056	.708	-.076	.575	-.177	.136	2.464	<.001	4.067	<.001
Resident- and Community Level Predisposing and Need factors												
Resident Acuity Index, *r*	.015	.691	-.017	.652	.009	.806	.069	.058	-.002	.952	.030	.420
Minority Residents %, *r*	-.278	<.001	-.262	<.001	-.071	.053	-.272	<.001	-.343	<.001	-.389	<.001
65 or Older Residents %, *r*	.431	<.001	.360	<.001	.219	<.001	.502	<.001	.470	<.001	.436	<.001
County-level Infection (pre-vaccination), *r*	-.006	.878	-.044	.226	-.024	.517	.062	.089	-.021	.560	-.042	.261
County-level Infection (two-year pandemic), *r*	-.071	.053	-.050	.168	-.172	<.001	-.023	.521	.042	.256	-.042	.260

Note. r = correlation coefficient; β = regression coefficient; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.

Better CMS Five Star Rating performers consistently have higher RN and CNA staffing and are less likely to have NHA and DON turnovers. Furthermore, higher yearly retention rates of LPN/RN staff have been linked to better results in Health Inspection and Overall ratings. Not surprisingly, providers who have utilized temporary nursing staff, including RNs, LPNs, and CNAs, seem to have higher staffing ratings. However, the use of agency RNs and LPNs is linked to lower overall Health Inspection ratings.

The size of a nursing home tends to have a negative correlation with many CMS Five Star Ratings, except for the Quality Measures domain. Nursing homes that are for-profit and not part of a CCRC generally receive higher ratings across all domains and Overall ratings. Chain-affiliated nursing homes appear to have lower Overall and Staffing ratings compared to their non-chain affiliated counterparts. Nursing homes in micropolitan areas receive significantly lower Quality Measures ratings when compared to those in metropolitan areas.

Nursing homes with a higher proportion of minority residents tend to receive lower Overall ratings, Health Inspection ratings, and Staffing ratings. Additionally, nursing homes with higher CMS Five Star Ratings typically have a larger proportion of residents aged 65 or older.

Although there are some differences, the profile of nursing homes with high consumer satisfaction is similar to that of CMS Five Star Rating. These nursing homes have higher Medicare payor mix, lower Medicaid payor mix, higher occupancy rates, more staffing hours for RN and CNA, no turnovers of NHA and DON for a three-year period, smaller sizes, for-profit ownership, and are not chain affiliated. Unlike the CMS Five Star Rating, nursing homes in micropolitan or rural areas tend to have higher satisfaction scores from residents and family than those in metropolitan areas. Additionally, similar to the CMS Five Star Rating, high Consumer Satisfaction scorers are nursing homes serving a smaller proportion of minority residents and larger proportion of 65 or older residents.

Table 3 displays the multiple linear regression results for neighborhood SES and nursing home quality. Socioeconomic resources levels in neighborhoods are neither significantly associated with any of CMS Five Star Ratings nor any Consumer Satisfaction scores ($p > .05$) after controlling for other variables.

Table 3. Multiple Linear Regression Results for Neighborhood Disadvantage and Nursing Home Quality

	CMS Five Star Rating				Consumer Satisfaction	
	Overall	Health Inspection	Quality Measures	Staffing	Overall Resident Satisfaction	Overall Family Satisfaction
	β	*β*	*B*	*β*	*β*	*β*
Neighborhood disadvantage (National ADI rank)	-.003	-.001	-.000	-.003	.005	.012
Organizational Enabling Factors						
Medicare %	-.000	-.011	-.013*	.008	-.011	-.059
Medicaid %	-.007*	-.004	-.004	-.006***	-.030*	-.009
Occupancy rate	.012**	.015***	.008*	-.002	.014	.046*
RN HPRD		.828***	.419*		1.154	1.707
LPN HPRD		.156	-.186		.173	-.522
CNA HPRD		.084	.214		1.439**	1.802*
NHA turnover (ref=no turnover)						
Has turnover	-.442***	-.324***	-.099	-.150*	.070	-1.227†
DON turnover (ref=no turnover)						
Has turnover	-.355**	-.323***	-.188	-.016	-.435	-.371
LPN/RN retention	.002	.003	-.000	-.002	-.000	.030
CNA retention	.001	.001	-.002	.001	-.005	.030
Any agency RN (ref=No)						
Yes	-.304**	-.285**	-.170	.055	-.542	-1.252
Any agency LPN (ref=No)						
Yes	-.198	-.365**	-.007	.094	.299	.274
Any agency CNA (ref=No)						
Yes	.144	.279*	-.038	-.029	-.101	.421
Facility size	-.004***	-.003**	.001	-.002	-.013*	-.029***
Ownership type (ref=non-profit/government owned)						
Profit	-.196	.065	-.028	-.502***	-1.284*	-1.426
Chain affiliation (ref=Not affiliated						
Affiliated	.049	.104	.193*	-.165*	.128	-2.005**
CCRC membership (ref=not a member)						
Yes	.059	-.146	.129	.166	-.885	-1.086
Dementia care unit (ref=no)						
Yes	.290	.183	.311	.116	.296	-.340
Other care unit (ref=no)						
Yes	-.231	-.136	-.433	-.148	-.038	1.691
Location rurality (ref=metropolitan)						
Micropolitan	-.297*	-.182	-.423***	-.019	.897	-.003
Rural	-.253	-.094	-.051	-.252*	1.421*	1.901*
Resident- and Community-Level Predisposing and Need factors						
Resident Acuity Index	-.031	-.051	-.029	.020	-.228	-.255
Minority Residents %	-.008**	-.006**	.001	-.005**	-.043***	-.087***
65 or Older Residents %	.021***	.013***	.008*	.015***	.088***	.125***

Note. SES= Socioeconomic Status; β = regression coefficient; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA =

Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
*p <.05, **p <.01, ***p < .001.

In contrast to the bivariate analyses, the multiple linear regressions reveal that nursing homes with a higher proportion of residents primarily supported by Medicare tend to have lower CMS Five-Star Quality Measures ratings. Additionally, those with a higher Medicaid payer mix show lower CMS Five-Star Overall and Staffing ratings, along with diminished Overall Resident Satisfaction scores. Conversely, nursing homes with increased occupancy rates tend to achieve higher CMS Five-Star Ratings in Overall, Health Inspection, and Quality Measures, as well as elevated Family Satisfaction Scores.

Workforce characteristics demonstrate significant relationships with nursing home quality. Increased RN staffing is positively associated with higher CMS Five-Star Health Inspection and Quality Measures ratings, although it does not correlate with any Consumer Satisfaction scores. Conversely, CNA staffing shows a positive association with both Overall Resident and Family Satisfaction scores. Leadership instability adversely impacts CMS Five-Star Ratings, as turnover among Nursing Home Administrators (NHA) and Directors of Nursing (DON) over a three-year period is linked to decreased Overall and Health Inspection ratings. Additionally, NHA turnover is associated with lower CMS Five-Star Staffing ratings. Notably, utilization of licensed temporary nursing staff including RN and LPN has negative impacts on CMS Five Star Rating performance. Nursing homes that have employed agency RN have significantly lower Overall ratings than those that have not. Nursing homes that have used agency RN and LPN are more likely to receive lower Health Inspection ratings. On the contrary, using agency CNAs is associated with higher Health Inspection ratings.

Multiple linear regression results suggest that nursing home size and ownership type are factors that impact nursing home quality. Larger nursing homes tend to receive lower ratings for Overall ($p < .05$) and Health Inspection ($p < .01$) domains of CMS Five Star Ratings, as well as lower scores for Overall Resident and Overall Family Satisfaction scores of Consumer Satisfaction ($p < .05$ and $p < .001$, respectively). Compared to not-for-profit or government-owned nursing homes, for-profit nursing homes have significantly lower CMS Five-Star Staffing ratings ($p < .001$) and Overall Resident Satisfaction scores ($p < .05$). Furthermore, chain affiliation affects nursing home quality in different ways. Chain-affiliated nursing homes

typically exhibit lower CMS Five-Star Staffing ratings and Overall Family Satisfaction scores ($p < .05$ and $p < .01$, respectively), while showing higher CMS Five-Star Quality Measures ratings ($p < .05$). Additionally, the quality performance reflected in CMS Five-Star and Consumer Satisfaction is influenced differently by the rurality of the nursing home's location. Nursing homes situated in more rural areas typically receive lower CMS Five-Star ratings than those in metropolitan regions. In particular, micropolitan nursing homes show reduced CMS Five-Star Overall ratings ($p < .05$) and Quality Measures ratings ($p < .001$), while rural nursing homes have lower CMS Five-Star Staffing ratings ($p < .05$). Despite these lower ratings, rural nursing homes tend to achieve higher Consumer Satisfaction scores for both residents and families ($p < .05$) compared to their metropolitan counterparts.

Resident composition plays a significant role in achieving higher ratings and satisfaction in nursing homes. Nursing homes that serve a population with fewer minorities tend to have higher ratings in CMS Five Star Overall ($p< .01$), Health Inspection ($p < .01$), and Staffing domains ($p < .01$), as well as higher scores in both Overall Resident and Overall Family Consumer Satisfaction ($p < .001$ and $p < .001$, respectively). Additionally, nursing homes that cater to a larger proportion of residents aged 65 or older also tend to have higher ratings in all four CMS Five Star domains Ratings (Overall [$p < .001$], Health Inspection [$p <.001$], Quality Measures [$p < .05$], and Staffing [$p < .001$]), as well as higher Overall Resident ($p < .001$) and Family Satisfaction scores ($p < .001$).

Research Aim 2. *How does the level of neighborhood disadvantage impact various COVID-19 outcomes?*

Table 4 displays the bivariate relationships on the characteristics of nursing homes with varying COVID outcomes using simple Poisson regressions. Regardless of pre-vaccination time and the two-year span of the pandemic, there is no significant difference in monthly cases and deaths of residents or cases among staff based on the socio-economic disadvantage levels of the neighborhood.

Table 4. Characteristics of Nursing Home by Different COVID-19 Outcomes

	Pre-Vaccination						*Two-year pandemic*					
	Monthly Resident COVID-19 Cases per 100 Beds		Monthly Resident COVID-19 Related Deaths per 100 Beds		Monthly Staff COVID-19 Cases per 100 Beds		Monthly Resident COVID-19 Cases per 100 Beds		Monthly Resident COVID-19 Related Deaths per 100 Beds		Monthly Staff COVID-19 Cases per 100 Beds	
	IRR	*p*	IRR	*p*	IRR	*p*	IRR	*p*	IRR	*p*	IRR	*p*
Neighborhood disadvantage (National ADI rank)	1.001	.255	1.002	.125	.999	.239	1.001	.250	1.002	.083	.999	.084
Organizational Enabling Factors												
Medicare %	.999	.680	.999	.756	1.013	<.001	1.001	.708	1.003	.433	1.015	<.001
Medicaid %	1.003	.066	.999	.645	.997	.004	1.002	.078	.999	.691	.996	<.001
Occupancy rate	1.006	.005	1.009	.003	1.008	<.001	1.007	<.001	1.008	<.001	1.010	<.001
RN HPRD	.830	.075	1.007	.958	1.478	<.001	.796	.001	1.113	.329	1.547	<.001
LPN HPRD	.758	.005	.759	.033	.938	.407	.805	.001	.769	.019	1.001	.988
CNA HPRD	.843	.009	1.002	.979	1.307	<.001	.853	<.001	1.031	.672	1.412	<.001
NHA turnover (ref=no turnover)												
Has turnover	.945	.298	.832	.008	.888	.005	.994	.875	.847	.006	.883	<.001
DON turnover (ref=no turnover)												
Has turnover	.960	.462	.875	.056	.889	.007	.924	.892	.878	.034	.872	<.001
LPN/RN retention, mean	1.000	.741	1.001	.535	1.000	.813	1.000	.590	1.003	.095	1.001	.167
CNA retention, mean	1.000	.959	1.000	.909	1.002	.221	.999	.603	.999	.597	1.001	.292
Any agency RN (ref=No)												
Yes	.941	.250	.998	.975	.979	.610	.938	.073	1.010	.870	.990	.755
Any agency LPN (ref=No)												
Yes	.922	.142	1.005	.941	.955	.287	.919	.024	1.007	.913	.954	.167
Any agency CNA (ref=No)												
Yes	.887	.028	.982	.799	.955	.273	.911	.011	.998	.973	.985	.653
Facility size	.999	.019	1.000	.689	.998	<.001	.999	.009	1.000	.397	.999	<.001
Ownership type (ref=non-profit/government owned)												
Profit	1.214	.002	0.939	.422	.816	<.001	1.210	<.001	.933	.306	.768	<.001
Chain affiliation (ref=Not affiliated)												
Affiliated	1.152	.012	0.978	.757	.962	.362	1.157	<.001	1.009	.882	.927	.023
CCRC (ref=not a member)												
Yes	.944	.416	1.235	.013	1.394	<.001	.948	.264	1.228	.006	1.403	<.001
Dementia care unit (ref=no)												
Yes	.876	.014	.974	.704	.938	.132	.892	.002	.951	.410	.974	.425

Other care unit (ref=no)												
Yes	.915	.089	.993	.915	.955	.266	.914	.011	.961	.500	.975	.433
Location rurality (ref=metropolitan)												
Micropolitan	1.020	.766	1.113	.220	1.072	.187	.988	.794	1.133	.096	1.094	.028
Rural	1.093	.306	1.177	.146	1.155	.033	1.073	.235	1.225	.034	1.138	.014
Resident- and Community Level Predisposing and Need factors												
Resident Acuity Index	.971	.242	.983	.618	1.006	.771	.961	.019	1.000	.998	1.017	.289
Minority Residents %	.997	.015	.994	.001	.995	<.001	.998	.020	.993	<.001	.994	<.001
65 or Older Residents %	1.002	.193	1.009	<.001	1.009	<.001	1.001	.506	1.010	<.001	1.010	<.001
County-level Incidence rate (pre-vaccination)	1.001	.028	1.001	.004	1.001	<.001						
County-level Incidence rate (two-year pandemic)							1.000	.617	1.001	.055	1.000	.010

Note. IRR = Incidence Rate Ratio; SES = Socioeconomic status; β = regression coefficient; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
*p < .05, **p < .01, ***p < .001

COVID-19 outcomes are different by financial status including payor mix and occupancy rates in nursing homes, regardless of whether older adults have access to vaccinations. In general, nursing homes with a higher percentage of residents that are primarily paid for by Medicare and a lower percentage that are primarily paid for by Medicaid are more likely to experience an increase in the expected number of monthly staff cases. Additionally, nursing homes with higher occupancy rates are more likely to experience a greater number of resident cases, resident deaths, and staff cases each month during the pre-vaccination period and the two years of the pandemic.

Higher nursing staffing levels are associated with increased cases and deaths in residents but decreased cases in staff personnel in nursing homes, regardless of the time status. Nursing homes with higher levels of RN and CNA staffing have reported more cases among their staff. Conversely, nursing homes with higher levels of LPN and CNA staffing have reported fewer cases among their residents. Furthermore, nursing homes with higher levels of LPN staffing have reported fewer COVID-19 related deaths among their residents.

Nursing homes that experience turnovers for their NHA and DON positions over a three-year period tend to have fewer COVID-19 cases in both residents and staff, regardless of pre-vaccination status or the two-year pandemic. Additionally, nursing homes with NHA turnovers also report fewer COVID-19 related deaths among their residents. Before the availability of vaccination, there were no significant differences in the average number of monthly cases and deaths among residents, as well as cases among staff members regardless of whether temporary nurses are used or not. In the two years since the pandemic began, nursing homes that employ agency nurses, including LPNs and CNAs, have on average experienced significantly fewer resident cases each month compared to those that don't.

Additionally, the sizes of nursing homes are positively associated with average monthly cases among residents and staff regardless of time status. COVID-19 related outcomes in nursing homes are also significantly different in other organizational characteristics. For example, for-profit providers have significantly more COVID-19 cases in both residents and staff members than their non-profit or government owned counterparts. Prior to the availability of the vaccination, chain-affiliated nursing homes have significantly more COVID-19 related deaths in residents and cases in staff members. After two years in pandemic, chain affiliated nursing homes still have significantly more monthly average COVID-19 cases among residents but fewer

cases among staff members. Furthermore, nursing homes that are part of a CCRC have significantly more deaths among residents but fewer cases among staff members regardless of time status. There are also significant differences in COVID-19 cases between nursing homes with dementia or special care units and those without. Providers operating dementia care units are expected to have 12.4% lower cases among residents during the pre-vaccination period and 10.8% lower cases during the two years of the pandemic compared to those who do not operate such units. There is no significant difference in resident cases between nursing homes with special care units and those without before vaccination availability. However, during the two years of pandemic, there were 8.6% fewer cases on average every month in homes with special care units compared to those without. Nursing homes located in more rural areas are more likely to have more staff cases. Compared to those in metropolitan areas, nursing homes in rural areas on average have 15% more cases among their staff members before vaccination became available to Ohio older adults. After two years in the COVID-19 pandemic, related deaths among residents are 22.5% higher for nursing homes in rural areas compared to those in metropolitan areas. Additionally, cases among staff members are respectively 9.4% and 13.8% higher for nursing homes in micropolitan and rural areas compared to those in metropolitan areas.

COVID-19 outcomes in nursing homes also show differences in terms of their resident characteristics and infection rates in communities. Nursing homes that serve a higher proportion of non-white residents tend to have fewer cases and deaths among residents as well as cases among staff members across time. Nursing homes that serve a higher proportion of older adults that are 65 or older have increased number of deaths among residents and cases in staff members regardless of study period. Higher COVID-19 infection rates in counties where nursing homes are located are associated with all three nursing home COVID-19 outcome measures (resident case, resident deaths, and staff cases) during pre-vaccination, After two years in the pandemic, nursing homes that are in communities with higher incidence rates show little difference in terms of cases and deaths among residents and marginally higher cases among staff members (IRR = 1.000, $p < 0.5$).

COVID-19 Cases in Residents

Table 5 presents the associations between neighborhood disadvantage levels and resident COVID-19 case incidence rates, controlling for organizational, resident, and community-level factors during both the pre-vaccination and two-year pandemic periods.

Table 5. Adjusted Poisson Regression Results of Associations Between Neighborhood Disadvantage Levels and Monthly Nursing Home Resident COVID-19 Cases per 100 Beds

	Monthly Resident COVID-19 Cases per 100 Beds					
	Pre-Vaccination			Two-Year Pandemic		
N = 752	**IRR**	**95% CI**		**IRR**	**95% CI**	
Neighborhood disadvantage (National ADI rank)	1.001	.998	1.003	1.001	.999	1.002
Organizational Enabling Factors						
Medicare %	.999	.990	1.008	1.004	.998	1.009
Medicaid %	1.002	.999	1.005	1.001	.999	1.003
Occupancy rate	1.006**	1.002	1.010	1.007***	1.004	1.010
RN HPRD	.814	.618	1.071	.775**	.646	.929
LPN HPRD	.804	.645	1.003	.827*	.716	.956
CNA HPRD	.833*	.715	.971	.878*	.794	.971
NHA turnover (ref=no turnover)						
Has turnover	.927	.826	1.041	.972	.898	1.052
DON turnover						
Has turnover	.984	.877	1.104	1.019	.944	1.099
LPN/RN retention	.999	.996	1.001	1.000	.998	1.002
CNA retention	1.001	.998	1.004	1.000	.998	1.002
Any agency RN (ref=No)						
Yes	.976	.865	1.102	.990	.915	1.072
Any agency LPN (ref=No)						
Yes	1.033	.865	1.234	.981	.873	1.103
Any agency CNA (ref=No)						
Yes	.909	.770	1.072	.974	.874	1.084
Facility size	.999	.998	1.000	.999	.999	1.000
Ownership type (ref=non-profit/government owned)						
Profit	1.141	.992	1.313	1.128*	1.028	1.238
Chain affiliation						
Affiliated	1.088	.969	1.223	1.085*	1.005	1.172
CCRC						
Yes	1.030	.886	1.198	1.037	.939	1.145
Dementia care unit						
Yes	.719**	.560	.923	.829*	.699	.983
Other care unit						
Yes	1.255	.987	1.596	1.113	.94465	1.312
Location rurality (ref=metropolitan)						
Micropolitan	.932	.809	1.074	.930	.846	1.023
Rural	1.005	.843	1.198	1.008	.897	1.133
Resident- and Community Level Predisposing and Need factors						
Resident Acuity Index	.996	.945	1.049	.985	.952	1.019
Minority Residents %	.998	.995	1.001	.998	.996	1.000
65 or Older Residents %	1.006**	1.002	1.010	1.003*	1.001	1.006
County-level Incidence Rate	1.001**	1.000	1.001	1.000	1.000	1.000

Note. IRR = Incidence Rate Ratio; CI = Confidence Interval; SES= Socioeconomic Status; β = regression coefficient; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
*p <.05, **p <.01, ***p < .001.

Levels of neighborhood socioeconomic disadvantage are not significantly associated with COVID-19 cases in residents nursing homes receive prior to vaccination availability. Nursing homes that have higher occupancy rates (IRR =1.006, 95% CI = 1.002-1.010), lower CNA staffing levels (IRR = 0.833, 95% CI = 0.715 - 0.971), no dementia care units (IRR = 0.719, 95% CI = 0.560-0.923), a larger proportion of residents aged 65 or older (IRR = 1.006, 95% CI = 1.002-1.010), and are in counties with higher confirmed COVID-19 cases incidence rates (IRR = 1.001, 95% CI = 1.000-1.001) are at a greater risk of experiencing more COVID-19 cases among their residents before vaccination.

After two years of the pandemic, resident cases expected every month are not significantly associated with neighborhood socioeconomic disadvantage levels. Instead, higher case incidence rates among residents in nursing homes during two-year pandemic are explained by increased occupancy rates (IRR = 1.007, 95% CI = 1.004-1.010), lower staffing levels of RN (IRR = .775, 95% CI = 0.646-0.929), LPN (IRR = 0.827, 95% CI = 0.716-0.956), and CNA (IRR = 0.878, 95% CI = 0.794-0.971), for-profit ownership (IRR = 1.128, 95% CI = 1.028-1.238), chain affiliation (IRR = 1.085, 95% CI = 1.005-1.172), not having a dementia care unit (IRR = 0.829, 95% CI = 0.699-0.983), and a larger body of 65 or older residents (IRR = 1.003, 95% CI = 1.001-1.006).

COVID-19 Related Deaths in Residents

Table 6 presents the associations between neighborhood disadvantage levels and monthly COVID-19 related deaths among residents, accounting for relevant factors, during both the pre-vaccination and two-year pandemic periods. Before the availability of vaccines, nursing homes in economically disadvantaged neighborhoods had a higher COVID-19 mortality rate among residents.

For every one percentile increase in the ADI national ranking, the expected number of COVID-19 related deaths per 100 beds among residents increases by 0.4% (IRR = 1.004, 95% CI = 1.000-1.007) during the pre-vaccination period, after adjusting for other factors.

Additionally, nursing homes that are part of a CCRC (IRR = 1.230, 95% CI = 1.022-1.479), serve a higher proportion of residents aged 65 or older (IRR = 1.011, 95% CI = 1.005-1.017), and are located in counties with higher COVID-19 incidence rates (IRR = 1.001, 95% CI = 1.000-1.001) experience increased COVID-19 related deaths among residents.

Table 6. Adjusted Poisson Regression Results of Associations Between Neighborhood Disadvantage Levels and Monthly COVID-19 Related Deaths Among Residents per 100 Beds in Nursing Homes

N = 752	Monthly Resident COVID-19 related Deaths per 100 Beds					
	Pre-Vaccination			Two-Year Pandemic		
	IRR	**95% CI**		**IRR**	**95% CI**	
Neighborhood disadvantage (National ADI rank)	1.004*	1.000	1.007	1.003*	1.001	1.006
Organizational Enabling Factors						
Medicare %	.991	.979	1.003	.995	.985	1.005
Medicaid %	1.001	.997	1.005	1.002	.999	1.006
Occupancy rate	1.006	1.000	1.012	1.006*	1.001	1.011
RN HPRD	.840	.585	1.206	.967	.714	1.309
LPN HPRD	.758	.566	1.014	.808	.632	1.033
CNA HPRD	.833	.682	1.017	.856	.720	1.017
NHA turnover (ref=no turnover)						
Has turnover	.878	.753	1.023	.903	.790	1.033
DON turnover						
Has turnover	.944	.816	1.094	.967	.852	1.098
LPN/RN retention	.999	.995	1.003	1.002	.998	1.005
CNA retention	.999	.995	1.004	.998	.994	1.002
Any agency RN (ref=No)						
Yes	1.000	.852	1.174	1.029	.897	1.180
Any agency LPN (ref=No)						
Yes	1.093	.865	1.381	1.046	.854	1.280
Any agency CNA (ref=No)						
Yes	.921	.742	1.144	.969	.805	1.166
Facility size	1.000	.999	1.002	1.000	.999	1.001
Ownership type (ref=non-profit/government owned)						
Profit	1.031	.865	1.230	1.020	.876	1.188
Chain affiliation						
Affiliated	1.017	.875	1.183	1.062	.931	1.211
CCRC						
Yes	1.230*	1.022	1.479	1.235**	1.052	1.449
Dementia care unit						
Yes	.791	.562	1.114	.831	.614	1.125
Other care unit						
Yes	1.160	.833	1.616	1.09	.816	1.467
Location rurality (ref=metropolitan)						
Micropolitan	.974	.811	1.169	.985	.839	1.155

Rural	1.065	.847	1.339	1.122	.922	1.365
Resident- and Community Level Predisposing and Need factors						
Resident Acuity Index	.981	.914	1.053	.990	.931	1.052
Minority Residents %	.996	.992	1.001	.996*	.993	1.000
65 or Older Residents %	1.011***	1.005	1.017	1.010***	1.005	1.015
County-level Incidence Rate	1.001**	1.000	1.001	1.000	1.000	1.001

Note. IRR = Incidence Rate Ratio; CI = Confidence Interval; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
*p <.05, **p <.01, ***p < .001.

Although the increase is modest, each additional 1% in neighborhood disadvantage national ranking is associated with a 0.3% rise in COVID-19 related deaths over the two-year pandemic period (compared to 0.4% during the pre-vaccination period), after adjusting for other factors. Nursing homes with higher occupancy rates (IRR = 1.006, 95% CI = 1.001-1.011), those part of a CCRC (IRR = 1.235, 95% CI = 1.052-1.449), and those serving a greater proportion of residents aged 65 or older (IRR = 1.010, 95% CI = 1.005-1.015) remain at a higher risk of experiencing more COVID-19 related deaths per 100 beds each month. Interestingly, facilities with a larger proportion of minority residents (IRR = .996, 95% CI = .993-1.000) tend to have lower COVID-19 mortality rates. During the two-year pandemic period, county-level COVID-19 incidence rates no longer significantly influence resident mortality.

COVID-19 Cases in Staff

Results of adjusted Poisson regressions estimating association between neighborhood disadvantage levels and COVID-19 cases among staff members are presented in **Table 7**. COVID-19 incidence rates among staff members during the pre-vaccination period and the two-year vaccination phase show no significant relationship with the socioeconomic disadvantage levels of nursing home neighborhoods after controlling for other variables. However, prior to the availability of vaccines, a higher expected number of COVID-19 cases per 100 beds among staff members each month is associated with several factors: higher occupancy rates (IRR = 1.007, 95% CI = 1.004-1.010), increased RN staffing levels (IRR = 1.232, 95% CI: 1.046-1.451), fewer certified beds (IRR = 0.999, 95% CI: 0.998-1.000), being part of a CCRC (IRR = 1.227, 95% CI = 1.112-1.354), serving a larger proportion of residents aged 65 or older (IRR = 1.005, 95% CI:

1.001-1.008), and being located in counties with higher COVID-19 incidence rates (IRR = 1.001, 95% CI = 1.001-1.001).

Table 7. Adjusted Poisson Regression Results of Associations Between Neighborhood Disadvantage Levels and Monthly COVID-19 Staff Cases per 100 Beds in Nursing Homes

	Monthly Staff COVID-19 Cases per 100 Beds					
	Pre-Vaccination			Two-Year Pandemic		
N = 752	**IRR**	**95% CI**		**IRR**	**95% CI**	
Neighborhood disadvantage (National ADI rank)	1.000	.998	1.002	1.000	.999	1.001
Organizational Enabling Factors						
Medicare %	1.002	.996	1.008	1.002	.998	1.006
Medicaid %	1.002	1.000	1.005	1.001	1.000	1.003
Occupancy rate	1.007***	1.004	1.010	1.008***	1.006	1.010
RN HPRD	1.232*	1.046	1.451	1.259***	1.124	1.410
LPN HPRD	.996	.862	1.151	1.041	.942	1.151
CNA HPRD	1.015	.916	1.125	1.089*	1.013	1.171
NHA turnover (ref = No turnover)						
Has turnover	.966	.888	1.051	.992	.934	1.054
DON turnover						
Has turnover	.961	.886	1.042	.966	.912	1.023
LPN/RN retention	.999	.997	1.001	1.000	.999	1.002
CNA retention	1.001	.999	1.004	1.000	.998	1.002
Any agency RN (ref=No)						
Yes	.980	.898	1.068	1.015	.955	1.079
Any agency LPN (ref=No)						
Yes	.993	.875	1.126	.948	.867	1.037
Any agency CNA (ref=No)						
Yes	.929	.827	1.044	.985	.908	1.069
Facility size	.999**	.998	1.000	.999***	.998	.999
Ownership type (ref=non-profit/government owned)						
Profit	.948	.863	1.041	.915**	.856	.977
Chain affiliation						
Affiliated	1.024	.943	1.111	1.013	.956	1.074
CCRC						
Yes	1.227***	1.112	1.354	1.202***	1.121	1.288
Dementia care unit						
Yes	.807*	.669	.973	.912	.795	1.047
Other care unit						
Yes	1.166	.972	1.398	1.070	.936	1.222
Location rurality (ref=metropolitan)						
Micropolitan	.974	.880	1.077	.991	0.923	1.065
Rural	1.110	.979	1.258	1.118*	1.022	1.222
Resident- and Community Level Predisposing and Need factors						
Resident Acuity Index	.993	.958	1.029	.992	.967	1.017
Minority Residents %	.998	.996	1.000	.998*	.996	1.000

65 or Older Residents %	1.005**	1.001	1.008	1.003**	1.001	1.006
County-level Incidence Rate	1.001***	1.001	1.001	1.000**	1.000	1.001

Note. IRR = Incidence Rate Ratio; CI = Confidence Interval; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
*p <.05, **p <.01, ***p < .001.

After two years of the COVID-19 pandemic, the incidence rates of COVID-19 among staff members do not significantly vary based on the disadvantage levels of nursing home neighborhoods. However, several factors are associated with higher incidence rates among staff. Nursing homes with higher occupancy rates (IRR = 1.008, 95% CI = 1.006 - 1.010), as well as those with increased RN (IRR = 1.259, 95% CI = 1.124 - 1.410) and CNA (IRR = 1.089, 95% CI = 1.013-1.171) staffing levels, tend to experience more cases. Additionally, providers with fewer certified beds (IRR = 0.999, 95% CI = 0.998 - 0.999), those that are part of a CCRC (IRR = 1.202, 95% CI = 1.121-1.288), and those that are non-profit or government-owned (IRR = 0.915, 95% CI = 0.856 - 0.977) are also associated with higher incidence rates. Furthermore, nursing homes located in rural areas (IRR = 1.118, 95% CI = 1.022 - 1.222) or in counties with higher overall COVID-19 incidence rates (IRR = 1.000, 95% CI = 1.000-1.001) also report elevated rates. Interestingly, providers that serve a lower proportion of minority residents (IRR = 0.998, 95% CI = 0.996 - 1.000) and a higher proportion of residents aged 65 or older (IRR = 1.003, 95% CI = 1.001 - 1.006) are also more likely to experience increased COVID-19 incidence rates among staff members during the two-year pandemic.

Research Aim 3. *How different levels of nursing home quality affect the relationship between neighborhood disadvantage and COVID-19 outcomes?*

Simple Poisson regressions are employed to estimate the bivariate relationships between quality measures and COVID-19 outcomes, as shown in Table 8. Prior to the availability of vaccinations, there are no significant differences in monthly COVID-19 cases among residents per 100 beds based on the performance of CMS Five-Star Ratings or Consumer Satisfaction scores. However, after two years of the pandemic, nursing homes with higher Staffing domain ratings in the CMS Five-Star Rating (p = .002) are expected to have fewer COVID-19 cases among residents per 100 beds each month. The expected number of cases among residents per 100 beds does not correlate with performance in other CMS Five-Star Rating domains or with Consumer Satisfaction scores during the two-year pandemic period.

Table 8. Bivariate Relationships Between Nursing Home Quality and COVID-19 Outcomes in Ohio

N = 752	*Pre-Vaccination*						*Two-year Pandemic*					
	Monthly Resident COVID-19 Cases per 100 Beds		Monthly Resident COVID-19 related Deaths per 100 Beds		Monthly Staff COVID-19 Cases per 100 Beds		Monthly Resident COVID-19 Cases per 100 Beds		Monthly Resident COVID-19 related Deaths per 100 Beds		Monthly Staff COVID-19 Cases per 100 Beds	
	IRR	*p*	IRR	*p*	IRR	*p*	IRR	*p*	IRR	*p*	IRR	*p*
CMS Five Star Rating												
Overall Rating	1.011	.544	1.068	.004	1.078	<.001	1.002	.896	1.068	.001	1.100	<.001
Health Inspection	1.020	.336	1.056	.041	1.074	<.001	1.011	.418	1.055	.021	1.099	<.001
Quality Measures	1.034	.147	1.081	.010	1.046	.013	1.016	.297	1.072	.008	1.054	<.001
Staffing	.961	.132	1.064	.070	1.132	<.001	.947	.002	1.083	.007	1.156	<.001
Consumer Satisfaction												
Overall Resident Satisfaction	.996	.302	1.014	.019	1.012	<.001	.994	.059	1.013	.012	1.018	<.001
Overall Family Satisfaction	1.001	.794	1.009	.027	1.009	<.001	.999	.560	1.010	.003	1.013	<.001

Note. IRR = Incidence Rate Ratio
*p <.05, **p <.01, ***p < .001

Before the availability of COVID-19 vaccinations, mortality rates among nursing home residents were associated with higher Overall (p = .004), Health Inspection (p = .041), and Quality Measures (p = .010) CMS Five-Star Ratings, as well as higher Overall Resident (p = .019) and Overall Family Satisfaction scores (p = .027). During the two-year pandemic, nursing homes with higher CMS Five-Star Ratings in Overall (p = .001), Health Inspection (p = .021), Quality Measures (p = .008), and Staffing (p = .007), along with higher Consumer Satisfaction scores from residents (p = .012) and family members (p = .03), experienced significantly more deaths among residents per 100 beds each month.

Additionally, providers with higher scores in all four CMS Five-Star Ratings (Overall, Health Inspection, Quality Measures, and Staffing), as well as higher Consumer Satisfaction scores for Overall Resident and Overall Family, tended to experience significantly more staff COVID-19 cases per 100 beds each month, regardless of the time period.

COVID-19 Cases Among Residents

The Role of CMS Five Star Rating

Results of adjusted Poisson regressions evaluating roles of Overall, Health Inspection, Quality Measures, and Staffing CMS Five-Star Ratings in the relationships between neighborhood disadvantage levels and COVID-19 cases among residents during the pre-vaccination and two-year pandemic periods are respectively shown in **Table 9** and **Table 10**.

Table 9. The Role of CMS Five-Star Rating in the Relationship Between Neighborhood Disadvantage Levels and Monthly COVID-19 Cases per 100 Beds Among Residents During the Pre-Vaccination Period.

N = 752	Monthly Resident COVID-19 Cases per 100 Beds (Pre-Vaccination)														
	IRR	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**	
Neighborhood disadvantage (National ADI rank)	1.001	.998	1.003	1.001	.999	1.004	1.001	.998	1.003	1.001	.998	1.003	1.001	.999	1.004
Organizational Enabling Factors															
Medicare %	.999	.990	1.008	.996	.988	1.005	.999	.991	1.008	.999	.991	1.008	.997	.988	1.005
Medicaid %	1.002	.999	1.005	1.003	1.000	1.006	1.002	.999	1.006	1.002	.999	1.006	1.003	.999	1.006
Occupancy rate	1.006**	1.002	1.010	1.006**	1.002	1.010	1.006**	1.001	1.010	1.006*	1.001	1.010	1.006**	1.001	1.010
RN HPRD	.814	.618	1.071				.805	.609	1.064	.798	.605	1.052			
LPN HPRD	.804	.645	1.003				.802	.643	1.001	.805	.646	1.004			
CNA HPRD	.833*	.715	.971				.831*	.713	0.969	.828*	.710	.965			
NHA turnover (ref=no turnover)															
Has turnover	.927	.826	1.041	.935	.831	1.051	.930	.828	1.046	.932	.829	1.047	.933	.831	1.047
DON turnover															
Has turnover	.984	.877	1.104	.996	.886	1.119	.988	.880	1.109	.990	.882	1.111	.997	.888	1.119
LPN/RN retention	.999	.996	1.001	.999	.996	1.002	.999	.996	1.001	.999	.996	1.001	.999	.996	1.002
CNA retention	1.001	.998	1.004	1.001	.998	1.004	1.001	.998	1.004	1.001	.998	1.004	1.001	.998	1.004
Any agency RN (ref=No)															
Yes	.976	.865	1.102	.961	.851	1.085	.978	.866	1.105	.980	.868	1.106	.966	.856	1.090
Any agency LPN (ref=No)															
Yes	1.033	.865	1.234	1.025	.857	1.227	1.037	.867	1.240	1.029	.862	1.229	1.028	.859	1.229
Any agency CNA (ref=No)															
Yes	.909	.770	1.072	.918	.777	1.084	.906	.768	1.070	.913	.774	1.076	.918	.778	1.084
Facility size	.999	.998	1.000	.999	.998	1.001	.999	.998	1.000	.999	.998	1.000	.999	.998	1.000
Ownership type (ref=non-profit/government owned)															
Profit	1.141	.992	1.313	1.199*	1.043	1.377	1.139	.990	1.312	1.140	.991	1.312	1.179*	1.022	1.359
Chain affiliation															
Affiliated	1.088	.969	1.223	1.117	.994	1.255	1.087	.968	1.222	1.082	.963	1.216	1.111	.989	1.249
CCRC															
Yes	1.030	.886	1.198	1.000	.860	1.163	1.032	.888	1.201	1.024	.880	1.191	1.006	.865	1.170
Dementia care unit															
Yes	.719**	.560	.923	.722*	.563	.928	.719**	.560	.923	.712**	.554	.914	.726*	.565	.933
Other care unit															
Yes	1.255	.987	1.596	1.240	.975	1.578	1.256	.987	1.597	1.272	1.000	1.619	1.232	.968	1.567
Location rurality (ref=metropolitan)															
Micropolitan	.932	.809	1.074	.940	.814	1.084	.933	.810	1.075	.945	.819	1.090	.941	.816	1.085
Rural	1.005	.843	1.198	1.026	.860	1.224	1.005	.842	1.198	1.006	.843	1.199	1.019	.853	1.216
Resident- and Community Level Predisposing and Need factors															
Resident Acuity Index	.996	.945	1.049	.983	.933	1.035	.996	.945	1.050	.999	.947	1.053	.983	.934	1.035

Minority Residents %	.998	.995	1.001	.997	.994	1.000	.998	.995	1.001	.998	.995	1.001	.997	.994	1.000
65 or Older Residents %	1.006**	1.002	1.010	1.005*	1.001	1.009	1.006**	1.002	1.010	1.006**	1.001	1.010	1.005*	1.001	1.009
County-level incidence rate	1.001**	1.000	1.001	1.000**	1.000	1.001	1.001**	1.000	1.001	1.001**	1.000	1.001	1.001**	1.000	1.001
Nursing Home Quality															
CMS Five Star Rating															
Overall Rating				.993	0.954	1.034									
Health Inspection							1.011	.965	1.059						
Quality Measures Rating										1.031	.985	1.080			
Staffing Rating													.965	.904	1.031

Note. IRR = Incidence Rate Ratio; CI = Confidence Interval; SES= Socioeconomic Status; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
*p <.05, **p <.01, ***p < .001.

Table 10. The Role of CMS Five-Star Ratings in the Relationship Between Neighborhood Disadvantage Levels and Monthly COVID-19 Cases per 100 Beds Among Residents during the Two-Year Pandemic Period.

	Monthly Resident COVID-19 Cases per 100 Beds (Two-Year Pandemic)														
N = 752	**IRR**	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**	
Neighborhood disadvantage (National ADI rank)	1.001	.999	1.002	1.001	.999	1.002	1.001	.999	1.002	1.001	.999	1.002	1.001	.999	1.002
Organizational Enabling Factors															
Medicare %	1.004	.998	1.009	1.000	.995	1.006	1.004	.998	1.010	1.004	.998	1.010	1.001	.996	1.006
Medicaid %	1.001	.999	1.003	1.002	1.000	1.004	1.001	.999	1.003	1.001	.999	1.003	1.002	1.000	1.004
Occupancy rate	1.007***	1.004	1.010	1.007***	1.005	1.010	1.007***	1.004	1.010	1.007***	1.004	1.010	1.007***	1.004	1.010
RN HPRD	.775**	.646	.929				.772**	.642	.928	.769**	.641	.923			
LPN HPRD	.827*	.716	.956				.826**	.715	.955	.828*	.716	.956			
CNA HPRD	.878*	.794	.971				.877*	.793	.971	.876*	.792	.969			
NHA turnover (ref=no turnover)															
Has turnover	.972	.898	1.052	.980	.904	1.062	.973	.898	1.054	0.974	.899	1.055	.978	.904	1.059
DON turnover															
Has turnover	1.019	.944	1.099	1.025	.948	1.108	1.020	.944	1.101	1.021	.946	1.102	1.027	.952	1.109
LPN/RN retention	1.000	.998	1.002	1.000	.998	1.002	1.000	.998	1.002	1.000	.998	1.002	1.000	.998	1.002
CNA retention	1.000	.998	1.002	1.000	.998	1.001	1.000	.998	1.002	1.000	.998	1.002	1.000	.998	1.002
Any agency RN (ref = No)															
Yes	.990	.915	1.072	.973	.898	1.054	.991	.915	1.073	.992	.916	1.074	.980	.904	1.061
Any agency LPN (ref = No)															
Yes	.981	.873	1.103	.972	.863	1.094	.982	.873	1.105	.980	.872	1.102	.977	.868	1.100
Any agency CNA (ref = No)															
Yes	.974	.874	1.084	.982	.880	1.095	.973	.873	1.084	.975	.876	1.086	.981	.880	1.094
Facility size	.999	.999	1.000	.999	.999	1.000	.999	.999	1.000	.999	.999	1.000	.999	.999	1.000

Ownership type (ref = non-profit/government owned)															
Profit	1.128*	1.028	1.238	1.179***	1.076	1.293	1.128*	1.028	1.237	1.128*	1.028	1.238	1.154**	1.050	1.269
Chain affiliation (ref = Not affiliated)															
Affiliated	1.085*	1.005	1.172	1.109*	1.026	1.198	1.085*	1.005	1.172	1.083*	1.002	1.170	1.101*	1.019	1.190
CCRC (ref=not a member)															
Yes	1.037	.939	1.145	1.014	.918	1.121	1.037	.939	1.146	1.034	.937	1.142	1.021	.924	1.128
Dementia care unit (ref=no)															
Yes	.829*	.699	.983	.831*	.700	.987	.829*	.699	.983	.826*	.696	.979	.835*	.704	.991
Other care unit (ref=no)															
Yes	1.113	.945	1.312	1.107	.938	1.307	1.114	.945	1.313	1.120	.949	1.320	1.099	.931	1.297
Location rurality (ref=metropolitan)															
Micropolitan	.930	.846	1.023	.933	.847	1.028	.931	.846	1.024	.935	.849	1.029	.936	.851	1.031
Rural	1.008	.897	1.133	1.028	.914	1.157	1.008	.897	1.133	1.009	.898	1.134	1.020	.906	1.147
Resident- and Community Level Predisposing and Need factors															
Resident Acuity Index	.985	.952	1.019	.974	.942	1.008	.985	.952	1.019	.986	0.952	1.020	.974	.942	1.008
Minority Residents %	.998	.996	1.000	.998	.996	1.000	.998	.996	1.000	.998	.996	1.000	.998*	.996	1.000
65 or Older Residents %	1.003*	1.001	1.006	1.003	1.000	1.005	1.003*	1.001	1.006	1.003*	1.001	1.006	1.003*	1.000	1.006
County-level incidence rate	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Nursing Home Quality															
CMS Five Star Rating															
Overall Rating				.988	.961	1.015									
Health Inspection							1.003	.973	1.034						
Quality Measures Rating										1.013	0.982	1.044			
Staffing Rating													.956*	.916	.999

Note. IRR = Incidence Rate Ratio; CI = Confidence Interval; SES= Socioeconomic Status; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.

*p <.05, **p <.01, ***p < .001.

As noted in the results for Aim 2, COVID-19 cases among nursing home residents during the pre-vaccination period are not linked to the socioeconomic disadvantage levels of the neighborhoods in which they are located, even when controlling for CMS Five-Star Ratings and other factors. Furthermore, none of the CMS Five-Star Ratings—including Overall, Health Inspection, Quality Measures, and Staffing—serve as predictors for the expected number of monthly cases per 100 beds among residents.

Instead, findings from multiple Poisson regressions controlling for different CMS Five-Star Ratings consistently indicate that factors such as higher occupancy rates, the absence of a dementia care unit, serving a larger proportion of residents aged 65 or older, and being located in counties with higher COVID-19 incidence rates are significant predictors of increased resident cases before vaccination became available. Additionally, nursing homes with higher CNA staffing levels are associated with lower COVID-19 incidence rates among residents when controlling for Health Inspection or Quality Measures ratings. For-profit nursing homes also tend to report fewer COVID-19 cases per 100 beds each month when accounting for CMS Five-Star Overall or Staffing ratings.

During the two-year pandemic period, as in the pre-vaccination period, COVID-19 incidence rates among residents do not significantly vary based on neighborhood disadvantage levels, even after adjusting for CMS Five-Star Ratings and other factors. Improved nurse staffing levels, however, significantly reduce the risk of increased COVID-19 incidence rates among residents during the two-year pandemic, particularly when accounting for CMS Five-Star Overall or Staffing ratings. While there are minimal differences in COVID-19 risk based on CMS Five-Star quality ratings, nursing homes with higher Staffing ratings experience a decreased risk. For each additional point in Staffing, the expected number of COVID-19 cases among residents decreases by 4.4% (IRR = 0.956, 95% CI = 0.916 - 0.999). Moreover, increased staffing hours for RNs, LPNs, and CNAs significantly lower the expected monthly COVID-19 cases among residents, even when controlling for Health Inspection or Quality Measures in the CMS Five-Star Rating.

Increased occupancy rates, for-profit ownership, chain affiliation, and absence of dementia care units explain higher COVID-19 rates for residents during the pandemic period, regardless of CMS-Five Star Rating. Additionally, nursing homes serving a larger 65 or older

population are more likely to experience higher COVID-19 rates for residents, after controlling Health Inspection, Quality Measures. or Staffing of CMS Five-Star Rating and other factors.

The Role of Consumer Satisfaction

Table 11 and **Table 12** display adjusted Poisson regression results for the roles of Consumer Satisfaction in the relationships between neighborhood disadvantage levels and COVID-19 rates for residents during the pre-vaccination and two-year pandemic periods, respectively.

Table 11. The Role of Consumer Satisfaction Scores in the Relationship Between Neighborhood Disadvantage Levels and Monthly COVID-19 Cases per 100 Beds Among Residents During the Pre-Vaccination Period.

	Monthly Resident COVID-19 Cases per 100 Beds (Pre-Vaccination)								
N = 752	**IRR**	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**	
Neighborhood SES disadvantage (National ADI rank)	1.001	.998	1.003	1.001	.998	1.003	1.001	.998	1.003
Organizational Enabling Factors									
Medicare %	.999	.990	1.008	.999	.990	1.008	.999	.990	1.008
Medicaid %	1.002	.999	1.005	1.002	.999	1.005	1.002	.999	1.005
Occupancy rate	1.006**	1.002	1.010	1.006**	1.002	1.010	1.006**	1.002	1.010
RN HPRD	.814	.618	1.071	.821	.624	1.080	.814	.618	1.072
LPN HPRD	.804	.645	1.003	.805	.645	1.004	.803	.644	1.002
CNA HPRD	.833*	.715	.971	.841*	.721	.981	.834**	.715	.974
NHA turnover (ref=no turnover)									
Has turnover	.927	.826	1.041	.930	.828	1.045	.927	.825	1.041
DON turnover									
Has turnover	.984	.877	1.104	.981	.875	1.101	.984	.878	1.104
LPN/RN retention	.999	.996	1.001	.999	.996	1.002	.999	.996	1.002
CNA retention	1.001	.998	1.004	1.001	.998	1.004	1.001	.998	1.004
Any agency RN (ref=No)									
Yes	.976	.865	1.102	.975	.864	1.101	.976	.864	1.101
Any agency LPN (ref=No)									
Yes	1.033	.865	1.234	1.034	.865	1.235	1.033	.865	1.234
Any agency CNA (ref=No)									
Yes	.909	.770	1.072	.910	.771	1.073	.909	.770	1.073
Facility size	.999	.998	1.000	.999	.998	1.000	.999	.998	1.000
Ownership type (ref=non-profit/government owned)									
Profit	1.141	.992	1.313	1.133	.984	1.304	1.140	.990	1.313
Chain affiliation									
Affiliated	1.088	.969	1.223	1.089	.969	1.223	1.087	.967	1.222
CCRC									
Yes	1.030	.886	1.198	1.024	.880	1.191	1.029	.885	1.197
Dementia care unit									
Yes	.719**	.560	.923	.720*	.561	.925	.719**	.560	.924
Other care unit									
Yes	1.255	.987	1.596	1.256	.988	1.597	1.256	.987	1.597
Location rurality (ref=metropolitan)									
Micropolitan	.932	.809	1.074	.936	.813	1.079	.932	.809	1.074
Rural	1.005	.843	1.198	1.014	.850	1.211	1.006	.843	1.201

Resident- and Community Level Predisposing and Need factors									
Resident Acuity Index	.996	.945	1.049	.995	.944	1.048	.996	.945	1.049
Minority Residents %	.998	.995	1.001	.997	.994	1.000	.998	.994	1.001
65 or Older Residents %	1.006**	1.002	1.010	1.006**	1.002	1.011	1.006**	1.002	1.010
County-level Incidence Rate	1.001**	1.000	1.001	1.001**	1.000	1.001	1.001**	1.000	1.001
Nursing Home Quality									
Consumer Satisfaction									
Overall Resident Satisfaction				.994	.985	1.004			
Overall Family Satisfaction							.999	.992	1.006
ρ									

Note. RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
*p <.05, **p <.01, ***p < .001.

Table 12. The Role of Consumer Satisfaction Scores in the Relationship Between Neighborhood Disadvantage Levels and Monthly COVID-19 Cases per 100 Beds Among Residents During the Two-Year Pandemic Period.

N = 752	Resident Cases (Two-Year Pandemic)								
	IRR	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**	
Neighborhood SES Disadvantage (National ADI rank)	1.001	.999	1.002	1.001	.999	1.002	1.001	.999	1.002
Organizational Enabling Factors									
Medicare %	1.004	.998	1.009	1.004	.998	1.009	1.004	.998	1.009
Medicaid %	1.001	.999	1.003	1.001	.999	1.003	1.001	.999	1.003
Occupancy rate	1.007***	1.004	1.010	1.007***	1.004	1.010	1.007***	1.005	1.010
RN HPRD	.775**	.646	.929	.783**	.653	.938	.776**	.647	.930
LPN HPRD	.827*	.716	.956	.829*	.718	.958	.824**	.713	.952
CNA HPRD	.878*	.794	.971	.886*	.801	.981	.884*	.799	.978
NHA turnover (ref=no turnover)									
Has turnover	.972	.898	1.052	.974	.900	1.055	.968	.894	1.049
DON turnover									
Has turnover	1.019	.944	1.099	1.015	.941	1.096	1.019	.944	1.100
LPN/RN retention	1.000	.998	1.002	1.000	.998	1.002	1.000	.998	1.002
CNA retention	1.000	.998	1.002	1.000	.998	1.002	1.000	.998	1.002
Any agency RN (ref=No)									
Yes	.990	.915	1.072	.988	.913	1.070	.988	.913	1.070
Any agency LPN (ref=No)									
Yes	.981	.873	1.103	.982	.873	1.104	.981	.872	1.103
Any agency CNA (ref=No)									
Yes	.974	.874	1.084	.975	.875	1.086	.975	.875	1.086
Facility size	.999	.999	1.000	.999	.999	1.000	.999	.999	1.000
Ownership type (ref=non-profit/government owned)									
Profit	1.128*	1.028	1.238	1.120*	1.020	1.228	1.124*	1.024	1.233
Chain affiliation (ref=Not affiliated)									
Affiliated	1.085*	1.005	1.172	1.086*	1.006	1.173	1.081*	1.000	1.167
CCRC (ref=not a member)									
Yes	1.037	.939	1.145	1.030	.933	1.137	1.034	.936	1.141
Dementia care unit (ref=no)									
Yes	.829*	.699	.983	.830*	.700	.984	.830*	.700	.984
Other care unit (ref=no)									
Yes	1.113	.945	1.312	1.115	.946	1.314	1.117	.948	1.317
Location rurality (ref=metropolitan)									
Micropolitan	.930	.846	1.023	.935	.850	1.028	.932	.848	1.025
Rural	1.008	.897	1.133	1.018	.905	1.145	1.012	.900	1.138
Resident- and Community Level Predisposing and Need factors									

Resident Acuity Index	.985	.952	1.019	.984	.951	1.018	.984	.951	1.018
Minority Residents %	.998	.996	1.000	.998*	.996	1.000	.998	.996	1.000
65 or Older Residents %	1.003*	1.001	1.006	1.004**	1.001	1.007	1.004**	1.001	1.007
County-level Incidence Rate	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Nursing Home Quality									
Consumer Satisfaction									
Overall Resident Satisfaction				.994*	.987	1.000			
Overall Family Satisfaction							.997	.993	1.002

Note. IRR = Incidence Rate Ratio; CI = Confidence Interval; SES= Socioeconomic Status; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
*p <.05, **p <.01, ***p < .001.

Before the availability of vaccination, the relationships between neighborhood disadvantage levels and COVID-19 rates among residents are unaffected by Consumer Satisfaction scores. During the pre-vaccination period, neighborhood disadvantage levels are not associated with the expected number of COVID-19 cases per 100 beds among residents each month, a finding that persists even after controlling for Overall Resident or Family Satisfaction scores. Instead, the increased risk of higher COVID-19 incidence rates among residents is linked to factors such as higher occupancy rates, decreased CNA staffing hours, the absence of dementia care units, a larger proportion of residents aged 65 and older, and elevated COVID-19 rates in the counties where nursing homes are located.

During the two-year pandemic period, COVID-19 rates among residents remain largely unassociated with socioeconomic disadvantage levels in neighborhoods, even after controlling for various organizational, resident, and community-level factors. While higher Overall Resident Satisfaction scores significantly reduce the risk of increased COVID-19 cases among residents, neither Consumer Satisfaction score alters the relationship between neighborhood disadvantage levels and COVID-19 incidence rates during this period.

Moreover, nursing homes with high occupancy rates, lower staffing hours for RNs, LPNs, and CNAs, for-profit ownership, chain affiliation, and the absence of dementia care units, as well as those with a higher proportion of residents aged 65 and above, are more likely to experience a greater number of COVID-19 cases among residents per 100 beds each month.

COVID-19 Related Deaths Among Residents

The Role of CMS Five Star Rating

The results of adjusted Poisson regression models, which examine the roles of CMS Five-Star Ratings in the relationships between neighborhood disadvantage levels and COVID-19-

related deaths among residents in Ohio nursing homes, are presented in **Table 13** for the pre-vaccination period and in **Table 14** for the two-year pandemic period.

Table 13. The Role of CMS Five-Star Ratings in the Relationships Between Neighborhood Disadvantage Levels and Monthly COVID-19-Related Deaths per 100 Beds Among Residents During the Pre-Vaccination Period

N = 752	Monthly Resident COVID-19 related Deaths per 100 Beds (Pre-Vaccination)														
	IRR	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**	
Neighborhood SES Disadvantage (National ADI rank)	1.004*	1.000	1.007	1.004*	1.001	1.007	1.004*	1.000	1.007	1.003*	1.000	1.007	1.004*	1.001	1.007
Organizational Enabling Factors															
Medicare %	.991	.979	1.003	.989*	.978	1.000	.991	.980	1.003	.991	.980	1.003	.989*	.977	1.000
Medicaid %	1.001	.997	1.005	1.002	.998	1.006	1.001	.997	1.005	1.001	.997	1.006	1.002	.998	1.006
Occupancy rate	1.006	1.000	1.012	1.006	1.000	1.011	1.006	1.000	1.012	1.005	1.000	1.011	1.006	1.000	1.012
RN HPRD	.840	.585	1.206				.829	.574	1.197	.813	.565	1.171			
LPN HPRD	.758	.566	1.014				.756	.565	1.012	.758	.567	1.014			
CNA HPRD	.833	.682	1.017				.831	.680	1.016	.825	.676	1.008			
NHA turnover (ref=no turnover)															
Has turnover	.878	.753	1.023	.890	.763	1.038	.881	.755	1.028	.885	.759	1.031	.883	.758	1.029
DON turnover															
Has turnover	.944	.816	1.094	.970	.837	1.125	.948	.818	1.100	.952	.822	1.103	.964	.832	1.116
LPN/RN retention	.999	.995	1.003	.999	.995	1.003	.999	.995	1.003	.999	.995	1.003	.999	.995	1.003
CNA retention	.999	.995	1.004	.999	.995	1.004	.999	.995	1.004	1.000	.995	1.004	.999	.995	1.004
Any agency RN (ref=No)															
Yes	1.000	.852	1.174	.990	.844	1.162	1.004	.854	1.179	1.007	.858	1.182	.986	.841	1.157
Any agency LPN (ref=No)															
Yes	1.093	.865	1.381	1.090	.861	1.380	1.098	.868	1.389	1.087	.861	1.372	1.086	.858	1.374
Any agency CNA (ref=No)															
Yes	.921	.742	1.144	.929	.748	1.155	.918	.739	1.141	.926	.746	1.148	.931	.749	1.158
Facility size	1.000	.999	1.002	1.000	.999	1.002	1.000	.999	1.002	1.000	.999	1.002	1.000	.999	1.002
Ownership type (ref=non-profit/government owned)															
Profit	1.031	.865	1.230	1.083	.910	1.289	1.030	.863	1.229	1.028	.862	1.226	1.081	.904	1.293
Chain affiliation (ref=Not affiliated)															
Affiliated	1.017	.875	1.183	1.044	.899	1.214	1.017	.874	1.182	1.008	.867	1.173	1.044	.898	1.214
CCRC (ref=not a member)															
Yes	1.230*	1.022	1.479	1.192	.992	1.433	1.234*	1.025	1.485	1.216*	1.011	1.463	1.193	.992	1.435
Dementia care unit (ref=no)															
Yes	.791	.562	1.114	.796	.566	1.120	.790	.561	1.113	.777	.552	1.095	.799	.568	1.125
Other care unit (ref=no)															
Yes	1.160	.833	1.616	1.140	.819	1.587	1.162	.834	1.619	1.187	.851	1.655	1.135	.815	1.582
Location rurality (ref=metropolitan)															
Micropolitan	.974	.811	1.169	.988	.822	1.187	.975	.812	1.170	.994	.827	1.196	.984	.819	1.182
Rural	1.065	.847	1.339	1.095	.872	1.376	1.064	.846	1.338	1.066	.848	1.340	1.092	.868	1.373
Resident- and Community Level Predisposing and Need factors															
Resident Acuity Index	.981	.914	1.053	.967	.902	1.037	.981	.914	1.053	.985	.918	1.058	.967	.902	1.037

Minority Residents %	.996	.992	1.001	.996	.992	1.000	.996	.992	1.001	.996	.992	1.001	.996	.992	1.000
65 or Older Residents %	1.011***	1.005	1.017	1.009**	1.003	1.015	1.011***	1.005	1.017	1.011***	1.005	1.016	1.010**	1.004	1.015
County-level incidence rate	1.001**	1.000	1.001	1.001**	1.000	1.001	1.001**	1.000	1.001	1.001**	1.000	1.001	1.001**	1.000	1.001
Nursing Home Quality															
CMS Five Star Rating															
Overall				1.016	.963	1.073									
Health Inspection							1.013	.952	1.078						
Quality Measures										1.051	.988	1.119			
Staffing													.999	.918	1.088

Note. IRR = Incidence Rate Ratio; CI = Confidence Interval; SES= Socioeconomic Status; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community. *p <.05, **p <.01, ***p < .001.

Table 14. The Role of CMS Five-Star Ratings in the Relationships Between Neighborhood Disadvantage Levels and Monthly COVID-19-Related Deaths per 100 Beds Among Residents During the Two-Year Pandemic Period

	Monthly Resident COVID-19 related Deaths per 100 Beds (Two-Year Pandemic)														
N = 752	**IRR**	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**	
Neighborhood SES disadvantage (National ADI rank)	1.003*	1.001	1.006	1.004*	1.001	1.007	1.003*	1.001	1.006	1.003*	1.000	1.006	1.004*	1.001	1.007
Organizational Enabling Factors															
Medicare %	.995	.985	1.005	.994	.985	1.004	.995	.985	1.005	.996	.986	1.006	.994	.984	1.003
Medicaid %	1.002	.999	1.006	1.003	1.000	1.007	1.002	.999	1.006	1.003	.999	1.006	1.003	1.000	1.007
Occupancy rate	1.006*	1.001	1.011	1.006*	1.001	1.011	1.006*	1.001	1.011	1.006*	1.001	1.011	1.006*	1.001	1.011
RN HPRD	.967	.714	1.309				.966	.710	1.314	.944	.696	1.281			
LPN HPRD	.808	.632	1.033				.808	.632	1.033	.808	.632	1.033			
CNA HPRD	.856	.720	1.017				.856	.720	1.017	.850	.715	1.010			
NHA turnover (ref=no turnover)															
Has turnover	.903	.790	1.033	.910	.795	1.042	.903	.789	1.034	.909	.794	1.040	.908	.794	1.038
DON turnover															
Has turnover	.967	.852	1.098	.989	.870	1.124	.967	.851	1.100	.973	.857	1.105	.984	.867	1.117
LPN/RN retention	1.002	.998	1.005	1.002	.998	1.005	1.002	.998	1.005	1.002	.998	1.005	1.002	.998	1.005
CNA retention	.998	.994	1.002	.998	.994	1.002	.998	.994	1.002	.998	.994	1.002	.998	.994	1.002
Any agency RN (ref=No)															
Yes	1.029	.897	1.180	1.023	.893	1.174	1.029	.896	1.181	1.033	.901	1.185	1.017	.888	1.166
Any agency LPN (ref=No)															
Yes	1.046	.854	1.280	1.044	.852	1.279	1.046	.853	1.282	1.042	.852	1.274	1.038	.847	1.273
Any agency CNA (ref=No)															
Yes	.969	.805	1.166	.975	.810	1.175	.969	.804	1.167	.972	.808	1.169	.977	.811	1.177
Facility size	1.000	.999	1.001	1.000	.999	1.002	1.000	.999	1.001	1.000	.999	1.001	1.000	.999	1.002
Ownership type (ref=non-profit/government owned)															
Profit	1.020	.876	1.188	1.054	.907	1.225	1.020	.876	1.189	1.019	.875	1.186	1.069	.916	1.247

Chain affiliation (ref=Not affiliated)															
Affiliated	1.062	.931	1.211	1.085	.952	1.236	1.062	.931	1.211	1.053	.923	1.201	1.090	.957	1.243
CCRC (ref=not a member)															
Yes	1.235**	1.052	1.449	1.206*	1.029	1.414	1.235*	1.052	1.450	1.224*	1.043	1.437	1.201*	1.025	1.409
Dementia care unit (ref=no)															
Yes	.831	.614	1.125	.837	.619	1.132	.831	.614	1.125	.818	.605	1.108	.835	.618	1.130
Other care unit (ref=no)															
Yes	1.09	.816	1.467	1.073	0.801	1.438	1.094	.816	1.467	1.116	.831	1.497	1.076	.803	1.443
Location rurality (ref=metropolitan)															
Micropolitan	.985	.839	1.155	.994	.847	1.166	.985	.839	1.155	.999	.851	1.173	.991	.844	1.162
Rural	1.122	.922	1.365	1.143	.941	1.39	1.122	.922	1.365	1.125	.925	1.369	1.149	.944	1.397
Resident- and Community Level Predisposing and Need factors															
Resident Acuity Index	.990	.931	1.052	.980	.922	1.041	.990	.931	1.052	0.993	.934	1.056	.980	.922	1.041
Minority Residents %	.996*	.993	1.000	.996*	.993	1.000	.996	.993	1.000	.996	.993	1.000	.997*	.992	1.000
65 or Older Residents %	1.010***	1.005	1.015	1.009***	1.004	1.014	1.010***	1.005	1.015	1.010***	1.005	1.015	1.009***	1.004	1.014
County-level incidence rate	1.000	1.000	1.001	1.000	1.000	1.001	1.000	1.000	1.001	1.000	1.000	1.001	1.000	1.000	1.001
Nursing Home Quality															
CMS Five Star Rating															
Overall				1.017	.971	1.065									
Health Inspection							1.001	.949	1.055						
Quality Measures										1.043	.988	1.100			
Staffing													1.032	0.959	1.111

Note. IRR = Incidence Rate Ratio; CI = Confidence Interval; SES= Socioeconomic Status; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
*p <.05, **p <.01, ***p < .001.

Before the availability of vaccines, for each additional percentile increase in neighborhood disadvantage ranking nationwide, the expected number of COVID-19-related deaths per 100 beds among residents increased by 0.4% (IRR = 1.004, 95% CI = 1.000 – 1.007), even after controlling for organizational enabling factors, as well as resident and community-level predisposing and need factors. This relationship between neighborhood socioeconomic disadvantage and COVID-19 mortality rates among residents remains unchanged regardless of the CMS Five-Star Rating. Higher COVID-19 mortality rates are consistently predicted by a larger population of residents aged 65 or older and being located in counties with higher COVID-19 incidence rates, independent of the CMS Five-Star Rating. Additionally, decreased mortality rates during the pre-vaccination period are linked to an increased Medicare payor-mix, after accounting for CMS Five-Star Overall or Staffing ratings and other factors. Nursing homes that are part of CCRCs have over 20% higher expected numbers of COVID-19-related deaths compared to those that are not, after adjusting for Health Inspection or Quality Measures ratings.

Two years into the COVID-19 pandemic, nursing homes in more socioeconomically disadvantaged neighborhoods face an increased risk of higher resident mortality rates, even after controlling for organizational enabling factors and community-level predisposing and need factors. This disparity persists even when CMS Five-Star Ratings and other factors are taken into account. Nursing homes with a larger proportion of minority residents see a slight decrease in monthly COVID-19-related deaths per 100 beds after controlling for Overall or Staffing CMS Five-Star Ratings. Furthermore, nursing homes with higher occupancy rates, CCRC memberships, and a larger population of residents aged 65 or older consistently experience a greater risk of COVID-19-related deaths per 100 beds during the two-year pandemic period.

The Role of Consumer Satisfaction

The roles of Consumer Satisfaction scores in the relationship between neighborhood disadvantage levels and COVID-19 mortality rates among residents during the pre-vaccination and two-year pandemic periods are shown in **Table 15** and **Table 16**, respectively.

Table 15. The Role of Consumer Satisfaction Scores in the Relationship Between Neighborhood Disadvantage Levels and Monthly COVID-19 Related Deaths per 100 Beds Among Residents During the Pre-Vaccination Period

	Monthly Resident COVID-19 related Deaths per 100 Beds (Pre-Vaccination)					
IRR	**95% CI**	**IRR**	**95% CI**	**IRR**	**95% CI**

Neighborhood disadvantage (National ADI rank)	1.004*	1.000	1.007	1.003*	1.000	1.007	1.004*	1.000	1.007
Organizational Enabling Factors									
Medicare %	.991	.979	1.003	.991	.980	1.003	.991	.979	1.003
Medicaid %	1.001	.997	1.005	1.001	.997	1.006	1.001	.997	1.005
Occupancy rate	1.006	1.000	1.012	1.006	1.000	1.012	1.006	1.000	1.012
RN HPRD	.840	.585	1.206	.833	.579	1.198	.840	.585	1.207
LPN HPRD	.758	.566	1.014	.758	.566	1.014	.758	.566	1.014
CNA HPRD	.833	.682	1.017	.827	.676	1.011	.834	.682	1.021
NHA turnover (ref=no turnover)									
Has turnover	.878	.753	1.023	.876	.752	1.021	.877	.752	1.023
DON turnover									
Has turnover	.944	.816	1.094	.946	.817	1.096	.944	.815	1.094
LPN/RN retention	.999	.995	1.003	.999	.995	1.003	.999	.995	1.003
CNA retention	.999	.995	1.004	.999	.995	1.004	.999	.995	1.004
Any agency RN (ref=No)									
Yes	1.000	.852	1.174	1.002	.854	1.176	1.000	.852	1.174
Any agency LPN (ref=No)									
Yes	1.093	.865	1.381	1.093	.865	1.381	1.093	.865	1.382
Any agency CNA (ref=No)									
Yes	.921	.742	1.144	.920	.741	1.142	.921	.742	1.144
Facility size	1.000	.999	1.002	1.000	.999	1.002	1.000	.999	1.002
Ownership type (ref=non-profit/government owned)									
Profit	1.031	.865	1.230	1.038	.870	1.240	1.030	.863	1.230
Chain affiliation (ref=Not affiliated)									
Affiliated	1.017	.875	1.183	1.017	.874	1.182	1.016	.873	1.183
CCRC (ref=not a member)									
Yes	1.230*	1.022	1.479	1.236*	1.027	1.488	1.229*	1.021	1.479
Dementia care unit (ref=no)									
Yes	.791	.562	1.114	.790	.561	1.113	.791	.562	1.114
Other care unit (ref=no)									
Yes	1.160	.833	1.616	1.159	.832	1.615	1.161	.833	1.617
Location rurality (ref=metropolitan)									
Micropolitan	.974	.811	1.169	.969	.807	1.165	.974	.811	1.170
Rural	1.065	.847	1.339	1.056	.839	1.329	1.066	.847	1.341
Resident- and Community Level Predisposing and Need factors									
Resident Acuity Index	.981	.914	1.053	.981	.914	1.053	.980	.913	1.053
Minority Residents %	.996	.992	1.001	.997	.992	1.001	.996	.992	1.001
65 or Older Residents %	1.011***	1.005	1.017	1.010***	1.004	1.017	1.011***	1.005	1.017
County-level incidence rate	1.001**	1.000	1.001	1.001**	1.000	1.001	1.001*	1.000	1.001
Nursing Home Quality									
Consumer Satisfaction									
Overall Resident Satisfaction				1.005	.992	1.018			
Overall Family Satisfaction							.999	.990	1.009

Note. IRR = Incidence Rate Ratio; CI = Confidence Interval; SES= Socioeconomic Status; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.

*p <.05, **p <.01, ***p < .001

Table 16. The Role of Consumer Satisfaction Scores in the Relationship Between Neighborhood Disadvantage Levels and Monthly COVID-19 Related Deaths per 100 Beds Among Residents During the Two-Year Pandemic Period

	Monthly Resident COVID-19 related Deaths per 100 Beds (Two-Year Pandemic)								
	IRR	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**	
Neighborhood disadvantage (National ADI rank)	1.003*	1.001	1.006	1.003*	1.001	1.006	1.003*	1.001	1.006
Organizational Enabling Factors									
Medicare %	.995	.985	1.005	.995	.985	1.005	.995	.985	1.005
Medicaid %	1.002	.999	1.006	1.003	.999	1.006	1.002	.999	1.006
Occupancy rate	1.006*	1.001	1.011	1.006*	1.001	1.011	1.006*	1.001	1.011
RN HPRD	.967	.714	1.309	.965	.712	1.308	.966	.713	1.309
LPN HPRD	.808	.632	1.033	.808	.632	1.033	.808	.632	1.033
CNA HPRD	.856	.720	1.017	.855	.719	1.017	.855	.719	1.017
NHA turnover (ref=no turnover)									
Has turnover	.903	.790	1.033	.903	.789	1.033	.903	.789	1.034
DON turnover									
Has turnover	.967	.852	1.098	.968	.852	1.099	.967	.852	1.098
LPN/RN retention	1.002	.998	1.005	1.002	.998	1.005	1.002	.998	1.005
CNA retention	.998	.994	1.002	.998	.994	1.002	.998	.994	1.002
Any agency RN (ref=No)									
Yes	1.029	.897	1.180	1.030	.897	1.181	1.029	.897	1.181
Any agency LPN (ref=No)									
Yes	1.046	.854	1.280	1.046	.854	1.281	1.046	.854	1.280
Any agency CNA (ref=No)									
Yes	.969	.805	1.166	.968	.804	1.166	.969	.805	1.166
Facility size	1.000	.999	1.001	1.000	.999	1.001	1.000	.999	1.001
Ownership type (ref=non-profit/government owned)									
Profit	1.020	.876	1.188	1.022	.876	1.191	1.021	.876	1.190
Chain affiliation (ref=Not affiliated)									
Affiliated	1.062	.931	1.211	1.062	.931	1.211	1.063	.931	1.212
CCRC (ref=not a member)									
Yes	1.235**	1.052	1.449	1.236**	1.053	1.452	1.236**	1.053	1.451
Dementia care unit (ref=no)									
Yes	.831	.614	1.125	.831	.614	1.125	.831	.614	1.125
Other care unit (ref=no)									
Yes	1.09	.816	1.467	1.094	.816	1.467	1.094	.816	1.467
Location rurality (ref=metropolitan)									
Micropolitan	.985	.839	1.155	0.984	.838	1.154	.984	.839	1.155
Rural	1.122	.922	1.365	1.120	.920	1.364	1.121	.921	1.364
Resident- and Community Level Predisposing and Need factors									
Resident Acuity Index	.990	.931	1.052	.990	.931	1.052	.990	.931	1.052
Minority Residents %	.996*	.993	1.000	.996	.993	1.000	.996	.993	1.000
65 or Older Residents %	1.010***	1.005	1.015	1.011***	1.005	1.015	1.010***	1.005	1.015
County-level incidence rate	1.000	1.000	1.001	1.000	1.000	1.001	1.000	1.000	1.001
Nursing Home Quality									
Consumer Satisfaction									
Overall Resident Satisfaction				1.001	.990	1.012			
Overall Family Satisfaction							1.000	.992	1.009

Note. IRR = Incidence Rate Ratio; CI = Confidence Interval; SES= Socioeconomic Status; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
*p <.05, **p <.01, ***p < .001

Before the availability of vaccination, socioeconomic disadvantages in neighborhoods independently influence COVID-19 related deaths among residents, regardless of Consumer Satisfaction scores. For each 1 percentile increase in the ADI rank nationwide (representing neighborhood disadvantage), the expected number of deaths among residents during the pre-vaccination period rises by approximately 0.3% to 0.4%, even after controlling for Overall Resident or Family Satisfaction scores. Additionally, higher COVID-19 mortality rates are linked to being part of a CCRC, serving a larger population of residents aged 65 or older, and being located in counties with higher COVID-19 rates.

After two years of the COVID-19 pandemic, nursing homes in more socioeconomically disadvantaged neighborhoods continue to experience higher rates of COVID-19 related deaths among residents, regardless of their Consumer Satisfaction scores. After adjusting for Consumer Satisfaction performance and other factors, the increased risk of more deaths among residents per 100 beds each month is associated with higher occupancy rates, CCRC membership, and a greater proportion of residents aged 65 and older.

COVID-19 Cases Among Staff Members

The Role of CMS Five Star Rating

The adjusted Poisson regression results, which explore the roles of CMS Five-Star Ratings in the relationships between neighborhood disadvantage levels and monthly COVID-19 cases among staff members in Ohio nursing homes, are presented in **Table 17** for the pre-vaccination period and **Table 18** for the two-year pandemic period.

Table 17. The Role of CMS Five-Star Rating in the Relationships Between Neighborhood Disadvantage Levels and Monthly COVID-19 Cases Among Staff Members per 100 Beds During the Pre-Vaccination Period

	Monthly Staff COVID-19 Cases per 100 Beds (Pre-Vaccination)														
	IRR	95% CI		IRR	95% CI		IRR	95% CI		IRR	95% CI		IRR	95% CI	
Neighborhood SES Disadvantage (National ADI rank)	1.000	.998	1.002	1.000	.998	1.002	1.000	.998	1.002	1.000	.998	1.002	1.000	.998	1.002
Organizational Enabling Factors															
Medicare %	1.002	.996	1.008	1.005	.999	1.010	1.002	.996	1.008	1.002	.996	1.008	1.004	.999	1.010
Medicaid %	1.002	1.000	1.005	1.002	1.00	1.004	1.002	1.000	1.005	1.002	1.000	1.005	1.002	1.000	1.005
Occupancy rate	1.007***	1.004	1.010	1.006***	1.003	1.009	1.007***	1.003	1.010	1.007***	1.004	1.010	1.007***	1.004	1.010
RN HPRD	1.232*	1.046	1.451				1.214*	1.027	1.435	1.234*	1.047	1.455			
LPN HPRD	.996	.862	1.151				.994	.860	1.149	.996	.862	1.151			
CNA HPRD	1.015	.916	1.125				1.013	.914	1.123	1.015	.916	1.126			
NHA turnover (ref=no turnover)															
Has turnover	.966	.888	1.051	.962	.884	1.047	.970	.891	1.056	.966	.888	1.050	.959	.882	1.043
DON turnover															
Has turnover	.961	.886	1.042	.968	.892	1.051	.965	.889	1.047	.960	.885	1.041	.963	.888	1.044
LPN/RN retention	.999	.997	1.001	.999	.997	1.001	.999	.997	1.001	.999	.997	1.001	.999	.997	1.001
CNA retention	1.001	.999	1.004	1.001	.999	1.004	1.001	.999	1.004	1.001	.999	1.004	1.001	.999	1.004
Any agency RN (ref=No)															
Yes	.980	.898	1.068	.990	.907	1.079	.984	.902	1.073	.979	.898	1.068	.980	.899	1.069
Any agency LPN (ref=No)															
Yes	.993	.875	1.126	.997	.879	1.132	.998	.879	1.133	.993	.875	1.127	.993	.874	1.127
Any agency CNA (ref=No)															
Yes	.929	.827	1.044	.923	.821	1.038	.925	.823	1.040	.929	.827	1.044	.925	.822	1.040
Facility size	.999**	.998	1.000	.999**	.998	1.000	.999**	.998	1.000	.999**	.998	1.000	.999**	.998	1.000
Ownership type (ref=non-profit/government owned)															
Profit	.948	.863	1.041	.931	.849	1.020	.946	.861	1.039	.948	.863	1.041	.949	.864	1.043
Chain affiliation (ref=Not affiliated)															
Affiliated	1.024	.943	1.111	1.016	.937	1.102	1.023	.942	1.110	1.024	.943	1.111	1.023	.943	1.110
CCRC (ref=not a member)															
Yes	1.227***	1.112	1.354	1.231***	1.115	1.358	1.231***	1.115	1.359	1.227***	1.112	1.355	1.223***	1.109	1.350
Dementia care unit (ref=no)															
Yes	.807*	.669	.973	.812*	.673	0.980	.805*	.667	.971	.808*	.669	.975	.812**	.673	.979
Other care unit (ref=no)															
Yes	1.166	.972	1.398	1.153	.961	1.383	1.168	.974	1.401	1.164	0.971	1.397	1.158	.965	1.389
Location rurality (ref=metropolitan)															
Micropolitan	.974	.880	1.077	.976	.882	1.081	.975	.881	1.080	.972	.878	1.078	.972	.878	1.076

Rural	1.110	.979	1.258	1.103	.972	1.250	1.110	.979	1.259	1.110	.979	1.258	1.111	.979	1.260
Resident- and Community Level Predisposing and Need factors															
Resident Acuity Index	.993	.958	1.029	.994	.958	1.031	.993	.958	1.029	.992	.957	1.029	.993	.958	1.030
Minority Residents %	.998	.996	1.000	.998	.996	1.000	.998	.996	1.000	.998	.996	1.000	.998	.996	1.000
65 or Older Residents %	1.005**	1.001	1.008	1.004**	1.001	1.007	1.004**	1.001	1.007	1.005**	1.001	1.008	1.004**	1.001	1.007
County-level incidence rate	1.001***	1.001	1.001	1.001***	1.001	1.001	1.001***	1.001	1.001	1.001***	1.001	1.001	1.001***	1.001	1.001
Nursing Home Quality															
CMS Five Star Rating															
Overall				1.022	.993	1.053									
Health Inspection							1.0151	.981	1.050						
Quality Measures										.997	.964	1.031			
Staffing													1.046	.999	1.094

Note. IRR = Incidence Rate Ratio; CI = Confidence Interval; SES= Socioeconomic Status; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
*p <.05, **p <.01, ***p < .001

Table 18. The Role of CMS Five-Star Rating in the Relationships Between Neighborhood Disadvantage Levels and Monthly COVID-19 Cases Among Staff Members per 100 Beds During the Two-Year Pandemic Period

	Staff cases (Two-Year Pandemic)														
	IRR	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**	
Neighborhood disadvantage (National ADI rank)	1.000	.999	1.001	1.000	.998	1.001	1.000	.999	1.001	1.000	.999	1.001	1.000	.998	1.001
Organizational Enabling Factors															
Medicare %	1.002	.998	1.006	1.006**	1.002	1.009	1.003	.999	1.007	1.002	.998	1.006	1.005*	1.001	1.009
Medicaid %	1.001	1.000	1.003	1.001	1.000	1.003	1.001	1.000	1.003	1.001	1.000	1.003	1.001	1.000	1.003
Occupancy rate	1.008***	1.006	1.010	1.007***	1.005	1.010	1.008***	1.005	1.010	1.008***	1.006	1.010	1.008***	1.006	1.010
RN HPRD	1.259***	1.124	1.410				1.226***	1.092	1.376	1.257***	1.122	1.409			
LPN HPRD	1.041	.942	1.151				1.036	.938	1.146	1.041	.942	1.151			
CNA HPRD	1.089*	1.013	1.171				1.086*	1.010	1.167	1.089*	1.013	1.171			
NHA turnover (ref=no turnover)															
Has turnover	.992	.934	1.054	.992	.932	1.055	1.001	.941	1.063	.992	.934	1.055	.985	.926	1.047
DON turnover															
Has turnover	.966	.912	1.023	.976	.920	1.034	.975	.920	1.033	.967	.913	1.024	.965	.910	1.022
LPN/RN retention	1.000	.999	1.002	1.000	.999	1.001	1.000	.999	1.002	1.000	.999	1.002	1.000	.999	1.002
CNA retention	1.000	.998	1.002	1.000	.999	1.002	1.000	.998	1.002	1.000	.998	1.002	1.000	.999	1.002
Any agency RN (ref=No)															

Yes	1.015	.955	1.079	1.032	.970	1.098	1.024	.963	1.088	1.016	.956	1.080	1.016	.956	1.081
Any agency LPN (ref=No)															
Yes	.948	.867	1.037	.960	.876	1.051	.959	.877	1.048	.948	.867	1.037	.950	.867	1.041
Any agency CNA (ref=No)															
Yes	.985	.908	1.069	.971	.894	1.056	.977	.900	1.060	.985	.908	1.069	.976	.898	1.061
Facility size	.999***	.998	.999	.999***	.998	.999	.999***	.998	1.000	.999***	.998	.999	.999***	.998	.999
Ownership type (ref=non-profit/government owned)															
Profit	.915**	.856	.977	.884***	.828	0.943	.911**	.853	.974	.915**	.856	.977	.907**	.848	.970
Chain affiliation (ref=Not affiliated)															
Affiliated	1.013	.956	1.074	.995	.939	1.055	1.012	.955	1.072	1.013	.956	1.073	1.005	.948	1.065
CCRC (ref=not a member)															
Yes	1.202***	1.121	1.288	1.212***	1.130	1.301	1.210***	1.128	1.297	1.201***	1.120	1.288	1.205***	1.122	1.293
Dementia care unit (ref=no)															
Yes	.912	.795	1.047	.918	.798	1.055	.909	.792	1.042	.911	.794	1.046	.919	.799	1.056
Other care unit (ref=no)															
Yes	1.070	.936	1.222	1.065	.930	1.220	1.074	.940	1.227	1.071	.937	1.225	1.069	.933	1.224
Location rurality (ref=metropolitan)															
Micropolitan	.991	0.923	1.065	.995	.925	1.071	.994	.925	1.068	.993	.923	1.067	.988	.919	1.063
Rural	1.118*	1.022	1.222	1.105*	1.009	1.210	1.118*	1.023	1.222	1.118*	1.022	1.22.	1.115*	1.018	1.221
Resident- and Community Level Predisposing and Need factors															
Resident Acuity Index	.992	.967	1.017	.996	.970	1.022	.993	.968	1.018	.992	.967	1.018	.995	.969	1.022
Minority Residents %	.998*	.996	1.000	.998*	.997	1.000	.998*	.997	1.000	.998*	.996	1.000	.998*	.997	1.000
65 or Older Residents %	1.003**	1.001	1.006	1.003**	1.001	1.006	1.003**	1.001	1.005	1.003**	1.001	1.006	1.003**	1.001	1.006
County-level incidence rate	1.000**	1.000	1.001	1.000**	1.000	1.001	1.000**	1.000	1.001	1.000**	1.000	1.001	1.000**	1.000	1.001
Nursing Home Quality															
CMS Five Star Rating															
Overall				1.040***	1.018	1.062									
Health Inspection							1.029*	1.005	1.054						
Quality Measures										1.003	.979	1.027			
Staffing													1.061***	1.027	1.096

Note. IRR = Incidence Rate Ratio; CI = Confidence Interval; SES= Socioeconomic Status; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.

*p <.05, **p <.01, ***p < .001

Before the availability of vaccination, COVID-19 cases among nursing home staff per 100 beds each month do not significantly differ based on the socioeconomic disadvantage of their neighborhoods, regardless of their performance in CMS Five-Star Ratings. However, increased COVID-19 incidence rates for staff during the pre-vaccination period are consistently linked to higher occupancy rates, fewer certified beds, CCRC membership, the absence of dementia care units, a larger proportion of residents aged 65 and older, and being located in counties with higher COVID-19 rates, regardless of CMS Five-Star Ratings. When controlling for non-staffing-related ratings, such as Health Inspection or Quality Measures, nursing homes with higher RN staffing hours tend to report more COVID-19 cases among staff per 100 beds during the pre-vaccination period.

Two years into the pandemic, staff COVID-19 incidence rates still show no significant differences based on neighborhood disadvantage levels, regardless of CMS Five-Star Ratings. Interestingly, higher CMS Five-Star Overall, Health Inspection, and Staffing ratings are associated with an increased risk of COVID-19 cases among staff. Staffing levels significantly affect staff COVID-19 rates during the pandemic:

After adjusting for non-staffing domains (Health Inspection or Quality Measures), higher RN and CNA staffing hours are linked to increased COVID-19 cases among staff during the two-year pandemic. Nursing homes with higher staffing performance-based ratings (Overall or Staffing) report more staff COVID-19 cases per 100 beds monthly during the pandemic. Additionally, a greater Medicare payor mix is linked to a higher risk of COVID-19 cases among staff, even after accounting for staffing-related ratings.

Nursing homes with higher occupancy rates, fewer certified beds, not-for-profit or government ownership, CCRC membership, rural locations, smaller proportions of minority residents, larger proportions of residents aged 65 and older, and those in counties with higher COVID-19 incidence rates tend to report more staff COVID-19 cases per 100 beds monthly, regardless of their CMS ratings.

The Role of Consumer Satisfaction

Before the availability of vaccination, number of COVID-19 cases among nursing home staff members are not associated with the disadvantage levels of neighborhoods where they are located, regardless of Consumer Satisfaction scores (see **Table 19**). Instead, increased COVID-19 morbidity rates for staff members during the pre-vaccination period are associated

with higher occupancy rates, higher RN staffing hours, fewer certified beds, being part of CCRCs, absence of dementia care units, having larger proportion of 65 or older residents, and being in counties with higher COVID-19 incidence rates.

Table 19. The Role of Consumer Satisfaction Scores in the Relationships Between Neighborhood Disadvantage Levels and Monthly COVID-19 Cases Among Staff Members During the Pre-Vaccination Period

	Monthly Staff COVID-19 Cases per 100 Beds (Pre-vaccination)								
	IRR	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**	
Neighborhood disadvantage (National ADI rank)	1.000	.998	1.002	1.000	.998	1.002	1.000	.998	1.002
Organizational Enabling Factors									
Medicare %	1.002	.996	1.008	1.002	.996	1.008	1.002	.996	1.008
Medicaid %	1.002	1.000	1.005	1.002	1.000	1.004	1.002	1.000	1.004
Occupancy rate	1.007***	1.004	1.010	1.007***	1.004	1.010	1.007***	1.004	1.010
RN HPRD	1.232*	1.046	1.451	1.234*	1.047	1.454	1.236*	1.049	1.456
LPN HPRD	.996	.862	1.151	.996	.862	1.151	.994	.860	1.150
CNA HPRD	1.015	.916	1.125	1.017	.917	1.128	1.020	.920	1.132
NHA turnover (ref=no turnover)									
Has turnover	.966	.888	1.051	.966	.888	1.051	.963	.885	1.048
DON turnover									
Has turnover	.961	.886	1.042	.960	.885	1.041	.961	.886	1.042
LPN/RN retention	.999	.997	1.001	.999	.997	1.001	.999	.997	1.001
CNA retention	1.001	.999	1.004	1.001	.999	1.004	1.001	.999	1.004
Any agency RN (ref=No)									
Yes	.980	.898	1.068	.979	.898	1.068	.978	.897	1.066
Any agency LPN (ref=No)									
Yes	.993	.875	1.126	.993	.875	1.127	.993	.875	1.127
Any agency CNA (ref=No)									
Yes	.929	.827	1.044	.929	.827	1.044	.929	.827	1.044
Facility size	.999**	.998	1.000	.999**	.998	1.000	.999**	.998	1.000
Ownership type (ref=non-profit/government owned)									
Profit	.948	.863	1.041	1.002	.996	1.008	.945	.860	1.038
Chain affiliation (ref=Not affiliated)	1.024	.943	1.111	1.024	.943	1.111	1.020	.939	1.107
Affiliated									
CCRC (ref=not a member)									
Yes	1.227***	1.112	1.354	1.225***	1.110	1.353	1.224***	1.109	1.351
Dementia care unit (ref=no)									
Yes	.807*	.669	.973	.807*	.669	.974	.807*	.669	.974
Other care unit (ref=no)									
Yes	1.166	.972	1.398	1.166	.972	1.399	1.168	.974	1.401
Location rurality (ref=metropolitan)									
Micropolitan	.974	.880	1.077	.975	.880	1.079	.974	.880	1.078
Rural	1.110	.979	1.258	1.112	.981	1.262	1.114	.983	1.264
Resident- and Community Level Predisposing and Need factors									
Resident Acuity Index	.993	.958	1.029	.992	.957	1.029	.992	.957	1.028
Minority Residents %	.998	.996	1.000	.998	.996	1.000	.998	.996	1.000
65 or Older Residents %	1.005**	1.001	1.008	1.005**	1.001	1.008	1.005**	1.002	1.008
County-level incidence rate	1.001***	1.001	1.001	1.001***	1.001	1.001	1.001***	1.001	1.001
Nursing Home Quality									

Consumer Satisfaction									
Overall Resident Satisfaction				.999	.992	1.006			
Overall Family Satisfaction							.998	.993	1.003

Note. IRR = Incidence Rate Ratio; CI = Confidence Interval; SES= Socioeconomic Status; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
*p <.05, **p <.01, ***p < .001

After two years of the COVID-19 pandemic, COVID-19 cases among staff per 100 beds each month are not predicted by the socioeconomic resources available in neighborhoods, regardless of Consumer Satisfaction scores (see **Table 20**). Nursing homes with increased occupancy rates, higher staffing hours for RNs and CNAs, fewer certified beds, non-profit or government ownership, CCRC membership, rural locations, a decreased proportion of minority residents, an increased proportion of residents aged 65 and older, and those situated in counties with higher COVID-19 incidence rates significantly report more COVID-19 cases among staff per 100 beds each month.

Table 20. The Role of Consumer Satisfaction Scores in the Relationships Between Neighborhood Disadvantage Levels and Monthly COVID-19 Cases Among Staff Members During the Two-Year Pandemic Period

	Monthly Staff COVID-19 Cases per 100 Beds (Two-Year Pandemic)								
	IRR	**95% CI**		**IRR**	**95% CI**		**IRR**	**95% CI**	
Neighborhood Disadvantage (National ADI rank)	1.000	.999	1.001	1.000	.999	1.001	1.000	.999	1.001
Organizational Enabling Factors									
Medicare %	1.002	.998	1.006	1.002	.998	1.006	1.002	.998	1.006
Medicaid %	1.001	1.000	1.003	1.001	1.000	1.003	1.001	1.000	1.003
Occupancy rate	1.008***	1.006	1.010	1.008***	1.006	1.010	1.008***	1.006	1.010
RN HPRD	1.259***	1.124	1.410	1.257***	1.121	1.408	1.258***	1.123	1.409
LPN HPRD	1.041	.942	1.151	1.040	.941	1.150	1.041	.942	1.151
CNA HPRD	1.089*	1.013	1.171	1.087*	1.011	1.169	1.088*	1.011	1.170
NHA turnover (ref=no turnover)									
Has turnover	.992	.934	1.054	.992	.933	1.054	.993	.934	1.055
DON turnover									
Has turnover	.966	.912	1.023	.967	.913	1.024	.966	.912	1.023
LPN/RN retention	1.000	.999	1.002	1.000	.999	1.000	1.000	.999	1.002
CNA retention	1.000	.998	1.002	1.000	.998	1.002	1.000	.998	1.002
Any agency RN (ref=No)									
Yes	1.015	.955	1.079	1.016	.956	1.080	1.016	.956	1.080
Any agency LPN (ref=No)									
Yes	.948	.867	1.037	.948	.867	1.037	.948	.867	1.037
Any agency CNA (ref=No)									
Yes	.985	.908	1.069	.984	.907	1.068	.985	.907	1.069
Facility size	.999***	.998	.999	.999***	.998	.999	.999***	.998	1.000
Ownership type (ref=non-profit/government owned)									

Profit	.915**	.856	.977	.916**	.857	.979	.915**	.857	0.978
Chain affiliation (ref=Not affiliated)									
Affiliated	1.013	.956	1.074	1.013	.956	1.073	1.015	.957	1.075
CCRC (ref=not a member)									
Yes	1.202***	1.121	1.288	1.203***	1.122	1.291	1.203***	1.122	1.290
Dementia care unit (ref=no)									
Yes	.912	.795	1.047	0.912	.795	1.047	.912	.795	1.047
Other care unit (ref=no)									
Yes	1.070	.936	1.222	1.069	.935	1.222	1.069	.935	1.222
Location rurality (ref=metropolitan)									
Micropolitan	.991	0.923	1.065	.990	.922	1.064	.991	.922	1.065
Rural	1.118*	1.022	1.222	1.115*	1.020	1.220	1.117*	1.021	1.221
Resident- and Community Level Predisposing and Need factors									
Resident Acuity Index	.992	.967	1.017	.992	.968	1.018	.992	.967	1.018
Minority Residents %	.998*	.996	1.000	.998*	.996	1.000	.998*	.996	1.000
65 or Older Residents %	1.003**	1.001	1.006	1.003**	1.001	1.006	1.003**	1.001	1.006
County-level incidence rate	1.000**	1.000	1.001	1.000**	1.000	1.001	1.000**	1.000	1.001
Nursing Home Quality									
Consumer Satisfaction									
Overall Resident Satisfaction				1.001	.996	1.006			
Overall Family Satisfaction							1.001	.997	1.004

Note. IRR = Incidence Rate Ratio; CI = Confidence Interval; SES= Socioeconomic Status; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
*p <.05, **p <.01, ***p < .001

Research Aim 4. *Whether spatial effects should be considered when evaluating the complex relationships between neighborhood disadvantage, quality, and COVID-19 outcomes*

Since the spatial autoregressive parameters (λ) from the SEM and SMA models are not the primary focus of this study and lack intuitive interpretations, and because the results across different spatial model specifications are not drastically different, this section only presents the spatial regression results from the SAR model specifications.

a) the relationships between neighborhood disadvantage levels and various quality performance measures

The multiple linear regression models (Aim 1) estimating CMS Five-Star Overall, Health Inspection, and Quality Measures ratings, as well as Overall Resident and Family Consumer Satisfaction scores, might not fully account for spatial dependence in the relationships between neighborhood disadvantage levels and nursing home quality. This is suggested by Moran's I statistics, which indicate significant spatial dependence at $p < .05$ (detailed results can be found in **Table D.1** of **Appendix D**). **Table 21** presents the results of the linear regressions alongside

their SAR model counterparts, estimating the relationships between neighborhood disadvantage levels and nursing home quality.

Table 21. Results of Linear and Spatial Autoregressive Models Estimating Associations Between Neighborhood Disadvantage Levels and Nursing Home Quality

	CMS Five Star Rating								Consumer Satisfaction			
	Overall		Health Inspection		Quality Measures		Staffing		Overall Resident Satisfaction		Overall Family Satisfaction	
	Model Specification											
	Linear	SAR	Linear	SAR	Linear	SAR	Linear	SAR	OLS	SAR	OLS	SAR
Neighborhood Disadvantage (National ADI rank)	-.003	-.002	-.001	-.001	-.000	.001	-.003	-.002	.005	.002	.012	.007
Organizational Enabling Factors												
Medicare %	-.000	.004	-.011	-.007	-.013*	-.009	.008	.008*	-.011	-.014	-.059	-.056
Medicaid %	-.007*	-.006*	-.004	-.002	-.004	-.004	-.006***	-.006***	-.030*	-.029*	-.009	-.007
Occupancy rate	.012**	.013***	.015***	.015***	.008*	.008**	-.002	-.002	.014	.019	.046*	.049*
RN HPRD			.828***	.730***	.419*	.348*			1.154	1.279	1.707	1.662
LPN HPRD			.156	.024	-.186	-.212			.173	.306	-.522	-.452
CNA HPRD			.084	.065	.214	.195			1.439**	1.430**	1.802*	1.743*
NHA turnover (ref=no turnover)												
Has turnover	-.442***	-.402***	-.324***	-.297***	-.099	-.095	-.150*	-.146*	.070	-.004	-1.227	-1.261*
DON turnover (ref=no turnover)												
Has turnover	-.355**	-.319**	-.323***	-.287**	-.188	-.187	-.016	-.015	-.435	-.448	-.371	-.394
LPN/RN retention	.002	.002	.003	.003	-.000	.000	-.002	-.002	-.001	-.002	.030	.029
CNA retention	.001	.001	.001	.001	-.002	-.002	.001	.001	-.005	-.005	.030	.030
Any agency RN (ref=No)												
Yes	-.304**	-.283**	-.285**	-.249**	-.170	-.172	.055	.048	-.542	-.558	-1.252	-1.202
Any agency LPN (ref=No)												
Yes	-.198	-.164	-.365**	-.336**	-.007	-.007	.094	.096	.299	.428	.274	.306
Any agency CNA (ref=No)												
Yes	.144	.081	.279*	.221	-.038	-.046	-.029	-.032	-.101	-.223	.421	.380
Facility size	-.004***	-.005***	-.003**	-.004***	.001	.000	-.002	-.002*	-.013*	-.012*	-.029***	-.029***
Ownership type (ref=non-profit/government owned)												
Profit	-.196	-.232*	.065	.012	-.028	-.060	-.502***	-.512***	-1.284*	-1.282*	-1.426	-1.584*
Chain affiliation (ref=Not affiliated												
Affiliated	.049	.054	.104	.120	.193*	.190*	-.165*	-.178**	.128	.069	-2.005**	-2.063***

CCRC membership (ref=not a member)												
Yes	.059	.006	-.146	-.164	.129	.094	.166	.151	-.885	-.725	-1.086	-.988
Dementia care unit (ref=no)												
Yes	.290	.246	.183	.162	.311	.310	.116	.084	.296	.261	-.340	-.343
Other care unit (ref=no)												
Yes	-.231	-.179	-.136	-.107	-.433	-.426	-.148	-.118	-.038	-.046	1.691	1.660
Location rurality (ref=metropolitan)												
Micropolitan	-.297*	-.251*	-.182	-.180	-.423***	-.367***	-.019	.005	.897	.541	-.003	-.354
Rural	-.253	-.370*	-.094	-.215	-.051	-.043	-.252*	-.269**	1.421*	.737	1.901*	1.312
Resident- and Community Level Predisposing and Need factors												
Resident Acuity Index	-.031	-.019	-.051	-.048	-.029	-.017	.020	.028	-.228	-.189	-.255	-.250
Minority Residents %	-.008**	-.010***	-.006**	-.008***	.001	-.000	-.005**	-.006**	-.043***	-.041***	-.087***	-.083***
65 or Older Residents %	.021***	.022***	.013***	.015***	.008*	.009*	.015***	.014***	.088***	.084***	.125***	.122***
ρ		.763***		.776***		.458***		.425***		.370***		.287*
AIC, mean	2453.60	2366.60	2240.00	2143.40	2257.80	2244.60	1780.67	1771.20	4612.87	4603.93	5101.73	5098.13

Note. SAR = Spatial Autoregressive model; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
ρ - Autoregressive coefficient in the SAR specification
*p <.05, **p <.01, ***p < .001.

According to the spatial regression results, spatial dependence has been identified across all models estimating quality measures, including Overall, Health Inspection, Quality Measures, and Staffing ratings within the CMS Five-Star system, as well as Satisfaction scores for both residents and families. Although only the SAR models are presented, the spatial autoregressive parameters (ρ and λ) are significant at $p < .05$ and demonstrate positive relationships (detailed information for each model can be found in **Table D.2.a**–**Table D.2.b** of **Appendix D**). The significant positive spatial parameters (λ) from the SAR models indicate that nursing homes tend to achieve better quality performance in both the CMS Five-Star ratings and Consumer Satisfaction scores when neighboring providers, on average, exhibit higher performance.

Similar to the results from the linear regressions, neighborhood disadvantage levels remain insignificantly associated with CMS Five-Star Ratings and Consumer Satisfaction, even after accounting for spatial dependence. Financial conditions continue to play a significant role in nursing home quality performance from both CMS and consumer perspectives. Regardless of spatial dependence, higher occupancy rates are consistently associated with better quality. Nursing homes with higher occupancy rates tend to achieve higher ratings in the Overall, Health Inspection, and Quality Measures domains of the CMS Five-Star Ratings, as well as higher Overall Family Satisfaction scores ($p < .05$).

After accounting for spatial effects, financial conditions of nursing homes continue to play significant roles in nursing home quality performance, both linear and SAR models consistently indicate that a higher Medicaid payor mix negatively impacts nursing home quality. Nursing homes with a higher percentage of Medicaid residents are more likely to have lower Overall and Staffing CMS Five-Star ratings, as well as lower Overall Resident Satisfaction scores. Conversely, spatial models suggest higher Medicare payor mix positively influences CMS Five-Star Staffing ratings. Different from negative impacts suggested in the linear model, Medicare payor mix is not significantly associated with CMS Five-Star ratings in the Quality Measures domain after accounting for spatial effects.

Adequate staffing, consistent in-house nurse staffing, and stable leadership remain central themes in improved nursing home quality in the spatial models. Higher nurse staffing levels continue to be linked to better quality outcomes, even after accounting for spatial dependence. Increased RN hours per resident day (HPRD) are associated with higher CMS Five-Star Health

Inspection and Quality Measures ratings. Nursing homes with higher CNA staffing levels tend to report greater Overall Resident and Family Satisfaction scores.

Leadership stability becomes even more crucial after adjusting for spatial dependence. In addition to lower CMS Five-Star Overall, Health Inspection, and Staffing ratings, spatial models reveal that nursing homes experiencing administrator (NHA) and director of nursing (DON) turnover over a three-year period also see lower Overall Family Satisfaction scores.

Furthermore, spatial models highlight the positive impact of consistent in-house nurses, particularly RNs and LPNs, on quality performance. In contrast, the use of temporary RNs is associated with lower Overall and Health Inspection CMS Five-Star ratings. Similarly, nursing homes that rely on agency LPNs show significantly lower Health Inspection ratings compared to those that do not. However, the use of temporary CNAs does not appear to affect Health Inspection ratings once spatial effects are accounted for.

Consistent with the results from the linear regressions, spatial models also show that quality performance varies across nursing homes with different organizational characteristics, though with some nuances. Nursing homes with a larger number of certified beds continue to face a higher risk of lower quality performance. In addition to receiving lower Overall and Health Inspection ratings, as well as lower satisfaction scores from both residents and families, spatial models reveal that larger nursing homes also tend to have lower CMS Five-Star Staffing ratings.

Similarly, for-profit providers are more likely to exhibit lower quality performance. Besides having lower CMS Five-Star Staffing ratings and Overall Resident Satisfaction scores, for-profit nursing homes are also associated with lower Overall Family Satisfaction scores, after accounting for spatial effects.

Chain-affiliated nursing homes show mixed results. While chain affiliation is linked to higher Quality Measures ratings, these providers tend to have lower CMS Five-Star Staffing ratings and Overall Family Satisfaction scores, regardless of spatial dependence.

The rurality of nursing home locations also impacts CMS's perspective on quality performance. Nursing homes in more rural areas generally receive lower CMS Five-Star ratings compared to their metropolitan counterparts. Specifically, nursing homes in micropolitan areas are more likely to have lower Overall and Quality Measures ratings. In addition to lower CMS Five-Star Staffing ratings, spatial models indicate that nursing homes in rural areas also tend to

receive lower Overall ratings compared to those in metropolitan areas. However, Consumer Satisfaction scores are not significantly associated with the rurality of nursing home locations after accounting for spatial dependence.

Spatial and linear regression analyses produce consistent findings regarding the impact of resident characteristics on nursing home quality. Nursing homes with a higher percentage of minority residents tend to have lower quality performance across most measures, including CMS Five-Star Overall, Health Inspection, Staffing ratings, as well as Overall Resident and Family Satisfaction scores. The only exception is the Quality Measures domain of the CMS Five-Star Ratings, where no significant association is found.

Conversely, nursing homes serving a higher proportion of residents aged 65 or older consistently demonstrate better performance across all quality metrics, including CMS Five-Star Ratings and Consumer Satisfaction scores.

b) the relationships between neighborhood disadvantage levels and COVID-19 outcomes in nursing homes

Among all adjusted Poisson models estimating the relationships between neighborhood disadvantage levels and COVID-19 outcomes in Aim 2, only the model for COVID-19 incidence rates among residents during the Pre-Vaccination period fails to sufficiently account for spatial effects, as indicated by significant Moran's I statistics at $p < .001$ (Moran's I = .023). A full display of Moran's I statistics analyzing Pearson residuals from these adjusted Poisson models can be found in **Table E.1** of **Appendix E**.

Table 22 presents the results of the linear regression and its SAR counterpart estimating the relationship between neighborhood disadvantage levels and Box-Cox transformed COVID-19 incidence rates during the Pre-Vaccination period. Although modest, positive spatial relationships are identified in both SAR and SEM models, with spatial parameters being significant at $p < .05$ (details of each model are provided in **Table E.2** of **Appendix E**). The positive spatial parameter (ρ) from the SAR model suggests that nursing homes are at a higher risk of having more resident cases if neighboring providers, on average, report more cases as well.

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Table 22. Results of Linear and Spatial Autoregressive Models Estimating Associations Between Neighborhood Disadvantage Levels and Box-Cox Transformed Monthly Resident COVID-19 Cases per 100 Beds During the Pre-Vaccination Period

N = 752	Box-Cox Transformed Monthly Resident COVID-19 Cases per 100 Beds During the Pre-Vaccination Period (λ=0.5)	
	Model Specification	
	Linear	SAR
Neighborhood Disadvantage (National ADI rank)	.002	.002
Organizational Enabling Factors		
Medicare %	-.011	-.011
Medicaid %	.003	.003
Occupancy rate	.011*	.011*
RN HPRD	-.407	-.417
LPN HPRD	-.424	-.401
CNA HPRD	-.493**	-.458*
NHA turnover (ref=no turnover)		
Has turnover	-.162	-.170
DON turnover		
Has turnover	-.107	-.105
LPN/RN retention	-.005	-.005
CNA retention	.004	.005
Any agency RN (ref=No)		
Yes	-.046	-.057
Any agency LPN (ref=No)		
Yes	.133	.139
Any agency CNA (ref=No)		
Yes	-.287	-.272
Facility size	.000	.000
Ownership type (ref=non-profit/government owned)		
Profit	.367*	.338
Chain affiliation		
Affiliated	.264	.269
CCRC		
Yes	.053	.025
Dementia care unit		
Yes	-.835*	-.806*
Other care unit		
Yes	.651	.621
Location rurality (ref=metropolitan)		
Micropolitan	-.122	-.132
Rural	-.070	-.134
Resident- and Community Level Predisposing and Need factors		
Resident Acuity Index	.045	.035
Minority Residents %	-.006	-.006
65 or Older Residents %	.014*	.013*
County-level Infection	.002***	.002**
ρ		.261*
AIC, mean	2987.93	2985.40

Note. SAR = Spatial Autoregressive model; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.

ρ - Autoregressive coefficient in the SAR specification
*p <.05, **p <.01, ***p < .001.

Despite accounting for spatial relationships, neighborhood disadvantage levels remain non-significant in influencing COVID-19 incidence rates among residents before vaccine availability. Furthermore, ownership type also shows no significant association with resident COVID-19 incidence rates during the Pre-Vaccination period after accounting for spatial effects.

Consistent with the linear regression findings, increased COVID-19 incidence rates among residents before vaccine availability are associated with higher occupancy rates, reduced CNA staffing levels, the absence of dementia care units, a larger proportion of residents aged 65 or older, and higher county-level COVID-19 infection rates.

c) the role of quality performance measures in mediating the relationship between neighborhood disadvantages and COVID-19 outcomes.

Moran's I statistics for Pearson residuals from adjusted Poisson models in Aim 3 are statistically significant for models estimating COVID-19 incidence rates for residents while controlling for quality performance during the pre-vaccination period, as well as for models estimating COVID-19 incidence rates while controlling for CMS Five-Star Overall or Staffing ratings during the two-year pandemic. These findings suggest that spatial effects may need to be accounted for when investigating these relationships (detailed information on Moran's I statistics can be found in **Table F.1** of **Appendix F**).

However, none of the spatial regression models estimating relationships between neighborhood disadvantage levels and Box-Cox transformed COVID-19 incidence rates for residents during the two-year pandemic period (while controlling for CMS Five-Star Overall or Staffing ratings) identify statistically significant spatial autoregressive parameters (detailed information on these models is provided in **Table F.2** of **Appendix F**). Therefore, for concise presentation, this section only presents results of linear and SAR models assessing the role of quality performance in the relationships between neighborhood disadvantage levels and Box-Cox transformed COVID-19 incidence rates for residents during the pre-vaccination period, as shown in **Table 23**[2].

[2] A full display of results for linear and spatial regression models assessing the role of quality performance in the relationships between neighborhood disadvantage levels and Box-Cox transformed COVID-19 incidence rates for residents during the pre-vaccination period can be found in Table F.3.a and Table F.3.b of Appendix F.

Table 23. Results of Linear and Spatial Autoregressive Models Estimating the Roles of Quality in the Associations Between Neighborhood Disadvantage Levels and Box-Cox Transformed Monthly Resident COVID-19 Cases per 100 Beds During the Pre-Vaccination Period

	Box-Cox Transformed Monthly Resident COVID-19 Cases per 100 Beds During the Pre-Vaccination Period (λ=0.5)													
	Model Specification													
	Linear	SAR	Linear	SAR	Linear	SAR	Linear	SAR	Linear	SAR	Linear	SAR	Linear	SAR
Neighborhood Disadvantage (National ADI rank)	.002	.002	.003	.003	.002	.002	.002	.002	.003	.002	.002	.002	.002	.001
Organizational Enabling Factors														
Medicare %	-.011	-.011	-.020*	-.020*	-.010	-.011	-.010	-.010	-.020*	-.020*	-.011	.011	-.010	-.011
Medicaid %	.003	.003	.004	.004	0.003	.003	.003	.003	.004	.004	.002	.002	.003	.003
Occupancy rate	.011*	.011*	.012*	.012*	.011*	.011*	.011*	.011	.011*	.011*	.012*	.011*	.011*	.011*
RN HPRD	-.407	-.417			-.418	-.432	-.432	-.443			-.386	-.397	-.409	-.419
LPN HPRD	-.424	-.401			-.426	-.404	-.412	-.389			-.422	-.400	-.423	-.401
CNA HPRD	-.493**	-.458*			-.494**	-.460*	-.506**	-.471**			-.466**	-.434*	-.495**	-.460*
NHA turnover (ref=no turnover)														
Has turnover	-.162	-.170	-.141	-.149	-.157	-.165	-.156	-.164	-.138	-.147	-.161	-.169	-.160	-.169
DON turnover														
Has turnover	-.107	-.105	-.088	-.087	-.102	-.100	-.096	-.094	-.079	-.080	-.114	-.112	-.106	-.105
LPN/RN retention	-.005	-.005	-.004	-.004	-.005	-.005	-.005	-.005	-.005	-.005	-.005	-.005	-.005	-.005
CNA retention	.004	.005	.004	.004	.004	.005	.005	.005	.004	.004	.004	.004	.004	.004
Any agency RN (ref=No)														
Yes	-.046	-.057	-.069	-.079	-.042	-.052	-.036	-.047	-.057	-.069	-.055	-.064	-.045	-.056
Any agency LPN (ref=No)														
Yes	.133	.139	.103	.111	.138	.145	.133	.139	.114	.122	.140	.145	.132	.139
Any agency CNA (ref=No)														
Yes	-.287	-.272	-.248	-.233	-.291	-.277	-.284	-.270	-.253	-.238	-.289	-.275	-.287	-.273
Facility size	.000	.000	.001	.001	.000	.000	.000	.000	.001	.001	.000	.000	.000	.000
Ownership type (ref=non-profit/government owned)														
Profit	.367*	.338	.527**	.487**	.366*	.337	.368*	.340	.501**	.461*	.342	.316	.369*	.339
Chain affiliation														
Affiliated	.264	.269	.345*	.346*	.263	.267	.253	.257	.333*	.334*	.267	.271	.267	.271
CCRC														
Yes	.053	.025	-.012	-.039	.055	.027	.045	.017	-.003	-.031	.037	.011	.054	.026
Dementia care unit														

Yes	-.835*	-.806*	-.851*	-.820*	-.838*	-.810*	-.854*	-.826*	-.853*	-.820*	-.829*	-.802*	-.834*	-.806*
Other care unit														
Yes	.651	.621	.635	.605	.653	.624	.677	.648	.632	.601	.651	.622	.649	.619
Location rurality (ref=metropolitan)														
Micropolitan	-.122	-.132	-.093	-.106	-.118	-.129	-.095	-.106	-.086	-.100	-.104	-.115	-.121	-.132
Rural	-.070	-.134	-.031	-.104	-.069	-.132	-.067	-.131	-.040	-.114	-.044	-.107	-.073	-.136
Resident- and Community Level Predisposing and Need factors														
Resident Acuity Index	.045	.035	.029	.019	.046	.036	.047	.037	.032	.021	.041	.031	.045	.035
Minority Residents %	-.006	-.006	-.006	-.006	-.006	-.005	-.006	-.005	-.006	-.006	-.007	-.006	-.006	-.005
65 or Older Residents %	.014*	.013*	.011*	.011*	.013*	.013*	.013*	.013*	.012*	.011*	.015**	.015**	.013*	.013*
County-level Infection	.002***	.002**	.002***	.002**	.002***	.002**	.002***	.002**	.002***	.002**	.002***	.002**	.002***	.002**
Nursing Home Quality														
CMS Five Star Rating														
Overall Rating			-.028	-.025										
Health Inspection					.014	.018								
Quality Measures Rating							.060	.061						
Staffing Rating									-.063	-.062				
Consumer Satisfaction														
Overall Resident Satisfaction											-.018	-.017		
Overall Family Satisfaction													.001	.001
ρ		.261*		.293*		.262*		.262*		.294*		.254*		.261*
AIC, mean			2998.00	2994.33	2989.87	2987.33	2988.93	2986.33	2997.60	2994.00	2987.87	2985.47	2989.87	2987.40

Note. SAR = Spatial Autoregressive model; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
ρ - Autoregressive coefficient in the SAR specification
*p <.05, **p <.01, ***p < .001.

Modest and positive values of the spatial autoregressive parameter (λ) are identified in all models estimating COVID-19 incidence rates for residents during the pre-vaccination period, regardless of which quality performance measure is controlled for. This suggests that nursing homes surrounded by providers with increased resident incidence rates before vaccine availability continue to face a higher risk of experiencing more COVID-19 cases among their residents, irrespective of their quality performance. Despite accounting for spatial relationships and the quality performance of nursing homes, neighborhood disadvantage levels do not significantly impact COVID-19 incidence rates for residents during the pre-vaccination period.

COVID-19 incidence rates for residents are consistently associated with several factors: the absence of a dementia care unit, a larger proportion of residents aged 65 or older, and being located in counties with higher COVID-19 infection rates, regardless of whether spatial relationships or quality performance are accounted for. Nursing homes with higher occupancy rates remain at greater risk of higher COVID-19 incidence rates for residents, even after controlling for quality performance and spatial relationships, with the exception of models that control for Quality Measures ratings. When Quality Measures ratings are controlled for and spatial effects are accounted for, occupancy rates no longer show an association with COVID-19 incidence rates.

When CMS Five-Star staffing-related ratings (Overall and Staffing) are controlled, increased COVID-19 incidence rates for residents are also linked to reduced Medicare payor-mix, for-profit ownership, and chain affiliation. However, in models controlling for other quality performance measures—such as CMS Five-Star Health Inspection and Quality Measures ratings and Consumer Satisfaction scores—nursing homes with higher CNA staffing levels are at a reduced risk of higher COVID-19 incidence rates. Additionally, ownership type is no longer associated with COVID-19 incidence rates during the pre-vaccination period when controlling for CMS Five-Star Health Inspection and Quality Measures ratings, as well as Overall Family Satisfaction scores, after accounting for spatial relationships.

Chapter 5: Discussion

Introduction

The quality and care outcomes in nursing homes have come under intense national scrutiny, especially in light of the significant challenges posed by the COVID-19 pandemic. This concern is heightened in socioeconomically disadvantaged neighborhoods where access to community resources is limited. This dissertation seeks to explore the complex relationships between neighborhood socioeconomic disadvantage, nursing home quality, and COVID-19 outcomes in Ohio. The study focuses on four key aims: 1) to investigate the impact of neighborhood disadvantage levels on various measures of nursing home quality, including CMS Five-Star ratings and Consumer Satisfaction scores; 2) to assess the performance of nursing homes in different neighborhood disadvantage levels with respect to COVID-19 outcomes, such as resident and staff cases, and resident deaths; 3) to examine how nursing home quality influences COVID-19 outcomes in facilities located in neighborhoods with varying levels of socioeconomic disadvantage; and 4) to determine whether spatial effects should be accounted for when evaluating the relationships between neighborhood disadvantage, nursing home quality, and COVID-19 outcomes as explored in the previous aims**.** Using a spatial analysis approach, this study carefully controls for a broad range of factors, including organizational characteristics, resident demographics, and community-level variables, to provide a comprehensive understanding of this multifaceted issue.

Similar to nursing homes nationwide, those in socioeconomically disadvantaged neighborhoods in Ohio predominantly serve Medicaid-supported residents, with fewer relying on payment methods like Medicare. These facilities are disproportionately situated in less urban areas (micropolitan or rural), often located in counties with higher COVID-19 incidence rates. Notably, they exhibit lower RN or CNA staffing hours, are less likely to use agency nurses (RN, LPN, and CNA), and have a higher likelihood of serving minority and younger residents (below 65). Moreover, these nursing homes are typically for-profit and less likely to be part of a Continuing Care Retirement Community (CCRC). Organized by aims, this chapter explores possible explanations of results in this study and provides its implications to practice, policy, and research. Limitations and future research directions are also reviewed, followed by a conclusion of this dissertation.

Aim 1

The first aim is to investigate the impact of neighborhood disadvantage levels on various measures of nursing home quality, including CMS Five-Star ratings and Consumer Satisfaction scores. As expected, neighborhoods' socioeconomic disadvantage levels are negatively associated with all four CMS Five-Star ratings and resident satisfaction scores of consumers perceived quality in bivariate analyses. Notably, these significant relationships between neighborhood socioeconomic disadvantage and nursing home quality diminish when controlling other factors. This hints that socioeconomic resources alone may not entirely account for variations in nursing home quality, other factors and regional disparity within the organization and community that may or may not correlate with socioeconomic resources could also play a role in nursing home quality.

Initial observations have revealed an inverse correlation between neighborhood socioeconomic disadvantage levels and nursing home quality. These findings align with existing literature, indicating that nursing homes in more socioeconomically disadvantaged neighborhoods, whether at the ZIP code or county level, tend to exhibit lower CMS Five-Star ratings, heightened fiscal stress, reduced RN staffing ratios, and poorer resident outcomes (Konetzka & Gray, 2017; Park & Martin, 2018; Weech-Maldonado et al., 2018; Yuan et al., 2018). This study enhances the existing knowledge by employing refined measures of neighborhood socioeconomic conditions at the census block group level, providing a more nuanced depiction beyond poverty alone, including factors such as employment, education, and housing quality.

Furthermore, this research expands the current understanding of the impact of neighborhood socioeconomic disadvantages by exploring its associations with consumer satisfaction scores. The lower satisfaction scores among residents may indicate consumer concerns about the quality of care, with increased neighborhood disadvantage levels correlating with higher satisfaction scores among residents but not among family members. Residents, being direct recipients of daily care, may have their satisfaction influenced by day-to-day experiences, which could be affected by resource limitations in disadvantaged neighborhoods. Conversely, family satisfaction scores, reflecting broader aspects such as overall support and communication, may remain relatively unaffected by neighborhood socioeconomic factors. These findings align with Shippee and colleagues' work (2017), emphasizing that resident experiences and outcomes

are positively associated with family involvement and satisfaction, yet they are distinct dimensions that should be jointly considered for enhancing the quality of care in nursing homes. To gain a deeper understanding of nursing home quality, future research should delve into the mechanisms underlying the differences between resident and family perspectives.

A wide range of factors are able to be accounted for in this current study including resident-, organization-, and community- level characteristics. Attenuation of significant relationships between neighborhood disadvantage levels and nursing home quality after accounting for other factors highlights potential reasons and challenges of the current long-term care system especially those in disadvantaged areas maintaining higher quality and well-being of residents.

Financial conditions

This study highlights the crucial influence of financial conditions on nursing home quality, demonstrating that the source of payment significantly affects performance outcomes. Nursing homes with a higher proportion of residents relying on Medicaid, compared to those funded by more generous private or alternative payment sources, tend to exhibit lower quality performance. Specifically, facilities with a higher Medicaid payor-mix are associated with lower overall CMS Five-Star ratings, particularly in the staffing domain, and report lower resident satisfaction. The link between higher occupancy rates and quality performance further highlights the influence of financial robustness on quality delivery. Nursing homes in disadvantaged Ohio neighborhoods face a substantial financial challenge, aligning with Mor et al.'s (2004) "two-tier" system. These Medicaid-dependent facilities contend with lower reimbursement rates, creating financial constraints that ripple through staffing and care quality. Insufficient funds may limit providers' capacity to invest in competitive staff compensation, professional development, and supportive management, contributing to a dissatisfied workforce (Cherry et al., 2007; Rajamohan et al., 2019). As a result, providers with a higher Medicaid mix may struggle to maintain optimal staffing levels, leading to decreased attention to residents' needs and lower satisfaction scores, as evidenced in this and other existing study (Kogan et al., 2016). Additionally, given Medicaid disproportionately pays for services in disadvantaged areas, addressing payment disparity to ensure equitable quality of care is still an urgent issue for local and federal administration.

Workforce challenges

Overall data pattern of this study underscores the critical role of adequate staffing (RN and CNA), consistent in-house staffing (no usage of any agency RN and LPN), and stable leadership (no turnovers for NHA and DON) in shaping overall nursing homes care quality as their significant relationships. In contrast, nursing homes in disadvantaged neighborhoods exhibit distinctive characteristics, marked by significantly lower RN ($r = -.165$, $p < .001$) and CNA ($r = -.177$, $p < .001$) staffing hours, and a reduced likelihood of utilizing any temporary nursing staff (RN, LPN, CNA respectively, $\beta = -3.412$, $p < .05$; $\beta = -5.249$ $p < .01$; $\beta = -4.607$, $p < .01$). Given its unique workforce profile, several challenges faced by nursing homes in disadvantaged areas merit discussion.

First, the observed decline in quality within nursing homes situated in disadvantaged areas can be largely ascribed to insufficient staffing, particularly concerning RNs and CNAs, although not markedly so for LPNs. To comprehend the reasons behind these relationships, it is crucial to clarify the distinct roles of various nursing professionals in these healthcare settings. RNs bring advanced clinical expertise to nursing homes, overseeing complex medical care and contributing significantly to overall care quality. Their pivotal role ensures compliance with healthcare standards, meeting regulatory requirements, and positively impacting CMS Five-Star ratings. Conversely, CNAs play an essential role in providing direct, hands-on care, assisting with daily activities, and enhancing resident comfort and safety (e.g., reduced risk of falls). Their presence positively influences overall quality assessments, staffing, and consumer satisfaction scores.

Inadequate RN and CNA staffing hours can contribute to increased workloads for the existing staff, potentially leading to burnout and adversely impacting performance and job satisfaction. Bivariate findings reveal that CNA retention rates tend to be lower when CNA staffing hours are insufficient. Moreover, lower CNA retention rates correlate with decreased retention rates for LPN/RN staff. Nurses may actively seek employment opportunities that offer more manageable workloads and improved working conditions in response to these challenges.

LPNs, positioned between RNs and CNAs, undertake a mix of clinical and supportive tasks. While they can perform more specialized clinical duties than CNAs, they often require supervision by an RN. LPNs are often perceived as interchangeable with RNs but at a lower cost for providers. The study indicates no significant disparity, albeit a slight increase ($r = .035$,

$p > .05$), in LPN staffing hours among Ohio nursing homes in more disadvantaged areas, aligning with a nationwide study's findings that such homes use lower ratios of RN and CNA but higher ratios of LPN (Falvey et al., 2022). These results empirically support the notion of care substitution among providers in resource-limited neighborhoods. However, LPNs may lack the preparation and training for making clinical judgments, especially in the absence of RNs, potentially leaving residents with heightened safety concerns. Previous research has identified increased LPN staffing levels as associated with elevated risks of emergency department visits and hospitalizations (Travers et al., 2023).

Second, while leadership turnover (both NHA and DON) does not significantly differ between providers in more disadvantaged areas, the vital role of leadership stability in nursing home quality is clearly demonstrated in this study. Nursing homes with stable NHA and DON positions consistently achieve higher CMS Five-Star Overall and Health Inspection ratings. Additionally, facilities with stable NHA leadership are more likely to maintain higher nurse staffing levels, as evidenced by greater CMS Five-Star Staffing ratings. This emphasizes the importance of consistent leadership in fostering improved quality performance in nursing homes. Longer-tenured leaders, equipped with comprehensive knowledge of daily operations, can better commit to tasks such as budget and staffing decisions, addressing staff concerns, and initiating quality improvement initiatives (Castle, 2005). The general pattern in bivariate findings suggests that homes that have changed their NHA and/or DON over a three-year period demonstrate lower staffing hours (RN and CNA) and nurse retention rates (LPN/RN and CNA) and are more likely to use agency licensed nurses (RN and LPN), further evidencing the destabilizing impacts of leadership turnover within homes. These destabilizing impacts can translate into high staff turnovers, low retention rates for direct care workers, more deficiencies, and ultimately, worse resident outcomes and well-being (Castle, 2001, 2005; Kennedy et al., 2020a).

On a related note, NHA turnover is also negatively associated with Family Satisfaction scores, as demonstrated in the findings from Aim 4. The stability of key administrative roles can positively impact on the nursing home's reputation within the local community. Consistent leadership fosters trust and confidence among residents' families and the broader community, potentially leading to increased support and positive perceptions. Nursing homes in more disadvantaged areas, where staffing issues are more profound, may significantly benefit from stable leadership to address these challenges. Therefore, prioritizing stable leadership, effective

communication, and building trust with families remain essential for nursing homes in disadvantaged areas to ensure positive experiences and satisfaction with care provided. Implementing strategies to minimize turnover and support smooth leadership transitions can further enhance family satisfaction and overall quality of care in these homes.

Third, this study underscores that each type of temporary nurse is utilized by over 30% of Ohio nursing homes. The exacerbation of staffing shortages during and following the COVID-19 pandemic has led to a heightened reliance on temporary or agency nurses in today's nursing facilities. Recent research by Bowblis and colleagues (2024) has suggested potential negative impacts of agency staff on nursing home CMS Five-Star ratings. This current study builds upon existing knowledge by considering potential confounding factors and specifically examining three types of agency nurses. The findings reveal that the utilization of agency RNs and LPNs is associated with lower performance in state surveys, and the use of RNs is also linked to lower Overall ratings. Despite similar clinical training, agency RNs and LPNs may be less familiar with facility protocols, layouts, and resident populations compared to directly employed staff. This lack of familiarity can lead to inconsistencies in care delivery, compromising regulatory compliance and overall rating performance. Additionally, the use of agency staff can negatively affect team dynamics, as temporary workers may be unfamiliar with the nursing home’s routines and existing staff members. This lack of cohesion can disrupt communication and care processes. Furthermore, the disparity in wages between agency staff and permanent employees can lead to decreased morale among the regular staff, potentially undermining the overall efficiency and quality of care delivery within the facility (Castle, 2009; Karmacharya & Janssen, 2023)

Although the risks associated with agency staff are evident, many nursing homes still rely on temporary workers to meet regulatory standards. However, nursing homes in disadvantaged areas, despite facing greater difficulties in maintaining adequate staffing levels, are less likely to use agency staff due to the higher costs, which may leave residents' safety and well-being at risk. These findings underscore the chronic staffing issues in the industry as a multifaceted problem. While maintaining adequate staffing levels is critical for high-quality care, achieving high staff stability, including reducing the use of agency staff, should be addressed simultaneously.

Other organizational and resident characteristics

Other organizational and resident factors are also found associated with nursing homes quality which carry some important implications to nursing homes in disadvantaged neighborhoods.

First, analyses reveal that for-profit nursing homes tend to have lower CMS Five-Star Staffing ratings and receive lower satisfaction scores from both residents and their families[3], which is possibly due to the profit-driven nature of these providers, which underscore potential quality of care issues within these homes. To maximize operating margin, for profit homes may prioritize cost effective measures (e.g., reduce nurse wages) over maintaining adequate staffing levels and well-being of resident. Lower staffing ratings may indicate inadequate staffing levels, resulting in increased workloads for existing staff, higher turnover rates, and decreased quality of care. CNA and RN staffing is also consistently suggested in existing literature that are associated with higher resident and family satisfaction scores (Lucas et al., 2007; Shippee et al., 2017b). Lower satisfaction scores among residents and families may reflect dissatisfaction with the quality and availability of care, as well as communication and responsiveness from staff.

As evidenced in bivariate analyses, for-profit nursing homes disproportionately located in disadvantaged neighborhoods, enhancing staffing and quality of care among for-profit providers in these regions might be necessary for addressing health disparity and ensure equitable healthcare access. Policy interventions and regulatory oversight may be necessary to incentivize for-profit nursing homes to prioritize staffing levels and invest in improving care quality, particularly in areas with higher levels of socio-economic disadvantage. This could involve monitoring certain economic activities within nursing homes, such as ownership conversions, particularly from not-for-profit to for-profit status, which have been linked to declines in quality (Grabowski & Stevenson, 2008). Indeed, nursing homes undergoing such conversions may face financial challenges during the pre-conversion period and may resort to cost-cutting measures, such as aggressively reducing RN staffing, leading to substantial declines in quality (Lu & Lu, 2022). Additionally, efforts to increase transparency and accountability in the nursing home industry could empower residents and families to make informed decisions about their care options, regardless of their neighborhood's socio-economic status.

[3] For-profit ownership is associated with lower family satisfaction scores after accounting for spatial relationship, as demonstrated in the results from Aim 4.

Second, the performance contrast between chain-affiliated nursing homes becomes evident when comparing CMS Quality Measures ratings and family satisfaction scores. These facilities often receive higher ratings in CMS Quality Measures but lower scores in family satisfaction. This discrepancy may stem from the focus of chain-affiliated homes on clinical indicators tracked by CMS Quality Measures, such as the management of medical conditions and adherence to care protocols. This emphasis on clinical outcomes could be attributed to the knowledge repository within these facilities, especially since Quality Measures ratings are derived from the Minimum Data Set (MDS) completed by providers, where document and assessment practices are critical.

While prioritizing clinical outcomes may contribute to higher Quality Measures ratings, it may not necessarily translate into an optimal experience for residents' families. Bivariate analyses indicate that chain-affiliated nursing homes tend to have lower staffing levels of RNs, LPNs, and CNAs**.** Regression analyses further confirmed that these homes also demonstrate lower quality performance in maintaining sufficient staffing levels, potentially as a strategy to improve economic efficiency. With limited staffing resources, these nursing homes may face challenges in providing a satisfactory resident experience, effective communication, and responsiveness to family concerns.

In disadvantaged neighborhoods, where nursing homes already contend with limited resources, staffing shortages, and financial constraints, addressing these disparities becomes even more crucial. While chain-affiliated facilities may prioritize clinical quality, there appears to be a lack of adequate attention to the holistic experience of residents and their families. This underscores the importance of balancing clinical excellence with resident-centered care, particularly in settings where additional challenges are present.

Third, this study reveals that nursing homes serving a higher proportion of minority residents tend to exhibit lower quality across various measures, including most CMS ratings (with the exception of Quality Measures) and both resident and family satisfaction scores. Similar patterns of inadequate staffing hours (RN and CNA hours) and care substitution (from RN to LPN hours) observed in disadvantaged neighborhoods are also evident in other studies of nursing homes serving minority populations (Y. Li et al., 2015; Travers et al., 2023). Disadvantaged neighborhoods, which disproportionately serve more minority residents, may reflect historical patterns of housing segregation that have led to the concentration of minorities

in these areas. Structural racism likely plays a role in the historically underinvestment in these neighborhoods, making it challenging for providers to offer competitive pay and ideal working conditions to attract qualified care workers. This, in turn, may contribute to lower nursing home quality observed in these areas. The lack of relationship between minority proportion and Quality Measures rating suggests that minority serving homes perform comparably in terms of specific clinical and care-related indicators. Previous research indicates that minority-serving homes experience lower rates of emergency department visits, likely due to factors such as the younger age of minority residents and greater access to healthcare resources in urban settings (Travers et al., 2023). These findings highlight the reality that delivery of high quality nursing home care is unequitable and geographically constrained in certain communities roughly mirroring residential segregation. Minority populations have comparatively fewer alternatives for high quality nursing homes than their white counterparts.

In conclusion, aim 1 of this study finds that while nursing homes with lower CMS Five-Star ratings are more likely to cluster in more disadvantaged neighborhoods, the significant relationships diminish after accounting for organizational and resident characteristics of nursing homes. These findings provide potential reasons and challenges to the current long-term care system as well as lower quality in disadvantaged neighborhoods.

Aim 2

The second aim of this study is to evaluate nursing home performance across varying levels of socioeconomic disadvantage in relation to COVID-19 outcomes during both the pre-vaccination and two-year pandemic periods, focusing on cases among residents and staff, as well as resident deaths.

The analyses reveal consistent positive associations between neighborhood disadvantage levels of nursing homes and the number of COVID-19-related deaths among residents across study periods. This finding underscores the significant impact of neighborhood socioeconomic factors on the vulnerability of nursing home residents to the COVID-19 pandemic. There are several potential explanations of why neighborhood disadvantage levels may affect COVID-19 mortality rates for residents. First, nursing homes in disadvantaged neighborhoods often serve the population with limited access to healthcare resources. These residents may have more pre-existing conditions that are inadequately managed due to barriers such as lack of access to primary care, preventive services, and early interventions. This can lead to worse outcomes when

faced with severe illnesses like COVID-19. Previous research suggests that health conditions such as cognitive impairments, immunodeficiency, and end-stage kidney disease are important predictors for residents who die from COIVD-19 (Wolff et al., 2021). Second, disadvantaged neighborhoods have limited access to healthcare sources such as COVID-19 related sources and high quality health professionals (Fiscella & Williams, 2004; R. M. Lee et al., 2022; Reses et al., 2023). Nursing homes in these areas may struggle with frequent testing, high vaccination coverage rates, appropriate treatments due to limited access and its resulting high costs which can lead to delayed diagnosis and treatments exacerbating existing health issues, making residents more susceptible to severe outcomes from COVID-19. Additionally, nursing homes in disadvantaged neighborhoods are disproportionately for-profit. Given the profit maximization purpose of these providers and high dependency of Medicaid payments, providers in disadvantaged neighborhoods may be reluctant to invest adequate resources in infection control measures, personal protective equipment (PPE), proper staff to resident ratios, and staff training making it more difficult to prevent and manage outbreaks within the facility. Additionally, infrastructure and living conditions in these nursing homes could also play a role further exacerbating the situation. Nursing homes in disadvantaged neighborhoods may operate in older buildings with outdated designs that are not able to effectively manage and control infectious disease. For example, they might not have proper ventilation systems, which are crucial for reducing the spread of airborne pathogens like the coronavirus.

Overcrowding fueled by racial disparities could be another potential explanation for the increased COVID-19 mortality rates among residents in nursing homes located in disadvantaged areas. These nursing homes are often understaffed and tend to house a higher proportion of racial minorities, who are predominantly covered by Medicaid. This pattern likely stems from structural racism, as discussed in Aim 1. Racial minorities often have fewer financial resources and limited access to high-quality care, leading them to rely on lower quality and understaffed nursing homes (Carlson & Selassie, 2022). Research has shown that crowded living conditions, such as shared rooms, are associated with an increased risk of COVID-19 infection and mortality (Brown et al., 2021). Minority residents, who are more likely to be covered by Medicaid, are also more likely to live in shared rooms, making social distancing challenging and contributing to the elevated risk of COVID-19 mortality rates in nursing homes in disadvantaged areas. A recent report from the Illinois Department of Healthcare and Family Services underscores this risk,

highlighting how overcrowded living conditions and understaffing in nursing homes disproportionately affect minority residents, leading to greater COVID-19 mortality rates in nursing homes (The Nursing Home Abuse Center, 2021).

Contrary to finding from an existing study using ADI at county-level (C. S. Williams et al., 2021), neighborhood disadvantage levels are not associated with COVID-19 cases among residents in this study. This might be because data aggregated at the county level provide more robust statistical power to detect associations with COVID-19 cases due to larger sample sizes and broader contextual factors. Variations in testing rates, reporting practices, and data accuracy could also play a role. Nursing homes in more disadvantaged neighborhoods might have differing capacities for testing and reporting, which can affect the number of cases recorded. Additionally, counties often serve as administrative units for health and social services. Disadvantages at this level can reflect broader issues such as fewer healthcare facilities, lower availability of medical staff, and reduced funding for public health initiatives, which can significantly impact the spread and management of COVID-19 in nursing homes. Policies and resources to combat COVID-19, such as funding for PPE, testing, and staff support, are often managed at the county level. Counties with higher socioeconomic disadvantages might face more significant challenges in implementing effective public health measures, impacting nursing homes within those counties.

Consistent with the finding from Ryskina's team (2021), nursing home staff COVID-19 morbidity is not affected by regional socioeconomic characteristics. This is possibly due to the mobility of staff members who could commute from various regions, therefore encountering a range of socioeconomic environments. Staff members' personal living conditions and their adherence to public health guidelines at home can also vary widely, influencing their risk of contracting COVID-19 independently of the socioeconomic status of the neighborhood in which they work. Many staff members, such as CNAs have to work multiple jobs to make ends meet, which broadens their exposure beyond a single neighborhood socioeconomic context.

Impacts of local transmission to COVID-19 risk in nursing homes are evident in this study. Elevated county-level community COVID-19 incidence rates are associated with an increased risk of higher incidence rates for residents and staff members, as well as higher resident mortality rates during the pre-vaccination period. This trend continues for staff member cases throughout the entire two-year pandemic period. During the early stage of the pandemic,

when vaccines were not yet available and the virus was more fatal, nursing homes were particularly vulnerable to external COVID-19 surges. High community transmission rates means that staff, residents, and visitors who directly or indirectly interacted with the broader community could bring the virus into the nursing home. Nursing homes in areas with high transmission risks may struggle more with preventing infections, leading to higher resident and staff infection rates and increased mortality among residents. The continuation of this trend for staff cases over the entire pandemic period, despite the availability of vaccines, suggests that staff members remained exposed to community transmission risks. Staff often live in the same communities experiencing high COVID-19 rates and can inadvertently bring the virus into the facilities, especially if mitigation measures are inconsistent or if there is vaccine hesitancy among staff.

These findings highlight the importance of robust infection control measures not only within nursing homes but also at the community level. Coordinated public health efforts are essential to protect vulnerable populations in nursing homes. Efforts to this may include ensuring high vaccination rates, frequent testing, and strong support for infection control practices both in the community and within healthcare settings. By addressing community-level transmission, the risk of outbreaks in nursing homes can be significantly reduced, safeguarding both residents and staff.

In addition to community transmission risk, this study identified several organizational and resident characteristics associated with COVID-19 risks within nursing homes. As an infectious disease that spreads via respiratory droplets, COVID-19 outcomes in nursing homes are generally linked to organizational and resident characteristics that increase transmission risk. Factors such as higher occupancy, smaller facility size, lack of a dementia care unit, chain affiliation, CCRC membership, rural location, and a higher proportion of residents aged 65 or older are associated with increased risks of COVID-19 outcomes for both residents and staff members.

The specialized nature of dementia care units, which often implement stricter infection control measures, have dedicated staffing, and maintain a more controlled environment, may contribute to their enhanced ability to manage and prevent the spread of the virus. Increased numbers of resident cases in chain-affiliated homes could be attributed to the practice of sharing staff across locations, inadvertently facilitating the transmission of the virus. The vulnerability of

older residents to severe illness and death, coupled with their intensive care needs and close contact with staff, heightens the risk of both resident and staff cases, as well as resident mortality.

Similarly, residents in nursing homes with CCRC memberships tend to be older and have many underlying health conditions, making them more susceptible to severe outcomes from COVID-19. The integrated and communal nature of care environments in CCRC nursing homes necessitates more staff and increases the potential for cross-transmission across units, thereby raising the risk of more staff cases in these homes. More staff cases are found in rural nursing homes, possibly because these homes are more susceptible to staffing shortages during the pandemic than their urban counterparts, making existing staff work longer hours and multiple roles, thereby increasing their exposure to the virus (Yang et al., 2021).

More direct care staffing is associated with more staff cases but fewer resident cases. While increased staffing raises the risk of COVID-19 cases among staff due to higher exposure rates, it simultaneously enhances the care and protection of residents, resulting in fewer resident cases. This highlights the importance of balancing adequate staffing levels with robust infection control practices to protect both staff and residents in nursing homes.

As expected, for-profit homes exhibit higher rates of resident cases throughout the overall two-year pandemic period. Consistent with findings from Aim 1 and various other studies, for-profit homes often demonstrate poorer quality of care (e.g., Comondore et al., 2009). These facilities may prioritize financial gains at the expense of resident well-being, possibly by offering lower staff wages or limited full-time employment opportunities, which could lead to staff members working multiple jobs and inadvertently facilitating the spread of the virus. They may also be less proactive in ensuring adequate infection control equipment to safeguard both staff and residents (Kruse et al., 2021).

Surprisingly, for-profit homes are associated with fewer staff cases, which seems counterintuitive given the higher resident incidence rates in these facilities, which should logically increase the risk of staff contracting COVID-19. One possible explanation is the higher leadership turnover and lower nurse retention among these homes, as highlighted in bivariate analyses, which create a challenging environment for maintaining consistent health records for staff. Frequent changes in leadership may disrupt the implementation and continuity of health protocols, while low nurse retention could result in a less experienced workforce. Additionally, infected staff may leave the job before their cases are documented due to short tenure. Moreover,

for-profit homes tend to have lower staffing levels, meaning fewer staff members are present to contract and report cases, given the increased workload in healthcare settings during the pandemic. In conclusion, lower staff cases among for-profit homes might highlight issues with data collection and reporting issues within these homes. More research is needed to understand the extent and causes of these discrepancies, as well as to develop strategies for improving the accuracy of health data and ensuring better protection for staff and residents in these homes.

Aim 2 of this study provides a deeper understanding of the impacts of neighborhood disadvantage on COVID-19 outcomes in nursing homes. Higher COVID-19 related resident deaths in nursing homes located in lower-resourced neighborhoods highlight the urgent need for tailored interventions and support measures for providers in these areas. Overall, COVID-19 outcomes for both residents and staff are influenced by community incidence rates, as well as organizational and resident characteristics. Accessible emergency resources for providers in disadvantaged areas and their neighboring communities, particularly those facing elevated transmission risks, may help mitigate the threat of COVID-19 to nursing home residents and staff, while also minimizing the potential for cross-transmission between facilities and local communities.

Aim 3

The third aim of this study further examines whether the relationship between neighborhood disadvantage levels and COVID-19 outcomes in nursing homes is affected by their quality performance.

The findings reveal several important nuances about the impact of neighborhood disadvantage and nursing home quality on COVID-19 outcomes. This study finds no significant relationship between neighborhood disadvantage levels and the number of cases among residents and staff members regardless of provider's quality performance. This suggests that contrary to what might be expected, the socioeconomic context of the neighborhood does not directly drive the incidence of COVID-19 in nursing homes.

However, the study highlights the critical role of nursing home quality in influencing COVID-19 outcomes. Higher staffing ratings and resident satisfaction are associated with reduced incidence rates among residents. This indicates that better staffing practices and higher resident satisfaction can effectively mitigate the spread of COVID-19 within nursing homes. Adequate staffing ensures that infection control protocols are properly implemented and that

residents receive timely care, which can prevent the spread of the virus. High resident satisfaction often reflects better overall care quality and adherence to safety protocols, further protecting residents from infection. Buffering effect of nursing home quality is evident in these findings highlighting the importance of focusing on internal factors, such as staffing, infection control measures, and overall care quality in protecting residents from the threat of COVID-19.

Conversely, the finding that higher CMS Five-Star Overall ratings, particularly in the Health Inspection and Staffing domains, are associated with higher incidence rates among staff members is counterintuitive. This may be due to several factors: first, homes with higher quality ratings might be a reflection of more rigorous reporting and monitoring systems in place, leading to more accurate identification and reporting of staff cases, Second, better staffing ratings means more staff-resident interactions. In times of crisis, such as during the pandemic in which staffing shortage accelerates, higher-rated homes may be operating at full capacity with loss of staff and increased workloads for those still work for them, leading to higher exposure and infection rates. Targeted strategies to protect staff, especially in higher-rated facilities, and further research to understand the complex dynamics between quality ratings and infection risks are needed.

The study's finding that positive associations between neighborhood disadvantage of nursing homes and resident deaths remain even after controlling for nursing home quality, with no significant association found between nursing home quality measures (including CMS Five-Star ratings and resident and family satisfaction scores) and resident deaths. The continued association between neighborhood disadvantage and resident deaths suggests that broader socioeconomic factors play a substantial role in shaping health outcomes within nursing home populations. Factors such as poverty, limited access to health resources, environmental hazards, and social determinants of health prevalent in disadvantaged neighborhoods likely contribute to poorer health outcomes for residents. Additionally, residents in nursing homes located in disadvantaged neighborhoods may face compounding health challenges due to systemic inequities, which may exacerbate existing health conditions and increase the risk of mortality. Existing quality metrics, such as CMS Five Star ratings and satisfaction scores, may focus more on structural and procedural compliance and subjective satisfaction rather than directly capturing all aspects of health outcomes such as COIVD-19 mortality rates. These Quality measures may not fully capture the complexities of care quality that directly impact resident mortality, such as the effectiveness of medical interventions, staff competency in managing health emergencies,

and the overall health management strategies, which may especially challenging within nursing homes locate in under resourced communities.

In conclusion, the third aim of this study highlights the complex dynamics between neighborhood disadvantage, nursing home quality, and COVID-19 outcomes. The expectation that higher nursing home quality could offset the adverse effects of limited community resources on COVID-19 outcomes is not supported. Although neighborhood disadvantage levels do not significantly impact the number of cases among residents and staff after adjusting for various factors, higher staffing ratings and resident satisfaction are linked to reduced resident cases. Conversely, higher CMS Five-Star ratings, particularly in the Health Inspection and Staffing domains, are associated with increased staff cases. This underscores the importance of internal quality improvements to mitigate outbreak and transmission risks within nursing homes. Notably, nursing homes in disadvantaged neighborhoods experience significantly higher resident mortality rates, a risk unmitigated by quality measures such as CMS Five-Star ratings and Consumer Satisfaction scores. This persistent association points to broader socioeconomic factors affecting health outcomes and reveals limitations in current quality metrics in fully capturing care quality factors related to resident mortality. Targeted interventions and increased support for nursing homes in under-resourced communities are essential to addressing these disparities effectively.

Aim 4

The final aim of this study is to determine whether conventional non-spatial analysis approaches can appropriately assess the complex relationships between neighborhood disadvantage, nursing home quality, and COVID-19 outcomes, as explored in the previous three aims. Specifically, this aim evaluates whether spatial effects should be accounted for when analyzing these relationships.

When assessing the relationships between neighborhood disadvantage levels and nursing home quality, significant spatial effects are identified in all quality measures, including CMS Five-Star Ratings and Consumer Satisfaction scores. This indicates that the quality of nursing homes is not randomly distributed but rather exhibits discernible patterns based on geographic locations. Two plausible explanations for these findings emerge: first, the spatial clustering of quality may suggest that the measured and perceived performance of nursing homes is influenced by shared regional factors such as the availability of healthcare resources, local

healthcare infrastructure, environmental hazards, community support programs, community standards and expectations, and regional policies that impact clusters of nursing homes within specific areas. Second, proximity between nursing homes may facilitate spillover effects in quality; those situated near high-quality facilities may benefit from knowledge exchanges and operational strategies, leading to improved quality in certain geographic areas. Additionally, competition among nursing homes in close proximity could contribute to quality spillovers, as facilities strive to enhance their reputation to attract more customers, resulting in quality clustering.

Nursing homes located in disadvantaged neighborhoods already face challenges related to funding, staffing, and resource access, potentially placing them within lower-performing clusters. It is crucial for policymakers, providers, and other stakeholders to acknowledge the geographic disparity in quality, as this may exacerbate existing inequities. Without targeted interventions and additional support, low-performing nursing homes in disadvantaged neighborhoods may struggle to improve their quality and break the cycle of underperformance.

Notably, the disadvantage levels of neighborhoods housing nursing homes show no impact on quality performance after adjusting for organizational, resident, and community-level factors. These relationships persist even after accounting for spatial effects. Indeed, lower quality performance among providers in more socioeconomically disadvantaged neighborhoods may be explained by other factors including financial conditions (e.g., higher Medicaid payor-mix and occupancy rates), workforce challenges (e.g., reduced staffing and unstable leadership teams), and organizational and resident characteristics (e.g., for-profit ownership and higher minority resident percentages), as discussed in Aim 1.

Results from spatial regression models add nuances to our understanding of nursing home quality, particularly regarding the impacts of location rurality. Spatial analyses reveal that location rurality has varied effects on CMS and consumer perspectives of nursing home quality. Linear regression results indicate that nursing homes in non-metropolitan areas (including micropolitan and rural areas) generally exhibit lower ratings in the CMS perspective of quality, specifically in the Quality Measures and Staffing domains. In contrast, no significant differences in resident and family satisfaction scores are observed between homes in metropolitan and non-metropolitan areas after accounting for spatial relationships in the data.

The relationships between location rurality and CMS Overall ratings vary across different model specifications. Non-metropolitan homes show lower CMS Overall ratings in the linear and SAR models, but this difference is not statistically significant in models (SEM and SMA) that consider spatial relationships from omitted measures. Since the Overall rating is a composite measure of three domains, and location rurality consistently influences Quality Measures and Staffing domains across different analyses, it is essential to discuss the influences of geographic locales on these two domains to understand the inconsistent results regarding the relationship between location rurality and Overall rating across different spatial models.

Across regression analyses, nursing homes in micropolitan areas, characterized by smaller urban centers with populations typically between 10,000 and 49,999, are more likely to receive lower Quality Measures ratings compared to their metropolitan counterparts. Lower Quality Measures ratings among nursing homes in micropolitan areas may stem from increased post-acute admissions, as evidenced by bivariate results showing that micropolitan homes serve significantly more residents paid for by Medicare while having lower acuity index scores than their metropolitan counterparts. In recent years, there has been a trend of increased post-acute admissions in the nursing home industry to boost reimbursements. Metropolitan homes have historically maintained a steady stream of long-stay residents and a relatively higher proportion of short-stay residents, which might have better prepared them to deliver post-acute care (Bolin et al., 2006). Conversely, nursing homes in micropolitan areas may be new to post-acute care delivery and lag in fully mastering the provision of quality care to short-stay residents. Additionally, micropolitan homes are more likely to be located in disadvantaged neighborhoods, which may lack the robust infrastructure and healthcare resources available in larger cities, leading to challenges in meeting quality standards.

It's not surprising to find that nursing homes in small or isolated rural towns receive significantly lower ratings in the Staffing domain. This difference in staffing ratings between rural and metropolitan homes may be attributed to difficulties in attracting and retaining qualified staff, given the remote locations and limited socioeconomic resources available in rural settings (*Recruitment and Retention for Rural Health Facilities*, 2024). Furthermore, the smaller pool of job candidates resulting from lower (typically ranging from 2,500 to 9,999) and declining population density, coupled with competition from other providers and industries within this

limited pool, exacerbates the staffing challenges faced by rural nursing homes (Towsley et al., 2011).

Ratings in the Quality Measures domain among homes in rural communities, however, do not significantly differ from those in metropolitan areas. Unlike micropolitan homes, nursing homes in smaller or isolated rural areas may have recognized their limitations and maintained consistent admission strategies, ensuring a steady stream of long-stay residents. Nursing homes in these regions may have adapted to their unique circumstances and found ways to deliver quality care despite limited resources. Rural communities often have tight-knit networks that contribute to the overall well-being of residents in nursing homes. Nurses in rural communities often cultivate friend-like relationships with their patients and engage in broader social networks, potentially leading to more person-centered care compared to providers in other locations (Gillham et al., 2021). Thus, no significant differences are observed in resident outcomes among rural homes, even if they have lower staffing ratings than their metropolitan counterparts. The divergent performances in the Quality Measures and Staffing domains of micropolitan and rural homes could explain the inconsistent results regarding the relationship between location rurality and Overall ratings across analyses. These findings underscore the importance of addressing specific quality issues in each setting rather than assuming a linear continuum for location rurality.

In terms of consumer perspectives of quality, discrepancies identified between the results of linear regression and spatial models regarding resident and family satisfaction scores in rural nursing homes compared to metropolitan ones raise interesting questions about the underlying factors at play. In linear regression analysis, rural nursing homes are found to have higher resident and family satisfaction scores compared to their metropolitan counterparts. This finding aligns with the perception that homes located in isolated small rural towns, often within tight-knit communities and smaller in size, may facilitate less impersonal staff-resident and staff-family interactions, offer more person-centered care, and feature less institutional design(Lucas et al., 2007; Madrigal et al., 2023; Tornatore & Grant, 2024). Consequently, residents and families in rural areas may perceive these homes as providing a more comfortable and favorable environment than those in urban areas.

However, the lack of significance in the spatial models indicates that the relationship between location rurality and satisfaction scores is not consistent across different geographic

areas. This suggests that while rural nursing homes may generally perform well in terms of resident and family satisfaction, there are variations within rural areas that traditional non-spatial models do not capture. These findings have several implications.

First, they highlight the importance of considering spatial dependencies and geographic variations when studying nursing home quality. Traditional non-spatial models might not fully capture factors that influence satisfaction among residents and family members, as these factors may be spatially correlated. For instance, positive spatial dependency is identified in the SAR models for both resident and family satisfaction scores, suggesting that the satisfaction scores of nursing homes are affected by their neighbors' scores, possibly through competition or knowledge spillovers rather than the rurality of the geographic location. Additionally, results from SEM and SMA suggest that factors omitted in this study could also affect the relationship between rural location and satisfaction scores. Local demographics, community resources, the built environment of nursing homes, and regional healthcare systems and policies may influence residents' and families' satisfaction with nursing homes in ways that traditional regression models do not capture.

Second, the discrepancy between linear regression and spatial models underscores the need for further research to understand the underlying mechanisms driving satisfaction scores in rural nursing homes. Qualitative studies or mixed-method approaches could provide insights into the unique features of rural communities that contribute to resident and family satisfaction.

Overall, these findings suggest that while rural nursing homes may generally perform well in terms of resident and family satisfaction, the relationship between location rurality and satisfaction scores is complex and context-dependent. Further research is needed to unpack these complexities and inform efforts to improve nursing home quality in rural areas.

Spatial analyses reveal several factors considered more or less important in influencing nursing home quality performance in linear regressions, such as Medicare payor-mix, ownership type, and the use of agency CNAs. While neighborhood disadvantage—the key predictor—remains not significantly associated with nursing home quality performance, this study utilizes multiple measures from diverse data sources collected over different time periods specific to Ohio. Other studies examining different factors, locations, or time frames may find spatial effects influencing their results related to nursing home quality. Furthermore, AIC values for models estimating all quality measures generally decrease by more than 10, indicating significant

improvements in model fit when spatial effects are considered (Rao, 2015). These findings underscore the importance of employing spatial regression analyses to effectively account for potential underlying spatial processes, ultimately yielding more accurate results, especially when evaluating quality performance in nursing homes.

When assessing the impact of neighborhood disadvantage on COVID-19 outcomes and the role of nursing home quality in these relationships, modest spatial effects are identified in COVID-19 cases among residents during the pre-vaccination period. Higher numbers of COVID-19 cases in one nursing home could potentially affect neighboring nursing homes due to several factors. First, nursing homes located near each other often share the same local community. Residents, staff, and visitors from the same geographic area can contribute to virus spread. High infection rates in one nursing home might reflect a broader community outbreak, increasing the likelihood that neighboring nursing homes will also experience high infection rates due to shared community transmission dynamics. Despite controlling for county-level infection rates, spatial effects remained significant in resident cases during the pre-vaccination period, suggesting that virus transmission does not necessarily follow administrative borders. This underscores the importance of spatial analyses when studying public health issues, especially transmissible diseases.

Second, multi-facility employment might contribute to clustering of nursing homes with high resident incidence rates. During the pre-vaccination period, it was common for staff members and agency nurses to work at multiple nursing homes, either simultaneously or consecutively. One study revealed that 5% of shared staff and contractors entered more than one nursing home over an 11-week period following a federal visitor ban, with multi-facility employment predictive of COVID-19 cases in nursing homes (Chen et al., 2021). The movement of staff and contractors between facilities could facilitate virus spread from one nursing home to another. Similarly, external providers such as food suppliers, medical equipment vendors, and maintenance workers often serve multiple nursing homes in a region, potentially contributing to virus transmission between facilities.

Third, variations in adherence to public health measures (e.g., hygiene protocols, testing strategies) among neighboring nursing homes can lead to differences in infection rates. If one home has lax protocols, it might not only introduce transmission risk to the surrounding community but also influence nearby homes to adopt similar strategies. During the early stages

of the pandemic, response times to outbreaks were often slow due to limited testing and contact tracing capabilities, as well as limited knowledge of infection control measures. This delay allowed the virus to spread more easily between neighboring facilities.

Last, infrastructure and environmental factors might also contribute to hotspots of high resident incidence rates similar to those in nearby nursing homes. For example, certain heating, ventilation, and air conditioning (HVAC) systems might be widely used in nursing homes in the same area, influencing the spread of airborne viruses. Local environmental factors such as population density, age composition, and public transportation networks can also affect how easily the virus spreads between neighboring nursing homes.

In summary, the spatial effects of COVID-19 cases among residents during the pre-vaccination period highlights the importance of considering elevated risks of COVID-19 outbreak in one nursing homes and their neighbors when designing policies to mitigate the risk of virus spreading, especially during the early stage of a pandemic when knowledge about the disease is limited.

No spatial effect is identified in resident mortality rates and staff incidence rates, as opposed to the observed spatial effects in resident COVID-19 cases during the pre-vaccination period. During the pre-vaccination period, the overall vulnerability to COVID-19 was higher, leading to more pronounced geographic patterns of spread as the virus moved through communities and into nursing homes. As time progressed, with the introduction of vaccines and the establishment and widespread implementation of effective infection control measures within nursing homes, the severity of cases among residents reduced, making spatial patterns less pronounced over the entire pandemic period. The absence of spatial effects in resident mortality rates and staff incidence rates highlights that the driving factors for high staff cases and resident deaths in nursing homes are not related to geographic proximity. Instead, other factors such as individual nursing home characteristics, effective containment and control measures, and resident health conditions may be more important to these outcomes. This suggests that while geographic clustering can influence the spread of infections, the severity and management of cases among staff members depend more on the specific conditions and practices within each nursing home.

The last aim of this study, employing spatial analyses, offers a deeper understanding of the relationships between neighborhood disadvantage, nursing home quality, and COVID-19

outcomes. By identifying significant spatial effects across various quality measures, such as CMS Five-Star Ratings and Consumer Satisfaction scores, the study reveals that nursing home quality is not randomly distributed but follows geographic patterns. Factors like shared regional resources and proximity-driven knowledge exchanges and competition might contribute to this spatial clustering of quality. These findings highlight the need for policymakers to consider geographic disparities in quality when implementing interventions, especially in disadvantaged areas where nursing homes already face challenges related to funding, staffing, and resources. While neighborhood disadvantage was not directly associated with quality performance, spatial analyses provided nuanced insights into the effects of rurality and other nursing home characteristics. Additionally, modest spatial effects were found in COVID-19 cases during the pre-vaccination period, underscoring the importance of considering spatial dynamics in public health responses. Overall, the aim demonstrates the value of spatial regression models in capturing complex relationships and improving the accuracy of assessments in nursing home quality and COVID-19 outcomes.

Implications

Findings from this study have important implications for policy, practice, and research.

For policy

One of the major findings from this study is that nursing homes in more disadvantaged neighborhoods are at increased risk of COVID-19 deaths among residents, throughout the pandemic. Disparity in nursing homes might be a reflection of disparity observed in incidence rates among poor communities where resources are relatively limited which impacts one's health. Nursing homes located in more disadvantaged neighborhoods tend to struggle with maintaining adequate staffing and high-quality care, which are suggested to reduce the risk of virus transmission in the findings. However, even after accounting for care quality and staffing and other characteristics, there is still a disparity of COIVD-19 deaths among residents in these nursing homes. Policymakers may want to provide additional resources to support these nursing homes protecting their vulnerable residents. Such resources could include prevention, testing, and treatment supplies of COVID-19 or additional fundings that allows them to improve their care quality and support staffing.

This study finds that the lower care quality and staffing levels observed in more disadvantaged neighborhoods are largely explained by the extent to which facilities rely on

Medicaid payments and other organizational factors. Policymakers should consider providing direct incentives to nursing homes in these areas to invest in care quality and improve recruitment and workforce stability. One policy incentive could involve requiring providers to allocate a specific proportion of their revenues to care and staffing. Such requirements have been implemented in several states. In Ohio, for example, a law previously required facilities to use 70% of additional rebasing funds for direct care, though it has recently been repealed. However, this strategy should be practiced with caution, as it will not achieve its intended effect if facilities cannot cover their operational costs. Offering competitive Medicaid reimbursement rates should be a prerequisite for federal or state regulators implementing any similar intervention. This is particularly important for homes in disadvantaged neighborhoods, where any reduction in revenue could be detrimental to both the facility and the residents they serve. Ensuring that these facilities are financially sustainable is crucial for maintaining and improving the quality of care and protecting the health of their vulnerable residents.

Another strategy could involve direct financial support, such as enhanced Medicaid payments, from federal and state payers or other interventions aimed at improving staffing and care in nursing homes located in disadvantaged neighborhoods. One potential tool to facilitate this strategy is the Area Deprivation Index (ADI), a socioeconomic indicator for small areas. The ADI can be used to identify nursing homes with the greatest COVID-19 or staffing disparities and allocate resources or implement policy interventions accordingly. This targeted approach could be more cost-effective and efficient than strategies based on larger geographic areas, particularly in urban core areas where wealthy and disadvantaged neighborhoods are in close proximity. Additionally, using explicit race-based allocation strategies might be challenging under the current political climate. Instead, employing a geographic indicator like the ADI could be a legally safer and effective strategy to address disparities in these areas. This approach allows policymakers to address systemic inequalities without directly invoking race, thereby navigating potential legal and political obstacles while still targeting resources to the areas most in need (Schmidt et al., 2020). .

This study underscores the significant impact of staffing on nursing home care quality and residents' health outcomes, highlighting the need for sustained efforts to address chronic staffing challenges. With CMS’s final minimum staffing mandate issued in 2024, federal and state regulators should closely monitor how these requirements affect facilities in disadvantaged

neighborhoods(Medicare and Medicaid Programs; Minimum Staffing Standards for LongTerm Care Facilities and Medicaid Institutional Payment Transparency Reporting, 2024). Given the spatial clustering in staffing performance identified in this study, it is crucial to ensure these mandates do not inadvertently widen staffing disparities by placing additional pressure on already strained facilities, which could reduce their care delivery capacity and risk creating a cycle of underperformance.

Beyond the minimum staffing mandate, federal and state agencies should keep exploring solutions to alleviate the nursing home workforce shortage, making hiring additional nursing staff possible. This might include educating and training more new nurses, immigration policy to encourage foreign workers working in nursing homes and increase the volume of available nursing staff in the nation. Meanwhile, efforts of improving working conditions encouraging more nursing staff commitment to working in the nursing homes especially in disadvantaged areas are needed.

For practice

This study finds that the impact of COVID-19 on residents and staff is largely explained by community level transmission outside the nursing home. Additionally, spatial dependency is found in resident cases during the pre-vaccination period further highlighting the importance of addressing community-level transmission. Nursing home providers may want to collaborate closely with local public health agencies, hospitals, and community organizations to monitor and manage community-level transmission. By participating in community health initiatives and sharing information with other parties, nursing homes can stay informed about local COVID-19 trends and implement timely preventative measures. Additionally, nursing homes may want to continuously refine their infection control protocols and educate the importance of these protocols to staff and residents. Staff members who provide day-to-day care for residents and interact with the broader community should be provided with education about the risks of community transmission and be educated about behaviors that minimize exposure outside of work. Nursing homes may also want to provide resources and support, such as PPE for off-duty use and guidance on safe practices, to reduce the likelihood of staff bringing the virus into their facilities. The impacts of community transmission risks on residents' cases and deaths disappear in the two-year pandemic period underscore the importance of promoting high vaccination rates among staff, residents and their families. Providers may want to facilitate access to vaccines and

booster shots, organize on-site vaccination clinics, and provide education about the benefits and safety of vaccines to increase uptake. Higher resident satisfaction scores are associated with decreased resident cases reflecting the importance of communicating. Providers may want to maintain open lines of communication with residents, families, and staff about the risks of community transmission and the steps being taken to mitigate these risks. Transparency fosters trust and ensures that everyone involved is aware of the ongoing efforts to protect health and safety.

Providers should prioritize investment in staff development to provide better care quality and protect their residents from getting infected with virus, especially for those in disadvantaged areas whose residents are more vulnerable to this disease. Providers in disadvantaged and minority communities often use relatively more LPNs than RNs possibly due to financial reasons, which might undermine care quality. Nursing homes in disadvantaged neighborhoods might want to ensure that LPNs are effectively integrated into the care team, working under the supervision of RNs and within their scope of practice. This collaboration can optimize the use of LPNs while ensuring high standards of care are maintained. In the case of this study, all nursing staff members are very important to reduce the likelihood of resident cases. Improvement in the ability of recruitment and retention are still vital to providers in disadvantaged areas. Additionally, providers in disadvantaged areas could create career ladders systems for CNAs, LPNs, and RNs to improve care practice, increase job satisfaction, and decrease turnovers, and increase retention in the facilities (Coogle et al., 2011; Hunt et al., 2012; Pillemer et al., 2008).

It is important to note that this study's findings are based on facility-level aggregated data and do not reflect individual risks for residents or specific nursing homes. The strengths of individual facilities, as well as the social, economic, and health conditions of residents, can vary significantly even within disadvantaged neighborhoods. Residents and their families should not assume that a nursing home’s location in a disadvantaged area automatically indicates a higher COVID-19 mortality risk.

Families should recognize that nursing homes in these areas may serve residents with a higher prevalence of underlying health issues, which can affect outcomes. When selecting a facility, families can make informed decisions by choosing homes that provide specialized or enhanced care for those with complex needs. Consumer satisfaction scores are also helpful, offering insights into resident experiences and family perceptions of care quality. High

satisfaction scores often indicate good communication, active resident engagement, and a supportive environment.

Families are encouraged to ask about staff-to-resident ratios, infection control measures, COVID-19 protocols, and the facility's response during previous outbreaks to understand how well the nursing home manages health risks. Additionally, scheduling a tour can provide valuable insights, such as observing staff-resident interactions, assessing the condition of current residents, and evaluating the built environment, helping families determine whether a nursing home is the right fit for their loved ones.

For research

Although the impact of geographic socioeconomic factors is well-recognized in long-term care research, very few studies have examined their effects at smaller areas, such as neighborhoods or census-tract groups (Falvey et al., 2022). Interventions or support for nursing homes seldom occur at this localized level, even though it could be a more cost-effective approach. More research on the associations between small-area socioeconomic status and nursing home performance and resident outcomes is needed to provide empirical evidence for targeted interventions. The disparity in nursing home COVID-19 deaths found in this study suggests a need for more data at smaller geographic areas to be collected and made available for researchers to uncover the underlying mechanisms and inform targeted interventions. For example, neighborhood socioeconomic contexts influence health literacy and behaviors of individuals, ultimately impacting the health of the community (Knighton et al., 2017; Warren Andersen et al., 2018). In the context of this study, disadvantaged neighborhoods may not have high rates of mask-wearing, handwashing, or vaccine uptake due to lower health literacy, leading to higher incidence rates in the communities. The risk of COVID-19 outbreaks in nursing homes arises as staff or external providers who interact with the broader community could bring the virus into the facilities. By collecting and analyzing data at these smaller geographic levels, researchers can better understand these dynamics and develop interventions tailored to the specific needs of disadvantaged neighborhoods, thereby reducing health disparities and improving outcomes in nursing homes.

Future directions

Future research should delve deeper into understanding why nursing homes in more disadvantaged areas exhibit higher resident COVID-19 mortality rates despite not showing

significantly different COVID-19 morbidity rates among residents and staff compared to other areas. There are some directions that future research might want to consider. First, future studies might want to investigate underlying factors contributing to higher mortality rates in disadvantaged areas. This might include underlying pre-exiting health conditions such as cognitive impairments, immunodeficiency, and end-stage kidney disease which are suggested in previous literature that significantly associated with COVID-19 mortality for nursing home residents (Wolff et al., 2021). Another potential explanation for increased mortality in these areas is that nursing homes in disadvantaged areas may have limited capacity of testing leading to absence of diagnosis and delayed treatments. Future research, therefore, might also want to investigate access to testing and the quality of testing practices (e.g., intensity, timeliness, accuracy) and how they affect resident mortality in disadvantaged areas. Understanding disparities in testing availability, frequency, and accuracy could reveal critical gaps contributing to higher mortality rates.

Nursing home prior Health Inspection ratings are not associated with a reduced risk of COVID-19 incidence rates, which aligns with the notion that infection control deficiencies are widespread but rarely enforced before the pandemic (Government Accountability Office, 2020). With the new guidance on infection control practices and enhanced enforcement actions from state survey agencies and CMS locations in place, it is expected that Health Inspection ratings will be more effective in determining nursing home performance in protecting residents from the threat of COVID-19 (Centers for Medicare & Medicaid Services, 2023). Future research might want to continue to explore the impacts of CMS Five-Star rating performance on COVID-19 outcomes including both morbidity and mortality, especially in disadvantaged neighborhoods. Specifically, researchers might want to know whether high CMS ratings could help to mitigate the heightened risk of resident mortality among nursing homes in disadvantaged areas under the new guidelines and enforcement practices. This continued investigation can help assess the effectiveness of recent policy changes and guide further improvements in infection control practices and enforcement to better protect vulnerable populations in nursing homes.

A qualitative or mixed approach might also be of interest for future research to understand the relationships between neighborhood disadvantage and COVID-19 outcomes. In-depth interviews with staff and administrators in disadvantaged areas can explore their perceptions and experiences related to COVID-19 management to provide insights into the

facilitators and barriers they have. Case studies of nursing homes in disadvantaged neighborhoods with varying COVID-19 outcomes could identify the best practices and common pitfalls suitable for disadvantaged providers.

Finally, the COVID-19 pandemic has had a profound impact on the national economy, particularly affecting disadvantaged neighborhoods. These areas have seen heightened closures of retail stores, restaurants, and educational and recreational services (Motoyama, 2022). As operational costs continue to escalate during the pandemic, nursing homes in these areas not only confront increased financial strain and the threat of closure, but also navigate more challenging socioeconomic environments. Future research could explore how shifts in neighborhood disadvantage levels influence nursing home care quality and resident outcomes.

Using different specifications of spatial models, spatial effects are found in all nursing home quality measures in this study and resident cases during the pre-vaccination period. Future study might want to address mechanisms under these spatial effects. Future study should further explore spatial dependency found within CMS quality and COVID-19 outcomes among nursing homes. Neighboring nursing homes are defined as those within Euclidean distances of 0.5, which is the smallest distance that can be computed using SAS procedures and is sufficient to capture the spatial dependency in the data. Future research might want to use physical distance for more intuitive interpretations.

More importantly, understanding why a Euclidean distance of 0.5 best facilitates spillover effects or captures spatially correlated omitted measures is crucial. Is this distance optimal for facilitating knowledge or competition spillovers in terms of quality and the increased transmission risk of COVID-19 among Ohio nursing homes? Hospital literature suggests that knowledge and competition spillovers for treatment rates are stronger for more acute diseases, with neighboring providers often defined at larger distances (Baltagi & Yen, 2014). Therefore, future research should examine various distances to determine their impact on different quality and health outcomes.

Specifically, future research could consider examining different distances to determine the optimal range for spillovers in nursing home settings to provide insights into how far influences from high-quality homes extend and affect neighboring homes. Additionally, assessing how different definitions of neighboring facilities (based on distance) impact the effectiveness of policies aimed at improving quality and health outcomes in nursing homes can

help guide policymakers in designing interventions that leverage spatial dynamics effectively. Moreover, different aspects of nursing home performance may be influenced by spatial factors over varying distances. Researchers might also want to investigate whether the optimal distance for spillovers varies based on the type of outcomes measured, such as quality of care (e.g., complaints, fines, infection control deficiencies) and health outcomes (e.g., influenza). Comparative studies across different states or regions might be also needed to determine whether the findings in Ohio hold true elsewhere or if the observed spatial effects are consistent across different geographic and healthcare landscapes. Meanwhile, exploring how physical distance interacts with other factors such as community socioeconomic status, rural location, staffing shortages, and community minority density would provide a more comprehensive understanding of the factors influencing spatial dependencies in nursing home quality and outcomes. By addressing these questions, future research can provide more detailed and actionable insights into the spatial dynamics affecting nursing home performance, ultimately leading to more effective policies and improved care for residents.

Limitation

There are several limitations in this study that need to be acknowledged. First, the study focuses on nursing homes in Ohio, which may limit the generalizability of the findings to other states with different demographic, socioeconomic, and healthcare system characteristics. Second, nursing home characteristics and quality measures included in this study rely on data collected before the pandemic. The COVID-19 pandemic has had profound effects on nursing homes including changes in infection control practices, staffing levels, resident demographics, operation costs, and care quality. Data collected before the pandemic may not reflect these changes accurately, leading to the impacts of neighborhood disadvantage on nursing home quality and COVID-19 outcomes being underestimated in this study. Third, the measures of COVID-19 outcomes in this study are based on facility-reported data. While CMS performs quality assurance on the submitted data, research suggests that federal data might undercount cases and deaths in nursing homes (Shen et al., 2021). Additionally, high-quality nursing homes may have greater capacity for testing, leading to more accurate reporting. Conversely, the availability and frequency of testing and diagnosis may be more limited for nursing homes in disadvantaged neighborhoods. As a result, the impacts of neighborhood disadvantage levels and quality on COVID-19 outcomes in nursing homes may be underestimated. Fourth, because of the cross-

sectional design of this study, no causal inference is determined in this study. Fifth, the resident-level data obtained from LTCfocus has limitations, including a potentially large number of missing values. This study focuses on demographic and health characteristics that are likely correlated with increased risk of COVID-19 outcomes, employing multiple imputation techniques to best preserve the sample size and address missing data challenges.

Conclusion

The COVID-19 pandemic has starkly exposed vulnerabilities within the healthcare system, with nursing homes in under-resourced communities particularly impacted. Numerous studies have linked community socioeconomic status to both care quality and COVID-19 outcomes in these settings, often suggesting that nursing homes in disadvantaged neighborhoods provide suboptimal quality, resulting in poorer health outcomes for residents. However, it remains unclear whether high-quality nursing homes can effectively reduce these health disparities. Additionally, conventional long-term care research often overlooks spatial relationships, potentially introducing bias into findings. While COVID-19 no longer poses the same level of threat as it did initially, it is unlikely to be the last health crisis to challenge nursing homes and other long-term care settings. Understanding these dynamics is essential to building resilience against future health emergencies.

This study explores the complex relationships among neighborhood disadvantage, care quality, and COVID-19 outcomes in Ohio nursing homes, examining the potential influence of spatial relationships. Although nursing homes in more disadvantaged areas generally exhibit lower quality performance, these quality metrics do not show significant associations with neighborhood socioeconomic status after adjusting for organizational factors and resident characteristics. Instead, high-quality performance is attributed to factors like stronger financial health (e.g., Medicaid payor mix, occupancy rates), stable in-house staffing (e.g., RN hours per resident day, minimal agency RN use), consistent leadership (e.g., low turnover among Nursing Home Administrators), as well as organizational traits (e.g., for-profit ownership, smaller facility size) and resident demographics (e.g., lower proportions of minority residents).

The study also reveals persistently high resident mortality risks in nursing homes located in more disadvantaged neighborhoods, which remain unmitigated by any quality performance indicators examined. Interestingly, COVID-19 incidence rates among residents and staff show no significant associations with neighborhood socioeconomic status. However, higher CMS Five-

Star Staffing ratings and resident satisfaction scores significantly lower resident COVID-19 incidence rates over the two-year pandemic period, whereas higher CMS Five-Star Overall, Health Inspection, and Staffing ratings are linked to increased staff COVID-19 incidence rates. COVID-19 outcomes, including both staff and resident morbidity and resident mortality, are influenced not only by community incidence rates but also by various organizational and resident-level characteristics.

Significant spatial effects are identified across quality measures, including CMS Five-Star Overall, Health Inspection, Quality Measure, and Staffing ratings, as well as resident and family satisfaction scores. While neighborhood disadvantage is not directly associated with quality performance, spatial analyses offer nuanced insights into the effects of rurality and other nursing home characteristics (e.g., NHA turnover, ownership type, chain affiliation). Modest spatial effects are also found in resident COVID-19 cases during the pre-vaccination period, underscoring the importance of spatial dynamics in public health responses.

These findings highlight the complex nature of healthcare disparities in nursing homes, illuminating the nuanced relationships between neighborhood disadvantage, quality performance, and COVID-19 outcomes. Addressing these disparities requires targeted interventions that consider the intricate interdependencies within nursing home settings, with the goal of improving care quality and health outcomes for vulnerable residents and staff. Policymakers and researchers should consider spatial analysis approaches when developing such interventions, as overlooking spatial dynamics could lead to ineffective solutions.

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Appendix A.

Table A. 1. Domains and Items for the 2017 Ohio Nursing Home Resident Satisfaction Survey and 2018 Ohio Nursing Home Family Satisfaction Survey

Resident Satisfaction Survey	Family Satisfaction Survey
Moving In	
Do you remember what it was like when you first moved in here?	When the resident moved in, were you given thorough information to help you know what to expect?
Were you given enough help to learn how things are done here?	Was the resident given a thorough orientation to the nursing home?
Did you feel warmly welcomed as a new resident?	Did you feel warmly welcomed as a new family member?
Spending Time	
Do you usually enjoy how you spend your time?	
Do you usually have something enjoyable to look forward to every day?	Does the resident have something enjoyable to look forward to most days?
Do the staff do a good job keeping you connected to the community?	Do the staff do a good job keeping the resident connected to the community?
Are you given plenty of opportunities to do things that are meaningful to you?	Does the resident have plenty of opportunities to do things that are meaningful to them?
Do you like the provided activities?	Does the resident like the provided activities?
Do you spend too much time waiting for things?	
Does the nursing home provide things to do on the weekend that you enjoy?	Does the facility provide things the resident enjoys doing on the weekend?
	Do you have plenty of opportunities to be involved in the nursing home?
Care and Services	
Does the staff give you enough time to do things you want to do for yourself?	
Are your preferences about daily routines carried out?	Are the resident's preferences about daily routine carried out?
	Do you have enough opportunities for input into decisions about your resident's care?
	Do you get enough information to make decisions with or about your resident?
Have you gotten or are you getting special therapies, like physical therapy, occupational therapy or speech therapy, while living at this nursing home?	
Did the therapists help you set goals?	
Did the therapy help you meet your goals?	

Did (Do) you know who to speak to about your therapy progress?	
Caregivers	
Do you feel confident the staff is knowledgeable about your medical conditions and treatments?	Do you feel confident the staff is knowledgeable about the resident's medical condition(s) and treatment(s)?
Do the staff know what you like and don't like?	Do the staff know what the resident likes and doesn't like?
Do the staff regularly check on you to see if you need anything?	Do the staff regularly check to see if the resident needs anything?
Do the people who care for you treat you gently?	
	Have you gotten to know the staff who care for your resident?
Do the people who care for you do things the way you want them done?	
Does the staff come quickly anytime you call or ask for help?	Does staff come quickly anytime your resident needs help?
Do the staff ever get angry with you?	
Do the people who care for you explain your care and services to you?	
Do the same people take care of you most of the time?	
Meals and Dining	
Can you get the foods you like?	
Is there a lot of variety in the meals?	Is there a lot of variety in the meals?
Do you have input into the food that is served?	
	Are you included in mealtimes if you want to be?
Do they serve really good food here?	Is the food good?
Do you look forward to mealtimes?	
Environment	
Is it thoroughly clean here?	Is the nursing home thoroughly clean?
Can you enjoy the outdoors when you want to?	Can the resident get outside often enough?
Is there enough space for you to get around in your room?	
Are your belongings safe?	Are the resident's belongings safe?
Do you feel safe and secure?	
Do you feel that you have enough privacy?	Do you have a good place to visit privately?
Can you find a place to be alone when you want to be alone?	
Facility Culture	

Are you encouraged to speak up when you have a problem?	Are you encouraged to speak up when you have a problem?
Are your concerns addressed in a timely way?	Are your concerns addressed in a timely way?
Are you engaged in decisions about your care?	
	Are you kept well informed about how things are going with your resident?
Do the staff seem happy to work here?	Do the staff seem happy to work at the nursing home?
Do the people who work here know who you are as a person?	
Do the people who work here go above and beyond to give you a good life?	Do the staff go above and beyond to give your resident a good life?
	Do you feel confident that staff would help your resident beyond their personal care needs if you could not?
Do you feel included in life here?	
	Do you have peace of mind about the care your resident is getting when you aren't at the nursing home?
Do you think of anyone who lives here as a friend?	
Would you highly recommend this nursing home to a family member or friend?	Would you highly recommend this care facility to a family member or friend?

Appendix B.

Table B. 1. Missing Values on Measures in This Study by Data Source

Data Source	Measures	Specifications	Total NHs N=859 Missing N (%)
CMS Nursing Home COVID-19 Public File	Pre-vaccination monthly resident COVID-19 cases per 100 beds	The average number of residents with laboratory positive COVID-19 per 100 beds between 5/24/2020 and 01/31/2021 as reported by the provider each month	0
	Pre-vaccination monthly resident COVID-19 related deaths per 100 beds	The average number of residents with suspected or laboratory positive COVID-19 who died in the facility or another location per 100 beds between 5/24/2020 and 01/31/2021 as reported by the provider each month	0
	Pre-vaccination monthly staff COVID-19 cases per 100 beds	The average number of staff and facility personnel with laboratory positive COVID-19 per 100 beds between 5/24/2020 and 01/31/2021 as reported by the provider each month	0
	Two-year pandemic monthly resident COVID-19 cases per 100 beds	The average number of residents with laboratory positive COVID-19 per 100 beds between 5/24/2020 and 01/30/2022 as reported by the provider each month	0
	Two-year pandemic monthly resident	The average number of residents with suspected	0

	COVID-19 related deaths per 100 beds	or laboratory positive COVID-19 who died in the facility or another location per 100 beds between 5/24/2020 and 01/30/2022 as reported by the provider each month	
	Two-year pandemic monthly staff COVID-19 cases per 100 beds	The average number of staff and facility personnel with laboratory positive COVID-19 per 100 beds between 5/24/2020 and 01/30/2022 as reported by the provider each month	0
2019 Payroll-Based Journal (PBJ)	Any agency RN	Whether the provider uses any agency RN. (yes/no)	10 (1.16)
	Any agency LPN	Whether the provider uses any agency LPN.(yes/no)	10 (1.16)
	Any agency CNA	Whether the provider uses any agency CAN (yes/no).	10 (1.16)
Dec. of 2019 monthly Nursing Home Compare archive provider data	RN HPRD	Reported RN staffing-(hours per resident per day)	15 (1.75)
	LPN HPRD	Reported LPN staffing-(hours per resident per day)	15 (1.75)
	CNA HPRD	Reported CNA staffing-(hours per resident per day)	15 (1.75)
	Ownership type	Not-for-profit/government-owned; for-profit	1 (0.12)

	Facility size	Number of federally certified beds	0 (0.00)
	CCRC	Whether the provider is part of a CCRC (yes/no)	3 (0.35)
	Occupancy rate	Percentage of beds that are filled by residents	23 (2.68)
	Overall rating	1-5	10 (1.16)
	Health inspection rating	1-5	10 (1.16)
	Staffing rating	1-5	10 (1.16)
	Quality measure rating	1-5	10 (1.16)
2017 Biennial Survey	NHA turnover	Had more than one NHA between 2015 and 2017 (had turnover	119 (13.85)
	DON turnover	Had more than one DON between 2015 and 2017 (had turnover/ had no turnover)	120 (13.97)
	LPN/RN retention	Percentage of RNs remaining in that same position between the first and last payroll periods in 2017	162 (18.86)
	CNA retention	Percentage of CNAs remaining in that same position between the first and last payroll periods in 2017	162 (18.86)
RUCA data	Location rurality	Metropolitan area/ Micropolitan/ Smaller isolated small rural town	0 (0.00)
2017 Ohio Nursing Home Resident Satisfaction Survey	Overall resident satisfaction	0-100	18 (2.10)
2018 Ohio Nursing Home Family Satisfaction Survey	Overall family satisfaction	0-100	42 (4.89)
2019 LTCFoucs facility data	Medicare %	Percentage of residents who are primarily paid for by Medicare	56 (6.52)

	Medicaid %	Percentage of residents who are primarily paid for by Medicaid	56 (6.52)
	Chain affiliation	Whether the provider is part of a chains? (Yes/No)	56 (6.52)
	Dementia care unit	Whether or not facility has an Alzheimer's disease Special Care Unit (SCU) (Yes/No)	56 (6.52)
	Other care unit	Whether or not facility has any Special Care Unit (SCU) (excluding Ventilator Units	56 (6.52)
	Average Acuity Index	The care needed by a nursing home's residents (Special treatment + Activities of daily living)	56 (6.52)
	Minority Residents %	Percentage of residents that are racial/ethnic minority (African Americans, Hispanics, Asians or Pacific Islanders, and American Indians or Alaskan Natives)	71 (8.27)
	Hypertension Residents %	Percentage of residents who have hypertension	61 (7.10)
	Obese Residents %	Percentage of residents who have a body mass index (BMI) of 35 or higher	144 (16.76)
	Congestive Heart Failure Residents%	Percentage of residents who have congestive heart failure	264 (30.73)
	65 or Older Residents %	Percentage of residents who are 65 or older	204 (23.75)
USA Facts	Pre-vaccination community infection rate	The number of confirmed Covid-19 cases per 100,000 people in a county between	1 (0.12)

		05/24/2020 and 01/31/2021.	
	Two-year pandemic infection rate	The number of confirmed Covid-19 cases per 100,000 people in a county between 05/24/2020 and 01/30/2022.	1 (0.12)
Neighborhood Altas	Neighborhood disadvantage	ADI nation Percentile (1-100)	15 (0.01)

Table B. 2. Logistic Regression Results of Missingness on Measures

	Missingness of														
	65 or Older Residents %			NHA turnover			DON turnover			LPN/RN retention			CNA retention		
	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
Neighborhood SES Disadvantage (National ADI rank)	1.010*	1.001	1.019	.985	.936	1.036	1.007	.998	1.016	1.004	.996	1.012	1.005	.997	1.013
Organizational Enabling Factors															
Medicare %	.984	.967	1.001	1.132	.904	1.418	1.056	1.019	1.094	1.047**	1.016	1.078	1.058***	1.026	1.092
Medicaid %	1.019***	1.010	1.028	.998	.950	1.049	.990	.979	1.001	.992	.983	1.002	.989*	0.980	.999
Occupancy rate	.991	.975	1.007	1.006	.933	1.084	1.025***	1.011	1.039	1.019**	1.006	1.032	1.020**	1.007	1.033
RN HPRD	.425**	.246	.736	.961	.071	13.045	2.356*	1.052	5.277	2.438*	1.203	4.942	2.527*	1.239	5.154
LPN HPRD	.873	.431	1.769	16.284	.369	718.593	.572	.284	1.152	0.579	.311	1.077	.597	.320	1.111
CNA HPRD	.204***	.131	.319	2.945	.233	37.280	4.237***	2.350	7.642	4.205***	2.498	7.079	4.395***	2.598	7.435
NHA turnover (ref = No turnover)															
Has turnover	2.841***	1.931	4.180	.967	.934	1.001	.826	.137	4.974	1.870	.935	3.739	.457*	.224	.932
DON turnover (ref = No turnover)															
Has turnover	.679	.461	1.000	.167	.017	1.611				1.572	.782	3.159	.541	.264	1.110
LPN/RN retention	.990*	.980	.999	.967	.934	1.001	.975	.935	1.018				1.021	.994	1.048
CNA retention	.987	.977	.998	.939**	.896	.984	.959	.916	1.003	.959*	.929	.990			
Any agency RN (ref=No)															
Yes	.589	.388	.895	.593	.061	5.736	1.298	.854	1.975	0.852	.319	4.306	.913	.635	1.311
Any agency LPN (ref=No)															
Yes	.949	.629	1.431	.758	.078	7.326	.878	.571	1.351	.917	.628	1.339	1.051	.721	1.532
Any agency CNA (ref=No)															
Yes	1.536*	1.042	2.264	2.054	.287	14.674	1.044	.689	1.581	1.046	.727	1.505	.924	.643	1.328
Facility size	1.021***	1.014	1.027	1.001	.977	1.026	1.001	.996	1.006	1.000	.996	1.005	1.000	.996	1.004
Ownership type (ref = Not for profit/government owned)															
For profit	.265***	.177	.395	2.965***	1.596	5.509	2.998***	1.614	5.569	2.269**	1.391	3.702	2.269**	1.391	3.702
Chain affiliated (ref=Not affiliated)															
Yes	.243***	.164	.360	1.853*	1.119	3.068	1.879*	1.136	3.109	1.509	.993	2.291	1.674*	1.094	2.560

CCRC membership (ref = Not a member)															
A member	3.173***	2.045	4.924	.644	.350	1.184	.700	.387	1.264	.601	.350	1.032	.556	.319	.966
Dementia special care unit (ref = No)															
Yes	.802	.520	1.237	.526*	.309	.897	.558*	.331	.942	.735	.479	1.128	.727	.474	1.115
Other special care unit (ref = No)															
Yes	.772	.507	1.177	.584*	.355	.959	.613*	.376	.999	.768	.510	1.155	.759	.505	1.142
Location rurality (ref = Metropolitan															
Micropolitan	1.313	.738	2.337	.518	.232	1.158	.511	.229	1.143	.462*	.225	.948	.462*	.225	.948
Rural	1.593	.790	3.211	.632	.256	1.561	.632	.256	1.561	.614	.273	1.379	.614	.273	1.379
Resident- and Community Level Predisposing and Need factors															
Resident Acuity Index	.993	.838	1.176	1.182	.674	2.072	1.093	.926	1.289	1.089	.938	1.264	1.110	.957	1.286
Minority Residents	1.035***	1.019	1.052	.982	.942	1.024	.983***	0.974	.992	.982***	.974	.990	.981***	.973	.989
65 or Older Residents				1.026	.967	1.088	1.031***	1.018	1.043	1.028***	1.017	1.039	1.031***	1.020	1.042
County-level Infection (pre-vaccination), mean	1.000	.998	1.001	.993*	.986	.999	1.000	.998	1.001	1.000	.998	1.001	1.000	.999	1.002
County-level Infection (two-year pandemic), mean	1.001	.999	1.003	.992	.983	1.001	1.000	.998	1.002	1.000	.999	1.00	1.000	.999	1.002
Nursing Home Quality															
Overall	.598***	.513	.696	.805	.393	1.651	1.561***	1.341	1.817	1.515***	1.328	1.728	1.522***	1.333	1.737
Health Inspection	.613***	.519	.724	.624	.265	1.469	1.594***	1.336	1.900	1.576***	1.351	1.839	1.596***	1.367	1.864
Quality Measures	.785**	.656	.940	1.255	.554	2.841	1.260**	1.066	1.489	1.268**	1.092	1.472	1.246**	1.073	1.447
Staffing	.509***	.420	.618	1.228	.436	3.456	1.660***	1.329	2.073	1.479***	1.226	1.785	1.521***	1.258	1.838
Overall Resident Satisfaction	.884***	.851	.918	1.030	.874	1.213	1.076***	1.041	1.112	1.080***	1.049	1.113	1.088***	1.055	1.121
Overall Family Satisfaction	.873***	.845	.902	1.112*	1.026	1.207	1.051***	1.028	1.074	1.059***	1.038	1.080	1.055***	1.034	1.076
COVID-19 Outcomes															
Pre-vaccination															
Resident cases	.999	.944	1.056	.989	.738	1.325	1.000	.944	1.060	1.033	.980	1.088	1.056*	1.002	1.114
Resident deaths	.764**	.623	.937	.910	.311	2.658	1.305*	1.016	1.675	1.420**	1.131	1.782	1.472**	1.169	1.854
Staff cases	.886**	.824	.953	.859	.634	1.164	1.104*	1.012	1.206	1.145***	1.057	1.241	1.173***	1.080	1.273
Two-year pandemic															
Resident cases	1.120	.986	1.273	1.110	.568	2.170	1.003	.881	1.141	1.064	.948	1.194	1.087	.968	1.221

Resident deaths	.595*	.377	.938	0.925	.079	10.878	1.654	.949	2.883	2.057**	1.237	3.421	2.180**	1.304	3.643
Staff cases	.780***	.696	.874	.850	.625	1.157	1.241**	1.078	1.428	1.308***	1.151	1.487	1.345***	1.180	1.532

Note. OR = odds ratio; SES = Socioeconomic status; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.

*p <.05, **p <.01, ***p < .001

Appendix C

Table C. 1. Bivariate relationships between continuous measures

	Neighborhood SES disadvantage	Medicare %	Medicaid %	Occupancy rate	RN HPRD	LPN HPRD	CNA HPRD	LPN/RN retention	CNA retention	Facility size	Resident Acuity Index	Minority Residents %	65 or Older Residents %	County-level Infection (pre-vaccination)	County-level Infection (two-year pandemic)
	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r
Neighborhood SES disadvantage	1														
Medicare %	-.100**	1													
Medicaid %	.207***	-.515***	1												
Occupancy rate	.033	-.005	-.023	1											
RN HPRD	-.165***	.507***	-.391***	-.088*	1										
LPN HPRD	.035	.212***	-.178***	-.098**	-.036	1									
CNA HPRD	-.177***	.247***	-.282***	.174***	.398***	.056	1								
LPN/RN retention	.006	-.055	-.032	.072	-.014	-.006	.056	1							
CNA retention	.009	-.033	.013	.024	.034	-.043	.095*	.308*	1						
Facility size	.065	-.175***	.075*	.067	-.196***	.073*	-.099**	.087	.075	1					
Resident Acuity Index	-.049	-.170***	.025	-.041	-.033	.012	.084*	.001	-.013	.055	1				
Minority Residents %	.117**	-.176***	.140***	-.051	-.195***	.111**	-.202***	-.108*	-.062	.189***	-.053	1			
65 or Older Residents %	-.212***	.356***	-.448***	.163***	.343***	.039	.426***	.081	.021	-.055	.142***	-.431***	1		
County-level Infection (pre-vaccination)	.018	-.002	-.024	.025	.020	-.029	.057	.081	.010	-.009	-.015	.031	.044	1	
County-level Infection (two-year pandemic)	.220***	.066	.048	-.011	-.035	-.031	-.029	.049	-.017	-.080*	.054	-.080*	.026	.683***	1

Note. r = Pearson correlation coefficient; SES= Socioeconomic Status; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day.
*p <.05, **p <.01, ***p < .001.

Table C. 2. Bivariate relationships with categorical measures

NHA turnover	**DON turnover**	**Any agency RN**	**Any agency LPN**	**Any agency CNA**	**Ownership type**	**Chain affiliated**	**CCRC membership,**	**Dementia special care unit**	**Other special care unit**	**Location rurality (ref = Metropolitan)**	
(ref=no turnover)	(ref=no turnover)	(ref=No)	(ref=No)	(ref=No)	(ref= non-profit/gover	(ref=Not affiliated)				Micropolitan	Rural

						nment owned)						
Neighborhood SES disadvantage (National ADI rank), *β*	.274	-.211	-3.412*	-5.249**	-4.607**	5.359**	-1.417	-8.753***	-1.175	-.032	12.094***	9.614*
Organizational Enabling Factors												
Medicare %, *β*	-1.140	-.910	.761	-0.229	-.374	-2.981***	-1.367	6.304***	-2.383***	-2.476***	2.579*	1.030
Medicaid %, *β*	3.040	1.925	-2.345	-1.653	-3.912**	12.234***	3.424*	-16.975***	2.025	1.954	3.609	2.622
Occupancy rate	-4.322***	-3.740***	-.794	-1.340	-.612	-2.225*	.448	1.085	1.762	1.225	-.876	-3.483*
RN HPRD, *β*	-.097***	-.032	.033	.023	.014	-.189***	-.096***	.197***	-.055*	-.068**	.035	.001
LPN HPRD, *β*	-.004	-.029	.057**	.033	.046*	-.0761**	-.049*	.108***	0.007	0.028	-.052*	-.039
CNA HPRD, *β*	-.145***	-.122**	.006	.033	.048	-0.407***	-.200***	.332***	0.064	0.038	-.014	-.041
Administrator turnover (ref=no turnover), OR												
Has turnover												
DON turnover (ref=no turnover), OR												
Has turnover	4.242***											
LPN/RN retention, *β*	-6.585***	-10.348***	-.683	2.281	1.065	-3.838*	-2.085	1.289	2.265	2.321	-1.835	3.168
CNA retention, *β*	-2.419	-3.901*	-1.312	-1.608	-1.524	-4.449**	-3.180*	0.315	-.073	0.158	.218	1.454
Any agency RN (ref=No), OR												
Yes	.997	1.547*										
Any agency LPN (ref= No), OR												
Yes	1.248	1.531*	13.073***									
Any agency CNA(ref= No) , OR												
Yes	1.026	1.286	7.284***	59.456***								
Facility size	.461	-2.032	3.964	-.806	-2.118	.166	-0.894	-7.343	29.654***	29.286***	-13.548***	-20.589***
Ownership type (ref= non-profit/government owned), OR												
Profit	1.790**	1.608*	.695*	.537***	.415***							
Chain affiliation (ref=Not affiliated), OR												
Affiliated	2.503***	1.545*	1.103	.885	.748	2.746***						
CCRC membership (ref=not a member), OR												
Yes	.855	0.814	1.168	1.225	1.609*	.128***	.560**					
Dementia care unit (ref=no), OR												
Yes	.776	.933	1.185	1.158	1.314	.652*	1.051	1.187				
Other care unit (ref=no), OR												
Yes	.833	.921	1.084	1.158	1.315	.657*	1.059	1.336	>999.999***			

Location rurality (ref= Metropolitan), OR												
Micropolitan	.818	.661*	.677	.448***	.428***	.996	1.252	1.005	1.151	1.053		
Rural	1.378	.785	.552*	.758	.703	1.212	.851	.739	1.003	.883		
Resident- and Community Level Predisposing and Need factors												
Resident Acuity Index	-.024	.027	.066	.081	0.1504	-0.127	-0.216*	-.017	0.153	0.091	-.278**	-.088
Minority Residents %	3.070	6.284***	3.914**	2.445	2.3743	5.211**	1.710	-4.520*	1.540	2.243	-13.459***	-13.437***
65 or Older Residents %,	-7.876***	-6.168***	1.988	1.503	3.389*	-13.505***	-4.641***	13.905***	2.894*	1.057	2.702	2.953
County-level Infection (pre-vaccination)	-1.297	10.084	48.266***	42.679***	30.475**	-29.816**	8.584	21.350	29.467**	26.913**	7.411	1.688
County-level Infection (two-year pandemic)	-1.297	-.486	14.402*	7.775	3.887	-6.931	9.984	-10.638	8.961	9.041	54.881***	3.202

Note. OR = Odds Ratio; SES = Socioeconomic status; r = correlation coefficient; β = regression coefficient; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community. *p <.05, **p <.01, ***p < .001.

Appendix D

Table D. 1. Results of Moran's I Statistics Analyzing Residuals from Multiple Linear Regressions in Aim 1

	Moran's I	95 % CL		*p*
		Lower	Upper	
Nursing Home Quality				
CMS Five-Star Rating				
Overall	.084	.073	.096	<.001
Health Inspection	.085	.073	.097	<.001
Quality Measures	.016	.005	.027	.006
Staffing	.025	-.009	.013	<.001
Consumer Satisfaction				
Overall Resident Satisfaction	.031	.020	.042	<.001
Overall Family Satisfaction	.025	.012	.038	.001

Table D. 2. a. Association between Neighborhood Disadvantage Levels and CMS-Five Star Ratings Using Linear and Spatial Models

N = 752	**CMS Five Star** Rating															
	Overall Rating				Health Inspection Rating				Quality Measures				Staffing			
	Model Specification															
	Linear	SAR	SEM	SMA	Linear	SAR	SEM	SMA	Linear	SAR	SEM	SMA	Linear	SAR	SEM	SMA
Neighborhood Disadvantage (National ADI rank)	-.003	-.002	.001	.000	-.001	-.001	.000	.000	-.000	.001	.002	.001	-.003	-.002	-.001	-.001
Organizational Enabling Factors																
Medicare %	-.000	.004	.006	.004	-.011	-.007	-.005	-.005	-.013*	-.009	-.007	-.008	.008	.008*	.009*	.009*
Medicaid %	-.007*	-.006*	-.005	-.005*	-.004	-.002	-.002	-.002	-.004	-.004	-.003	-.003	-.006***	-.006***	-.007***	-.007***
Occupancy rate	.012**	.013***	.014***	.014***	.015***	.015***	.016***	.016***	.008*	.008**	.009**	.009**	-.002	-.002	-.003	-.003
RN HPRD					.828***	.730***	.653***	.610***	.419*	.348*	.310	.333*				
LPN HPRD					.156	.024	-.024	-.023	-.186	-.212	-.200	-.193				
CNA HPRD					.084	.065	.108	.117	.214	.195	.207	.211				
NHA turnover (ref=no turnover)																
Has turnover	-.442***	-.402***	-.382***	-.372***	-.324***	-.297***	-.284**	-.275**	-.099	-.095	-.096	-.092	-.150*	-.146*	-.137*	-.138*
DON turnover																
Has turnover	-.355**	-.319**	-.315**	-.317**	-.323***	-.287**	-.272**	-.265**	-.188	-.187	-.184	-.183	-.016	-.015	-.020	-.019
LPN/RN retention	.002	.002	.002	.002	.003	.003	.003	.003	-.000	.000	.000	.000	-.002	-.002	-.002	-.002
CNA retention	.001	.001	.001	.001	.001	.001	.001	.001	-.002	-.002	-.002	-.002	.001	.001	.001	.001

Any agency RN (ref=No)																
Yes	-.304**	-.283**	-.281**	-.281**	-.285**	-.249**	-.241**	-.251**	-.170	-.172	-.178	-.178	.055	.048	.051	.055
Any agency LPN (ref=No)																
Yes	-.198	-.164	-.128	-.162	-.365**	-.336**	-.309*	-.333**	-.007	-.007	-.006	-.012	.094	.096	.110	.109
Any agency CNA (ref=No)																
Yes	.144	.081	.041	.056	.279*	.221	.177	.176	-.038	-.046	-.055	-.048	-.029	-.032	-.030	-.032
Facility size	-.004***	-.005***	-.006***	-.006***	-.003**	-.004***	-.005***	-.004***	.001	.000	.000	.000	-.002	-.002*	-.002*	-.002*
Ownership type (ref=non-profit/government owned)																
Profit	-.196	-.232*	-.221	-.225	.065	.012	.022	.009	-.028	-.060	-.053	-.045	-.502***	-.512***	-.525***	-.522***
Chain affiliation																
Affiliated	.049	.054	.069	.052	.104	.120	.143	.137	.193*	.190*	.190*	.190*	-.165*	-.178**	-.175**	-.175**
CCRC																
Yes	.059	.006	-.044	-.039	-.146	-.164	-.188	-.183	.129	.094	.072	.084	.166	.151	.129	.135
Dementia care unit																
Yes	.290	.246	.256	.249	.183	.162	.202	.213	.311	.310	.336	.334	.116	.084	.054	.050
Other care unit																
Yes	-.231	-.179	-.190	-.170	-.136	-.107	-.153	-.158	-.433	-.426	-.458*	-.457*	-.148	-.118	-.079	-.076
Location rurality (ref=metropolitan)																
Micropolitan	-.297*	-.251*	-.124	-.190	-.182	-.180	-.038	-.061	-.423***	-.367***	-.364**	-.388**	-.019	.005	.030	.019
Rural	-.253	-.370*	-.275	-.361*	-.094	-.215	-.106	-.154	-.051	-.043	-.069	-.086	-.252*	-.269**	-.247*	-.261*
Resident- and Community Level Predisposing and Need factors																
Resident Acuity Index	-.031	-.019	-.006	.002	-.051	-.048	-.044	-.038	-.029	-.017	-.006	-.009	.020	.028	.031	.033
Minority Residents %	-.008**	-.010***	-.012***	-.012***	-.006**	-.008***	-.009***	-.009***	.001	-.000	-.001	-.000	-.005**	-.006**	-.006***	-.006***
65 or Older Residents %	.021***	.022***	.022***	.022***	.013***	.015***	.015***	.015***	.008*	.009*	.009*	.009*	.015***	.014***	.014***	.014***
ρ		.763***				.776***				.458***				.425***		
λ			.793***	-1.418***			.801***	-1.553***			.495***	-.534**			.531***	-.773***
AIC, mean	2453.60	2366.60	2348.07	2360.33	2240.00	2143.40	2128.00	2137.20	2257.80	2244.60	2246.33	2248.87	1780.67	1771.20	1764.93	1764.80

Note. SAR = Spatial Autoregressive model; SEM = Spatial Error Model; SMA = Spatial Moving Average model; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
ρ - Autoregressive coefficient in the SAR specification
λ - Autoregressive coefficient in SEM and SMA specifications
*p <.05, **p <.01, ***p < .001.

Table D. 2. b. Association between Neighborhood Disadvantage Levels and Consumer Satisfaction Scores Using Linear and Spatial Models

	Consumer Satisfaction							
	Overall Resident Satisfaction				Overall Family Satisfaction			
	Linear	SAR	SEM	SMA	Linear	SAR	SEM	SMA
Neighborhood Disadvantage (National ADI rank)	.005	.002	.003	.003	.012	.007	.008	.008
Organizational Enabling Factors								
Medicare %	-.011	-.014	-.017	-.017	-.059	-.056	-.053	-.054
Medicaid %	-.030*	-.029*	-.029*	-.029*	-.009	-.007	-.005	-.006
Occupancy rate	.014	.019	.023	.022	.046*	.049*	.051*	.051*
RN HPRD	1.154	1.279	1.264	1.263	1.707	1.662	1.390	1.410
LPN HPRD	.173	.306	.356	.319	-.522	-.452	-.434	-.420
CNA HPRD	1.439**	1.430**	1.523**	1.537**	1.802*	1.743*	1.823*	1.824*
NHA turnover (ref=no turnover)								
Has turnover	.070	-.004	-.081	-.080	-1.227†	-1.261*	-1.284*	-1.281*
DON turnover								
Has turnover	-.435	-.448	-.472	-.456	-.371	-.394	-.419	-.407
LPN/RN retention	-.001	-.002	-.002	-.001	.030	.029	.030	.030
CNA retention	-.005	-.005	-.005	-.004	.030	.030	.030	.030
Any agency RN (ref=No)								
Yes	-.542	-.558	-.555	-.568	-1.252	-1.202	-1.124	-1.139
Any agency LPN (ref=No)								
Yes	.299	.428	.681	.647	.274	.306	.456	.430
Any agency CNA (ref=No)								
Yes	-.101	-.223	-.384	-.341	.421	.380	.315	.325
Facility size	-.013*	-.012*	-.013**	-.014**	-.029***	-.029***	-.030***	-.030***
Ownership type (ref=non-profit/government owned)								
Profit	-1.284*	-1.282*	-1.294*	-1.272*	-1.426	-1.584*	-1.742*	-1.701*
Chain affiliation								
Affiliated	.128	.069	.153	.170	-2.005**	-2.063***	-1.953**	-1.961**
CCRC								
Yes	-.885	-.725	-.673	-.708	-1.086	-.988	-.985	-.987

Dementia care unit								
Yes	.296	.261	.372	.380	-.340	-.343	-.211	-.211
Other care unit								
Yes	-.038	-.046	-.167	-.175	1.691	1.660	1.499	1.484
Location rurality (ref=metropolitan)								
Micropolitan	.897	.541	.813	.821	-.003	-.354	.179	.197
Rural	1.421*	.737	.930	.956	1.901*	1.312	1.770	1.774
Resident- and Community Level Predisposing and Need factors								
Resident Acuity Index	-.228	-.189	-.181	-.185	-.255	-.250	-.274	-.273
Minority Residents %	-.043***	-.041***	-.043***	-.044***	-.087***	-.083***	-.084***	-.084***
65 or Older Residents %	.088***	.084***	.082***	.083***	.125***	.122***	.123***	.123***
ρ		.370***				.287*		
λ			.464***	-.568**			.368**	-.445*
AIC, mean	4612.87	4603.93	4601.33	4602.67	5101.73	5098.13	5096.20	5096.60

Note. SAR = Spatial Autoregressive model; SEM = Spatial Error Model; SMA = Spatial Moving Average model; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
ρ - Autoregressive coefficient in the SAR specification
λ - Autoregressive coefficient in SEM and SMA specifications
*p <.05, **p <.01, ***p < .001.

Appendix E

Table E. 1. Results of Moran's I Statistics Analyzing Pearson Residuals from Adjusted Poisson Regressions in Aim 2

	Moran's I	95 % CL		*p*
		Lower	Upper	
Pre-Vaccination				
Monthly Resident COVID-19 Cases per 100 Beds	.023	.012	.034	<.001
Monthly Resident COVID-19 related Deaths per 100 Beds	.002	-.009	.013	.734
Monthly Staff COVID-19 Cases per 100 Beds	.001	-.010	.012	.888
Two-Year Pandemic				
Monthly Resident COVID-19 Cases per 100 Beds	.009	-.002	.020	.126
Monthly Resident COVID-19 related Deaths per 100 Beds	-.004	-.015	.007	.448
Monthly Staff COVID-19 Cases per 100 Beds	.002	-.009	.013	.715

Table E. 2. Association between Neighborhood Disadvantage Levels and Monthly Nursing Home Resident COVID-19 Cases per 100 Beds (Pre-Vaccination Period) Using Linear and Spatial Models

N=752	Box-Cox Transformed Monthly Resident COVID-19 Cases per 100 Beds During the Pre-Vaccination Period (λ=0.5)			
	Model Specification			
	Linear	SAR	SEM	SMA
Neighborhood Disadvantage (National ADI rank)	.002	.002	0.002	.002
Organizational Enabling Factors				
Medicare %	-.011	-.011	-.011	-.011
Medicaid %	.003	.003	.003	0.003
Occupancy rate	.011*	.011*	.011*	.011*
RN HPRD	-.407	-.417	-.428	-.425
LPN HPRD	-.424	-.401	-.384	-.393
CNA HPRD	-.493**	-.458*	-.434*	-.445*
NHA turnover (ref=no turnover)				
Has turnover	-.162	-.170	-.163	-.163
DON turnover				
Has turnover	-.107	-.105	-.106	-.105
LPN/RN retention	-.005	-.005	-.005	-.005
CNA retention	.004	.005	.005	.005
Any agency RN (ref=No)				
Yes	-.046	-.057	-.043	-.043

Any agency LPN (ref=No)				
Yes	.133	.139	.135	.136
Any agency CNA (ref=No)				
Yes	-.287	-.272	-.268	-.273
Facility size	.000	.000	.000	.000
Ownership type (ref=non-profit/government owned)				
Profit	.367*	.338	.327	.335
Chain affiliation				
Affiliated	.264	.269	.280	.277
CCRC				
Yes	.053	.025	.010	.018
Dementia care unit				
Yes	-.835*	-.806*	-.777*	-.787*
Other care unit				
Yes	.651	.621	.583	.596
Location rurality (ref=metropolitan)				
Micropolitan	-.122	-.132	-.119	-.115
Rural	-.070	-.134	-.122	-.116
Resident- and Community Level Predisposing and Need factors				
Resident Acuity Index	.045	.035	.031	.035
Minority Residents %	-.006	-.006	-.005	-.006
65 or Older Residents %	.014*	.013*	.013*	.013*
County-level Infection	.002***	.002**	.002**	.002***
ρ		.261*		
λ			.279*	-.266
AIC, mean	2987.93	2985.40	2986.33	2986.87

Note. SAR = Spatial Autoregressive model; SEM = Spatial Error Model; SMA = Spatial Moving Average model; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
ρ - Autoregressive coefficient in the SAR specification
λ - Autoregressive coefficient in SEM and SMA specifications
*p <.05, **p <.01, ***p < .001.

Appendix F

Table F. 1. Results of Moran's I Statistics Analyzing Pearson Residuals from Adjusted Poisson Regressions in Aim 3

	Pre-Vaccination												*Two-year pandemic*											
	Monthly Resident COVID-19 Cases per 100 Beds				Monthly Resident COVID-19 Related Deaths per 100 Beds				Monthly Staff COVID-19 Cases per 100 Beds				Monthly Resident COVID-19 Cases per 100 Beds				Monthly Resident COVID-19 Related Deaths per 100 Beds				Monthly Staff COVID-19 Cases per 100 Beds			
	Moran's I	*95 % CL*		*p*	Moran's I	*95 % CL*		*p*	Moran's I	*95 % CL*		*p*	Moran's I	*95 % CL*		*p*	Moran's I	*95 % CL*		*p*	Moran's I	*95 % CL*		*p*
		Lower	Upper			Lower	Upper			Lower	Upper			Lower	Upper			Lower	Upper			Lower	Upper	
Nursing Home Quality																								
CMS Five-Star Rating																								
Overall	.029	.018	.040	<.001	.005	-.006	.016	.384	-.000	-.011	.011	.969	.014	.003	.025	.011	-.002	-.013	.009	.783	.001	-.010	.012	.866
Health Inspection	.022	.011	.033	<.001	.001	-.010	.012	.806	.000	-.011	.011	.976	.008	-.003	.019	.134	-.004	-.015	.007	.445	.000	-.011	.011	.980
Quality Measures	.022	.011	.033	<.001	.000	-.011	.011	.932	.001	-.010	.012	.883	.008	-.003	.019	.139	-.005	-.016	.006	.343	.002	-.009	.013	.727
Staffing	.029	.018	.040	<.001	.006	-.005	.017	.319	.001	-.010	.012	.864	.013	.002	.024	.021	-.000	-.011	.011	.936	.002	-.009	.013	.682
Consumer Satisfaction																								
Overall Resident Satisfaction	.023	.012	.034	<.001	.001	-.010	.012	.797	.001	-.010	.012	.878	.009	-.002	.020	.115	-.004	-.015	.007	.443	.002	-.009	.013	.724
Overall Family Satisfaction	.023	.012	.034	<.001	.002	-.010	.013	.732	.001	-.010	.012	.840	.009	-.002	.020	.092	-.004	-.006	-.003	.446	.002	-.009	.013	.731

Table F. 2. Results of Linear and Spatial Regression Models Estimating the Role of CMS Five-Star Overall and Staffing in Associations Between Neighborhood Disadvantage Levels and Box-Cox Transformed Monthly Resident COVID-19 Cases per 100 Beds During the Two-Year Period

N = 752	Box-Cox Transformed Monthly Resident COVID-19 Cases per 100 Beds During the Two-Year Pandemic Period (λ=0.5)							
	Model Specification							
	Linear	SAR	SEM	SMA	Linear	SAR	SEM	SMA
Neighborhood Disadvantage (National ADI rank)	.002	.002	.002	.002	.002	.002	.002	.002
Organizational Enabling Factors								
Medicare %	-.010*	-.010*	-.010*	-.010*	-.009*	-.009*	-.009*	-.009*
Medicaid %	.002	.002	.002	.002	.002	.002	.002	.002
Occupancy rate	.013***	.013***	.013***	.013***	.012***	.012***	.012***	.012***
RN HPRD								

LPN HPRD								
CNA HPRD								
NHA turnover (ref=no turnover)								
Has turnover	-.020	-.024	-.025	-.025	-.016	-.021	-.021	-.021
DON turnover								
Has turnover	.010	.012	.012	.012	.021	.022	.023	.023
LPN/RN retention	.000	.000	.000	.000	.000	.000	.000	.000
CNA retention	-.001	-.001	-.001	-.001	-.001	-.001	-.001	-.001
Any agency RN (ref=No)								
Yes	-.036	-.038	-.038	-.037	-.022	-.024	-.023	-.023
Any agency LPN (ref=No)								
Yes	-.059	-.058	-.056	-.056	-.046	-.045	-.043	-.043
Any agency CNA (ref=No)								
Yes	-.009	-.002	-.005	-.005	-.016	-.009	-.011	-.011
Facility size	.000	.000	.000	.000	.000	.000	.000	.000
Ownership type (ref=non-profit/government owned)								
Profit	.331***	.317***	.314***	.314***	.301**	.287**	.285**	.285**
Chain affiliation								
Affiliated	.219**	.220**	.221**	.221**	.205**	.206**	.207**	.207**
CCRC								
Yes	.010	.005	.001	.001	.020	.014	.011	.011
Dementia care unit								
Yes	-.404*	-.397*	-.384*	-.385*	-.406*	-.397*	-.388*	-.388*
Other care unit								
Yes	.262	.255	.240	.241	.259	.252	.240	.241
Location rurality (ref=metropolitan)								
Micropolitan	-.120	-.122	-.117	-.115	-.111	-.114	-.108	-.107
Rural	.052	.038	.043	.043	.043	.027	.035	.035
Resident- and Community Level Predisposing and Need factors								
Resident Acuity Index	.008	.004	.003	.004	.010	.007	.006	.006
Minority Residents %	-.004*	-.004	-.004	-.004	-.004*	-.004	-.004	-.004*
65 or Older Residents %	.004	.004	.004	.004	.004	.004	.004	.004
County-level Infection	.000	.000	.000	.000	.000	.000	.000	.000
Nursing Home Quality								
Overall Rating	-.035	-.032	-.035	-.035				
Health Inspection								
Quality Measures Rating								
Staffing Rating					-.073	-.071	-.071	-.071
Overall Resident Satisfaction								
Overall Family Satisfaction								
ρ		.199				.204		
λ			.185	-.210			.179	-.205

AIC, mean	2021.73	2021.67	2022.33	2022.33	2020.53	2020.20	2021.13	2021.13								

Note. SAR = Spatial Autoregressive model; SEM = Spatial Error Model; SMA = Spatial Moving Average model; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.
ρ - Autoregressive coefficient in the SAR specification
λ - Autoregressive coefficient in SEM and SMA specifications
*p <.05, **p <.01, ***p < .001.

Table F. 3. a. Results of Linear and Spatial Regression Models Estimating the Roles of CMS Five-Star Ratings in Associations Between Neighborhood Disadvantage Levels and Box-Cox Transformed Monthly Resident COVID-19 Cases per 100 Beds During the Pre-Vaccination Period.

N = 752	Box-Cox Transformed Monthly Resident COVID-19 Cases per 100 Beds During the Pre-Vaccination Period (λ=0.5)															
	Model Specification															
	Linear	SAR	SEM	SMA	Linear	SAR	SEM	SMA	Linear	SAR	SEM	SMA	Linear	SAR	SEM	SMA
Neighborhood Disadvantage (National ADI rank)	.003	.003	.003	.003	.002	.002	.002	.002	.002	.002	.002	.002	.003	.002	.003	.003
Organizational Enabling Factors																
Medicare %	-.020*	-.020*	-.021*	-.021*	-.010	-.011	-.011	-.010	-.010	-.010	-.010	-.010	-.020*	-.020*	-.020*	-.020*
Medicaid %	.004	.004	.004	.004	.003	.003	.003	.003	.003	.003	.003	.003	.004	.004	.004	.004
Occupancy rate	.012*	.012*	.012*	.012*	.011*	.011*	.011*	.011*	.011*	.011	.010	.010	.011*	.011*	.011*	.011*
RN HPRD					-.418	-.432	-.436	-.434	-.432	-.443	-.450	-.447				
LPN HPRD					-.426	-.404	-.385	-.395	-.412	-.389	-.372	-.381				
CNA HPRD					-.494**	-.460*	-.435*	-.447*	-.506**	-.471**	-.446*	-.458*				
NHA turnover (ref=no turnover)																
Has turnover	-.141	-.149	-.147	-.144	-.157	-.165	-.160	-.159	-.156	-.164	-.157	-.156	-.138	-.147	-.142	-.140
DON turnover																
Has turnover	-.088	-.087	-.093	-.091	-.102	-.100	-.103	-.102	-.096	-.094	-.095	-.094	-.079	-.080	-.084	-.082
LPN/RN retention	-.004	-.004	-.004	-.004	-.005	-.005	-.005	-.002	-.005	-.005	-.005	-.005	-.005	-.005	-.004	-.004
CNA retention	.004	.004	.004	.004	.004	.005	.005	.004	.005	.005	.005	.005	.004	.004	.004	.004
Any agency RN (ref=No)																
Yes	-.069	-.079	-.069	-.068	-.042	-.052	-.041	-.040	-.036	-.047	-.033	-.033	-.057	-.069	-.058	-.057
Any agency LPN (ref=No)																
Yes	.103	.111	.110	.111	.138	.145	.139	.140	.133	.139	.136	.136	.114	.122	.121	.122
Any agency CNA (ref=No)																
Yes	-.248	-.233	-.227	-.233	-.291	-.277	-.270	-.276	-.284	-.270	-.265	-.270	-.253	-.238	-.231	-.238
Facility size	.001	.001	.001	.001	.000	.000	.000	.000	.000	.000	.000	.000	.001	.001	.001	.001

Ownership type (ref=non-profit/government owned)																
Profit	.527**	.487**	.469**	.481**	.366*	.337	.327	.335	.368*	.340	.330	.338	.501**	.461*	.446*	.457*
Chain affiliation																
Affiliated	.345*	.346*	.359*	.356*	.263	.267	.279	.275	.253	.257	.269	.265	.333*	.334*	.347*	.344*
CCRC																
Yes	-.012	-.039	-.051	-.045	.055	.027	.012	.020	.045	.017	.004	.011	-.003	-.031	-.043	-.037
Dementia care unit																
Yes	-.851*	-.820*	-.767*	-.782*	-.838*	-.810*	-.779*	-.790*	-.854*	-.826*	-.796*	-.807*	-.853*	-.820*	-.771*	-.786*
Other care unit																
Yes	.635	.605	.543	.560	.653	.624	.585	.598	.677	.648	.610	.623	.632	.601	.544	.561
Location rurality (ref=metropolitan)																
Micropolitan	-.093	-.106	-.101	-.092	-.118	-.129	-.118	-.114	-.095	-.106	-.096	-.091	-.086	-.100	-.094	-.085
Rural	-.031	-.104	-.109	-.098	-.069	-.132	-.121	-.114	-.067	-.131	-.118	-.112	-.040	-.114	-.115	-.104
Resident- and Community Level Predisposing and Need factors																
Resident Acuity Index	.029	.019	.014	.0189	.046	.036	.032	.036	.047	.037	.033	.036	.032	.021	.016	.021
Minority Residents %	-.006	-.006	-.005	-.006	-.006	-.005	-.005	-.005	-.006	-.005	-.005	-.006	-.006	-.006	-.006	-.006
65 or Older Residents %	.011*	.011*	.012*	.011*	.013*	.013*	.013*	.013*	.013*	.013*	.013*	.013*	.012*	.011*	.012*	.012*
County-level Infection	.002***	.002**	.002**	.002***	.002***	.002**	.002**	.002***	.002***	.002**	.002***	.002***	.002***	.002**	.002**	.002***
Nursing Home Quality																
CMS Five-Star Rating																
Overall	-.028	-.025	-.030	-.029												
Health Inspection					.014	.018	.011	.012								
Quality Measures									.060	.061	.060	.061				
Staffing													-.063	-.062	-.057	-.058
Consumer Satisfaction																
Overall Resident Satisfaction																
Overall Family Satisfaction																
ρ		.293*				.262*				.262*				.294*		
λ			.340**	-.333*			.278*	-.266			.279*	-.270			.337**	-.331*
AIC, mean	2998.00	2994.33	2993.47	2994.73	2989.87	2987.33	2988.20	2988.80	2988.93	2986.33	2987.20	2987.93	2997.60	2994.00	2993.40	2994.60

Note. SAR = Spatial Autoregressive model; SEM = Spatial Error Model; SMA = Spatial Moving Average model; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.

ρ - Autoregressive coefficient in the SAR specification

λ - Autoregressive coefficient in SEM and SMA specifications

*p <.05, **p <.01, ***p < .001

Table F. 3. b. Results of Linear and Spatial Regression Models Estimating the Roles of Consumer Satisfaction Scores in Associations Between Neighborhood Disadvantage Levels and Box-Cox Transformed Monthly Resident COVID-19 Cases per 100 Beds During the Pre-Vaccination Period.

	Box-Cox Transformed Monthly Resident COVID-19 Cases per 100 Beds During the Pre-Vaccination Period (λ=0.5)							
	Model Specification							
	Linear	SAR	SEM	SMA	Linear	SAR	SEM	SMA
Neighborhood Disadvantage (National ADI rank)	.002	.002	.002	.002	.002	.001	.002	.002
Organizational Enabling Factors								
Medicare %	-.011	.011	-.011	-.011	-.010	-.011	-.011	-.011
Medicaid %	.002	.002	.002	.002	.003	.003	.003	.003
Occupancy rate	.012*	.011*	.011*	.011*	.011*	.011*	.011*	.011*
RN HPRD	-.386	-.397	-.408	-.404	-.409	-.419	-.429	-.426
LPN HPRD	-.422	-.400	-.381	-.391	-.423	-.401	-.384	-.393
CNA HPRD	-.466**	-.434*	-.410*	-.422*	-.495**	-.460*	-.434*	-.447*
NHA turnover (ref=no turnover)								
Has turnover	-.161	-.169	-.164	-.163	-.160	-.169	-.163	-.162
DON turnover								
Has turnover	-.114	-.112	-.113	-.113	-.106	-.105	-.106	-.105
LPN/RN retention	-.005	-.005	-.005	-.005	-.005	-.005	-.005	-.005
CNA retention	.004	.004	.004	.004	.004	.004	.005	.004
Any agency RN (ref=No)								
Yes	-.055	-.064	-.052	-.052	-.045	-.056	-.043	-.043
Any agency LPN (ref=No)								
Yes	.140	.145	.145	.145	.132	.139	.135	.136
Any agency CNA (ref=No)								
Yes	-.289	-.275	-.273	-.278	-.287	-.273	-.268	-.273
Facility size	.000	.000	.000	.000	.000	.000	.000	.000
Ownership type (ref=non-profit/government owned)								
Profit	.342	.316	.306	.314	.369*	.339	.328	.336
Chain affiliation								
Affiliated	.267	.271	.282	.279	.267	.271	.281	.278
CCRC								
Yes	.037	.011	-.001	.006	.054	.026	.011	.019
Dementia care unit								
Yes	-.829*	-.802*	-.772*	-.783*	-.834*	-.806*	-.776*	-.787*
Other care unit								
Yes	.651	.622	.584	.597	.649	.619	.582	.595

Location rurality (ref=metropolitan)								
Micropolitan	-.104	-.115	-.104	-.101	-.121	-.132	-.119	-.116
Rural	-.044	-.107	-.101	-.093	-.073	-.136	-.123	-.117
Resident- and Community Level Predisposing and Need factors								
Resident Acuity Index	.041	.031	.028	.032	.045	.035	.031	.035
Minority Residents %	-.007	-.006	-.006	-.006	-.006	-.005	-.005	-.006
65 or Older Residents %	.015**	.015**	.015**	.015**	.013*	.013*	.013*	.013*
County-level Infection	.002***	.002**	.002**	.002***	.002***	.002**	.002**	.002***
Nursing Home Quality								
CMS Five Star Rating								
Overall Rating								
Health Inspection								
Quality Measures Rating								
Staffing Rating								
Consumer Satisfaction								
Overall Resident Satisfaction	-.018	-.017	-.017	-.017				
Overall Family Satisfaction					.001	.001	.000	.001
ρ		.254*				.261*		
λ			.268	-.251			.278*	-.266
AIC, mean	2987.87	2985.47	2986.33	2986.93	2989.87	2987.40	2988.33	2988.73

Note. SAR = Spatial Autoregressive model; SEM = Spatial Error Model; SMA = Spatial Moving Average model; RN = Registered Nurse; LPN = Licensed Practical Nurses; CNA = Certified Nurse Aides; HPRD = Hours Per Resident Day; NHA = Nursing Home Administrator; DON = Director of Nursing; CCRC = Continuing Care Retirement Community.

ρ - Autoregressive coefficient in the SAR specification

λ - Autoregressive coefficient in SEM and SMA specifications

*p <.05, **p <.01, ***p < .001