# Enhancing healthcare operation in disadvantaged communities: The role of chain affiliation and dynamic capabilities

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**Statements and Declarations**

There are non-financial interests directly or indirectly related to the work submitted for publication. We confirm no conflicts of interest or competing interests related to this manuscript. Ethics approval was not required for this study in accordance with the institution policies. Additionally, We are grateful for the generous support provided by the Dean's Office at Rutgers Business School, which was instrumental to the successful completion of this project.

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Healthcare organizations operating in socially disadvantaged communities often struggle to deliver high-quality care due to challenges like limited health literacy, unstable transportation, and cultural mistrust. This study examines how chain affiliation in dialysis centers serving socially disadvantaged populations impacts clinical outcomes. Drawing on Dynamic Capabilities Theory, we propose that being part of a chain network enables facilities to adapt and improve quality of care in low-resource environments. We empirically test this hypothesis using a five-year panel dataset of dialysis facilities and apply robust econometric techniques—instrumental variable generalized method of moments (IV-GMM), two-stage least squares (2SLS), and limited-information maximum likelihood (LIML)—to address endogeneity. The analysis reveals that chain-affiliated facilities maintain higher quality scores and experience a smaller decline in performance due to social disadvantage compared to independent centers. Our findings suggest that chain networks confer dynamic capabilities that enhance resilience and quality in underserved settings. This work contributes to healthcare management science by demonstrating the value of chain affiliation as a strategy for quality improvement and by informing health policy on strengthening care delivery in resource-constrained settings.

**Highlights**

1. Social disadvantage significantly undermines clinical quality in dialysis centers.
2. Dynamic capabilities from chain networks enable rapid adaptation amid high social disadvantage.
3. Robust analyses show that chain networks mitigate quality declines from socioeconomic challenges.
4. These findings inform policy and management strategies in resource-constrained settings, with implications for broader healthcare systems.

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**Keywords:** Dynamic capabilities, social disadvantage, chain, health care quality, underserved populations

# 1 Introduction

In the early 2020s, DaVita, a leading U.S. dialysis chain, announces plans to expand its network of centers by over 20% within five years. It is Davita's second major expansion following a similar initiative a decade earlier. The announcement sparked significant discussions in industry reports and specialized media [1]. Unlike the past one, which centered on acquiring and merging existing facilities in urban areas, the current expansion more emphasizes acquiring or establishing new facilities in rural, underserved regions. Underdeveloped regions often grapple with economic constraints, cultural and linguistic diversity, and limited educational resources—factors contributing to these communities being described as socially disadvantaged [2]. Suffering from these disadvantages, patients in underdeveloped areas frequently lack access to adequate health services. Therefore, this new expansion raises a new debate: Can a dialysis chain achieve profitability while addressing social and ethical issues, such as delivering high-quality healthcare services to underserved populations in these regions? Or will such expansion efforts unintentionally worsen existing disparities?

Dialysis centers provide essential support for patients with end-stage renal disease (ESRD), the most advanced stage of kidney disease, by facilitating the removal of waste and excess water from the blood. Such treatment requires coordinating resources across multiple departments and adhering to stable, standardized procedures. However, ESRD patients in socially disadvantaged communities face persistent challenges, including low adherence to dialysis treatments, difficulties in managing complex comorbidities, high rates of complications, and significantly elevated healthcare costs [3]. Over the past decade, the U.S. Centers for Medicare & Medicaid Services (CMS) has introduced various payment reforms and value-based incentive programs to improve dialysis care quality and equity [2]. However, these measures have struggled to address structural inequalities rooted in socioeconomic factors. Disadvantaged communities experience disproportionately high readmission rates, healthcare expenditures, and lagging patient satisfaction [4, 3]. The results imply that conventional quality improvement (QI) initiatives—such as disseminating standardized clinical guidelines, forming isolated QI teams, or implementing limited patient education programs—often yield marginal benefits in complex and resource-constrained environments.

The independent facility, the other organizational structure, faces more significant challenges in securing timely resources and maintaining effective operations than more structured organizations in these communities [5, 6]. The COVID-19 pandemic has exacerbated the inequalities caused by strained resources, limited mobility, and personnel shortages, which has resulted in frequent disruptions to daily care services and delays in routine treatments for local patients during supply chain interruptions [7, 8]. Reports highlighted reduced dialysis frequency and rising late-stage complications, underscoring the fragility of care delivery under these adverse conditions [9]. Given these difficulties, questions raised from the expansion of chain organizations can be further described as how their affiliated facilities will perform in these regions following such integration of independent facilities in underdeveloped areas.

Traditional empirical research on chain organizations has primarily focused on examining whether joining a chain organization or expanding the scale of chains contributes to improving performance (e.g., quality outcomes, efficiency) at the operational level. In the healthcare context, numerous studies have demonstrated that chain organizations offer significant advantages in enhancing healthcare outcomes and efficiency [10, 11, 12]. However, the following research finds that these advantages are not always observed in healthcare chain organizations [13, 14, 15]. The emerging phenomena of expansion in different areas led to a new conjecture about inconsistency: the benefits of chain organizations are affected by the external environment. However, few studies have explored the impact of chain organizations when considering differences in the external environment. This gap is mainly due to the lack of theoretical frameworks and existing data's narrow temporal and spatial scopes. Addressing this research gap is particularly critical given the ongoing expansion of healthcare chain organizations into increasingly diverse regions, such as DaVita's growth in the dialysis sector.

Therefore, our research aims to address the gap by exploring the question: Will these chain organizations reshape dialysis care with organizational resilience and adaptability in areas with different

social disadvantage levels? To answer the problem, theoretically, we initiate the insight from Dynamic Capabilities Theory (DCT) to examine how chain organizations mitigate the challenges faced by facilities in underdeveloped regions. Empirically, we apply a 5-year CMS dataset (2015–2019), which includes detailed facility-level operational, clinical, and patient outcome metrics, providing a robust basis for empirical analysis. Our findings confirm the detrimental impact of social disadvantages on dialysis facility performance. Secondly, they demonstrate that the chain structure moderates these adverse effects, enhancing facility quality outcomes despite the challenges of socially disadvantaged contexts.

Our findings contribute to addressing the theoretical gap regarding the mechanisms underlying the effects of chain organization through the lens of DCT. These theoretical contributions offer valuable insights into strategic decision-making, enabling large dialysis chains and other healthcare organizations to better assess the risks and benefits of expanding into underserved communities. Furthermore, our analysis demonstrates that expanding chain organizations yields a win-win outcome, benefiting both facilities and socially disadvantaged ESRD patients. The emerging chain affiliations enhance health outcomes and improve the quality of life for countless underserved ESRD patients. From a policy standpoint, we highlight an alternative strategy to enhance the quality of health instead of long-term investing in improving socially disadvantaged environments.

In the following sections, we focus on the dialysis industry as our empirical context to explore the expansion and practices of chain organizations through the theoretical lens of dynamic capabilities. In Section 2, we conduct a literature review and propose our hypotheses. Section 3 describes the data sources and processing methods, while Section 4 explains the model construction. Section 5 presents and discusses the results, and Section 6 conducts sensitivity analyses to test the robustness of our findings. Finally, Section 7 summarizes key insights and implications for healthcare policy and management strategies.

# 2 Literature Review and Hypotheses Development

## 2.1 The relationship between social disadvantage and facility performance

Socially disadvantaged communities are an integrated concept, including measuring multiple indicators. For example, such communities usually face challenges from entrenched poverty, limited educational opportunities, cultural and linguistic barriers, inadequate housing, and insufficient preventive care resources [16, 17]. In healthcare, these disadvantages lead to patients' low health literacy, unstable insurance coverage, and weak trust in healthcare providers. As a result, these patients cannot seek timely care and preventive health behaviors, frequently encounter advanced disease states, complex comorbidities, and lower adherence to recommended treatments [18, 19]. Meanwhile, providers can hardly deliver effective and complete services due to a lack of patient cooperation. These situations are aggravated by the lack of skilled clinicians, unreliable supply chains, and fragmented referral networks [20, 21].

The challenges are especially pronounced in managing chronic conditions that demand ongoing patient engagement, strict adherence to care plans, and reliable coordination of complex treatment regimens. For example, effective dialysis delivery depends on precise treatment protocols, adherence to thrice-weekly sessions, integrated dietary counseling, and vigilant monitoring of vascular access [22, 23, 24]. In disadvantaged communities, ESRD patients may need more consistent transportation, face language barriers that limit comprehension of nutritional guidelines, or distrust the health system due to historical and cultural factors. Also, the facility may hardly understand patients' difficulties, only find patients often experience irregular attendance, suboptimal adherence, and frequent complications [18, 25, 26]. In more serious cases, it may be difficult for the facility to diagnose or treat patients with related conditions. Given these challenges, the interactions among various disadvantageous factors are complex and cumulative. Therefore, integrated measures of social disadvantages are

essential for exploring mechanisms. Recent studies also have noted that focusing on isolated factors potentially leads to biased conclusions [27, 28]. With a comprehensive measurement of the socially disadvantaged factors, we have the following assumption in dialysis industry context:

**Hypothesis 1.** Healthcare organizations will be associated with lower clinical quality performances in socially disadvantaged contexts, ceteris paribus.

## 2.2 Chain – the moderating effect

Chain organizations, often called multi-unit enterprises, are structured networks of facilities or service providers operating under centralized management and standardized protocols. These organizations aim to leverage economies of scale, resource centralization, and standardized care protocols to improve efficiency, reduce costs, and enhance service delivery consistency across locations. In the healthcare industry, chain organizations are defined as networks of healthcare facilities unified under centralized public or private management, often sharing a familiar brand. These organizations exhibit characteristics such as centralized strategic direction, standardized governance structures, and centralized back-end functions like human resources, finance, procurement, and legal services. They operate with standardized protocols to ensure consistent service delivery and pursue shared goals, including improving patient outcomes, optimizing resource utilization, and achieving operational efficiency. By leveraging economies of scale, resource centralization, and efficient governance, chain organizations aim to enhance efficiency, reduce costs, and deliver high-quality, consistent care across multiple locations [29, 30].

Several studies have discussed the effectiveness of chain organizations, but their conclusions remain mixed. On the positive side, some studies emphasize that chain organizations centralize resource pooling, integrate supply chain management with lower costs, and ensure reliable access to essential medications, equipment, and technological infrastructures [31, 32]. Also, chain-based learning networks enable rapid dissemination of best practices and targeted interventions across multiple sites [33]. Conversely, some studies show that chain organizations cannot help much in the efficiency and quality of dialysis treatment. Large chain organizations (LGOs) in the dialysis industry can face challenges such as organizational inertia, which limits their ability to make swift decisions [13]. Market consolidation may also reduce the personalization of patient care, prioritizing standardized operations instead [34].

Additionally, geographical clustering by chain organizations can limit localized flexibility in service provision [35]. We summarized both sides of existing research in Table 1. Recent studies have pointed out that existing research often has limited attention to analyzing chain organizations across diverse regions. This oversight may contribute to inconsistent conclusions, as much of the research only examines the applicability of chains in specific areas. Although some works have recognized these differences, they remain constrained by the temporal and geographical boundaries of data collection. They lack a sound theoretical basis to explain and validate the underlying mechanisms through empirical investigations.

The DCT, introduced by David Teece et al. [43], offers a valuable framework to address this theoretical gap. The DCT shows that organizations with stronger ability to sense environmental changes, seize improvement opportunities, and reconfigure internal and external resources can better deliver the outcomes in volatile and various environments [43, 44, 45]. In the healthcare context, socially disadvantaged communities represent a unique and challenging environment. Patients' needs in these areas are often harder to identify due to irregularities in service availability and limitations in data collection. Uncertainty surrounding patient conditions is exacerbated by poor public health infrastructure and more complex complication profiles. Furthermore, healthcare facilities face resource scarcity, including limited access to medical supplies and institutional support [17, 46]. From the perspective of DCT, these barriers significantly hinder the ability of healthcare organizations to sense patient needs, seize opportunities for care improvement, and reconfigure care processes effectively. Factors such as unstable institutional support and insufficient community engagement further amplify these challenges [44, 45, 47].

Under such conditions, more than static clinical guidelines and traditional process optimization

**Table 1**: Summary of Studies on Hospital Consolidations and Dialysis Facilities

| Author | Title | Year | Focus | Results | Limitations | Region |
|---|---|---|---|---|---|---|
| Luke et al. | Local Markets and Systems: Hospital Consolidations in Metropolitan Areas [36] | 1995 | Formation of local hospital systems (LHSs) and market consolidation among metropolitan hospitals | Chain organizations and local hospital systems enhance market power and resource control. LHSs improve efficiencies through shared infrastructure and market positioning yet face challenges balancing consolidation with service accessibility. | Focuses on data from the early 1990s, limiting insights into post-1992 changes; findings may not generalize to rural or non-metropolitan contexts. | × |
| Hirth et al. | Practice Patterns, Case Mix, Medicare Payment Policy, and Dialysis Facility Costs [37] | 1999 | Cost implications of dialysis practice patterns, Medicare payment policies, and facility characteristics | Dialysis practice patterns and Medicare payment policies have significant cost impacts; hospital-based units have higher costs; economies vary among chain sizes. | Case mix data limited by census measures; endogeneity issues in estimating cost drivers. | × |
| Ozgen and Ozcan | A National Study of Efficiency for Dialysis Centers: An Examination of Market Competition and Facility Characteristics [38] | 2002 | Technical efficiency in freestanding dialysis facilities under different market and organizational conditions | Ownership form, market competition, and affiliation with dialysis chains significantly affect efficiency; for-profits generally outperform non-profits in mixed markets. | Cross-sectional design limits causal inferences; quality measures were not directly assessed. | × |
| Burns and Pauly | Integrated Delivery Networks: A Detour on the Road to Integrated Health Care [30] | 2002 | The rationales, performance, and lessons learned from vertical and horizontal integration of hospitals | Vertical and horizontal integration generally failed to improve economic performance. Key lessons include misaligned assumptions, poor management, and ineffective execution. | Studies are primarily based on data from the 1990s; insights are limited by the maturity and scope of integrated delivery networks during this period. | × |
| Grabowski and Hirth | Competitive Spillovers Across Non-profit and For-profit Nursing Homes [33] | 2003 | Examines quality differences and spillover effects between non-profit and for-profit nursing homes | Chain-affiliated facilities showed differentiated quality outcomes. Non-profit chains provide a quality spillover to for-profit chains, improving overall market quality. The presence of chains enhances inter-organizational competition, contributing to quality dynamics. | Limited to data from the mid-1990s. Spillover effects require further study to confirm underlying mechanisms. | × |

**Table 1 (continued)**

| Author | Title | Year | Focus | Results | Limitations | Region |
|---|---|---|---|---|---|---|
| Ozgen and Sahin | Measurement of Efficiency of the Dialysis Sector in Turkey Using Data Envelopment Analysis [39] | 2010 | Factors influencing the efficiency of Turkey dialysis centers | Chain-affiliated facilities, especially those linked to international chains, demonstrate higher efficiency compared to independent facilities. Facilities in national chains also show better utilization of resources than non-chains. Efficiency is influenced by scale and geographic location. | Cross-sectional study with 2008 data limits longitudinal insights; excludes potential case-mix adjustments and structural quality indicators; Turkey-specific context may not generalize globally. | ✓ |
| Saunders et al. | Variation in Dialysis Quality Measures by Facility, Neighborhood and Region [40] | 2013 | The effects of facility characteristics, neighborhood, region and chain on dialysis outcomes. | The proportion of African Americans in the dialysis facility neighborhood is strongly and consistently associated with lower facility quality. | Separately consider several isolated factors of social environment. Results come from facility-level. | ✓ |
| Shreay et al. | Efficiency of U.S. Dialysis Centers: An Updated Examination of Facility Characteristics [41] | 2014 | Factors influencing the efficiency of U.S. dialysis centers | Chain-affiliated facilities, particularly large chains, are less efficient compared to smaller or independent organizations. Efficiency appears negatively correlated with chain size. | analysis is based on 2010 cross-sectional data; excludes hospital-based dialysAnalysisities and lacks direct quality-of-care measures. | × |
| Shay and Mick | Clustered and Distinct: A Taxonomy of Local Multihospital Systems [42] | 2017 | Local multihospital systems (LMSs), focusing on their differentiation, integration, and spatial configurations | Chain organizations, as part of LMSs, demonstrate distinct taxonomy based on integration and differentiation. Highly integrated systems are most efficient but less common; configurations vary significantly based on market characteristics. | study relies on data from six U.S. states, limiting generalizability; temporal inconsistencies in datasets (2010–2012) may affect accuracy. | × |
| Dreyfus et al. | The Impact of Chain Organization Size on Efficiency and Quality of Affiliated Facilities—Implications for Multi-Unit Organizational Forms [13] | 2020 | The effects of chain organization size on dialysis quality and efficiency. | There is a U-shaped relationship between chain organization size and quality, as well as efficiency. | The differences between regional chain organizations are not captured. | × |

**Table 1 (continued 2)**

| Author | Title | Year | Focus | Results | Limitations | Region |
|---|---|---|---|---|---|---|
| Aghili et al. | Chain Hospitals in the Health Industry: A Scoping Review of Principles and Definitions [29] | 2023 | The concepts, principles, and definitions of chain hospitals and their organizational structures | Defined 55 different definitions for chain hospitals, presenting 6 main components (e.g., governance, organization) and 16 subcomponents; emphasized clarity in defining hospital types before implementation. | study limited to English-language articles and five databases; findings rely on interpretation of existing studies and exclude direct assessment of chain hospital effectiveness. | × |

are needed [3, 4]. Conversely, by leveraging the structure property of chain networks, chain organizations can improve the corresponding abilities of the independent facilities. Chains provide governance structures, dedicated QI specialists, and roving clinical informatics teams that guide facilities through iterative changes in practice. These shared capabilities reduce the risk of "organizational inertia," helping to update care processes as local conditions differ [25, 18]. This approach significantly aids facilities in establishing effective patient information databases, thereby improving their ability to sense and respond to patient needs. Moreover, chain networks facilitate knowledge transfer: if one affiliated dialysis clinic successfully implements a culturally tailored patient education program to enhance treatment adherence among low-income, linguistically diverse patients, other chain facilities can rapidly learn from this pilot's success [13]. A deeper understanding of diverse patient populations enables facilities to precisely assess patient conditions and seize opportunities to deliver timely, appropriate treatments. Furthermore, chain affiliation enables a more fluid reallocation of resources and staff. Affiliated facilities can rapidly implement evidence-based interventions by pooling strategic decision-making and financial resources at the chain level, preventing further deterioration in quality outcomes [48, 49]. This capacity to reconfigure resources effectively addresses challenges stemming from resource scarcity. In summary, according to DCT, though disadvantaged environment exerts a direct, negative pressure on healthcare quality, organizational affiliation by a chain should help mitigate these effects.

These mitigation mechanisms are especially applicable in dialysis care. Large dialysis organizations (LDOs) employ centralized quality monitoring platforms and QI teams that continuously assess performance metrics, identify underperforming sites, and promote successful interventions with a proven track record [23, 22]. Shared clinical protocols, such as standardized vascular access management or anemia control strategies, ensure consistent adherence to evidence-based practices. Additionally, bulk purchasing and pre-negotiated supplier contracts secure steady access to essential resources, including dialyzers and pharmaceuticals, which are critical for maintaining treatment quality. A chain-affiliated dialysis center operating in a low-income, ethnically diverse neighborhood can leverage system-wide cultural competence training, patient navigation strategies, and telehealth education platforms perfected at another facility serving similar populations. Centralized QI teams can swiftly tailor these initiatives, ensuring that disadvantaged sites can approximate the quality performance of better-resourced settings. Collectively, these networked efforts enhance chain-affiliated clinics' ability to sense evolving needs, seize opportunities for improvement, and reconfigure processes to consistently deliver high-quality care, even under challenging external conditions. Based on the perspectives mentioned before, we assume in the dialysis industry:

**Hypothesis 2.** The positive effect of chain affiliation on clinical quality performance will be more pronounced in socially disadvantaged contexts, ceteris paribus.

# 3 Data, Operationalization of Variables, and Summary Statistics

## 3.1 Data sources and sample selection

The dialysis industry has experienced substantial consolidation in recent decades, driven in part by cost pressures, regulatory changes, and increased competition [24]. Federal initiatives, including the Medicare Improvements for Patients and Providers Act, require public reporting of facility-level performance metrics, thereby enhancing transparency and accountability [50]. The data used in this study reflect these broader industry conditions, providing a setting conducive to examining the drivers of performance and quality.

This study employs a comprehensive panel dataset from the year 2015–2019, drawn primarily from publicly available administrative sources maintained by the Centers for Medicare & Medicaid Services (CMS). Under federally mandated conditions of coverage, dialysis facilities must report detailed operational, clinical, and patient outcome metrics at regular intervals [51]. This requirement fosters consistent and transparent data, enabling large-scale empirical analyses of facility-level quality and operational efficiency [22, 26, 50].

The initial dataset includes 33,686 facility-year observations from 10,568 CMS-registered dialysis facilities over five years. To improve comparability, we restrict the sample to facilities offering only hemodialysis, thereby mitigating confounding effects arising from varying treatment modalities [23, 22]. Next, we merge these facility-level clinical data with information from the Healthcare Cost Report Information System (HCRIS), which provides standardized financial and human resource indicators. This integration follows established research practices that combine clinical and financial data to identify determinants of healthcare quality [13, 48, 49]. The final merged sample comprises 25,974 observations through 5,748 centers, forming a robust basis for investigating drivers of quality performance in a rapidly evolving industry.

## 3.2 Social disadvantage

Prior empirical research has frequently focused on single socioeconomic indicators—such as household income—to characterize community-level advantages [52, 53]. More recent work, however, has underscored the limitations of such narrow approaches and emphasized the need for more comprehensive measures that capture the broader array of social determinants influencing health outcomes [54, 55].

In this study, we employ the Social Vulnerability Index (SVI), a composite metric developed by the U.S. Centers for Disease Control and Prevention (CDC), which integrates socioeconomic, demographic, and housing indicators into a single measure of community-level social disadvantage [56, 57, 58]. By reflecting the multifaceted factors that shape a population's resilience to health-related threats, the SVI has gained widespread recognition in healthcare research as an effective tool for understanding disparities in health outcomes, healthcare access, and quality of care [59, 60]. The SVI ranges from 0 to 1, with higher values indicating greater social disadvantage. In our dataset, the mean SVI for communities in which the institutions are located is 0.57 (SD = 0.25).

## 3.3 Chain status

Chain affiliation reflects whether a dialysis facility is part of a larger organizational network or operating as an independent entity [30, 61]. Chain-affiliated facilities often benefit from shared governance, centralized procurement, standardized clinical protocols, and well-developed internal knowledge networks [31, 32]. We operationalize Chain as a binary indicator, coded as 1 if the facility is affiliated with a chain and 0 otherwise. The proportion of chain-affiliated facilities in our dataset increases steadily from 4,671 in 2015 to 5,618 in 2019. This growth aligns with broader consolidation patterns in the dialysis industry and enhances our capacity to examine whether chain affiliation moderates the impact of social disadvantage on quality performance.

## 3.4 Quality outcomes

We measure clinical quality performance using the CMS Quality Incentive Program (QIP), a

federal pay-for-performance initiative that links reimbursement adjustments to dialysis facility outcomes [51]. The QIP consolidates multiple clinical indicators designed to encourage adherence to evidence-based practices, enhance patient safety, and improve treatment effectiveness. Among these indicators are measures of dialysis adequacy (e.g., Kt/V, which captures toxin and fluid removal effectiveness) and vascular access management (e.g., increased use of arteriovenous fistulas and grafts over catheters), as well as other relevant quality measures.

Importantly, the QIP's comprehensive, nationally benchmarked framework confers credibility and consistency to our measures. Public reporting of QIP outcomes further induces facilities to maintain or improve quality, thereby capturing both the clinical execution of dialysis care and providers' responsiveness to institutional pressures. Prior studies have employed the QIP as a key measure of dialysis performance, demonstrating its utility in assessing facility-level quality improvements, guiding payment reforms, and examining the effects of incentives on clinical outcomes [13, 62, 63]. The QIP composite score ranges from 0 to 100. In our sample, the mean QIP score over the five-year period is 70.46 (SD = 13.70), indicating substantial variation in quality performance across dialysis providers. By employing the QIP composite metric, we adopt a policy-relevant, multi-dimensional score of dialysis care quality.

### 3.5 Control variables and operationalization

In addition to chain affiliation and social disadvantage, we include several facility-level controls to address potential confounding influences on clinical quality performance. Prior research in health services and organizational studies indicates that an institution's ownership structure, operational experience, scale of operations, resource availability, and staffing configuration can affect outcomes by shaping managerial priorities, patient care processes, and the implementation of improvement initiatives [64, 65, 66].

First, we control facility ownership form by including a binary indicator coded as 1 if the facility is for-profit and 0 otherwise. Ownership status may influence decision-making horizons, efficiency goals, and the emphasis placed on quality-improvement activities [67]. The dialysis sector features a high proportion of for-profit providers, and accounting for this characteristic helps isolate the effects of other organizational and environmental factors.

Second, we incorporate a measure of the facility's operational experience using the number of years since its initial certification under Medicare conditions. Greater operational tenure is often associated with accumulated expertise, more refined care protocols, and enhanced capacity to address clinical complexity, all of which may foster quality improvement over time [68, 69]. This variable offers insight into the learning curve that facilities undergo as they gain familiarity with patient populations, treatment technologies, and regulatory expectations.

We also include variables that capture the facility's scale and resource intensity. The number of dialysis stations serves as an indicator of physical capacity and scope, potentially influencing both the efficiency of care delivery and the ability to maintain high standards under varying patient loads [70]. Additionally, drug-related expenses, expressed in logged form to mitigate skewness, proxy for the complexity and breadth of clinical services. Facilities with higher drug expenditures may treat more clinically challenging patient populations or utilize a broader set of therapeutic interventions, potentially affecting outcomes and the feasibility of quality enhancement.

Further, we control overall patient volume, represented by the number of treatments. Patient volume can influence operational performance through learning-by-doing effects, scale economies, or strain on resources, as higher volumes may drive efficiency gains or intensify workload pressures [71, 72]. Recognizing these potential countervailing forces, including treatment volume allows us to discern whether higher patient throughput correlates with improved or diminished quality in the dialysis setting.

Finally, workforce composition can shape the delivery of clinical care and the facility's capacity to implement new initiatives. We include variables capturing the total number of clinical staff (physicians & registered nurses), and non-clinical

**Table 2**: Correlation Matrix

| **Variables** | Mean | SD | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Quality outcomes | 70.46 | 13.71 | 1.000 | | | | | | | | | | |
| (2) Social disadvantages | 58.83 | 26.73 | -0.085** | 1.000 | | | | | | | | | |
| (3) Chain status | 0.93 | 0.26 | 0.117** | -0.030** | 1.000 | | | | | | | | |
| (4) Profit status | 0.93 | 0.26 | -0.005 | -0.044** | -0.031** | 1.000 | | | | | | | |
| (5) Years certified | 18.80 | 10.12 | -0.066** | 0.103** | 0.079** | 0.097** | 1.000 | | | | | | |
| (6) Number of Station | 18.49 | 7.85 | -0.140** | 0.183** | 0.030** | 0.058** | 0.380** | 1.000 | | | | | |
| (7) Lab net-expenses† | 10.59 | 0.75 | 0.012* | 0.105** | -0.025** | 0.052** | 0.224** | 0.516** | 1.000 | | | | |
| (8) Drug net-expenses† | 12.64 | 0.74 | -0.076** | 0.170** | -0.024** | 0.067** | 0.241** | 0.635** | 0.633** | 1.000 | | | |
| (9) Treatment numbers† | 9.17 | 0.63 | -0.102** | 0.183** | -0.010 | 0.013* | 0.289** | 0.703** | 0.725** | 0.835** | 1.000 | | |
| (10) Clinical Staff | 5.75 | 4.05 | -0.098** | 0.112** | -0.098** | 0.078** | 0.205** | 0.544** | 0.571** | 0.711** | 0.767** | 1.000 | |
| (11) Nonclinical Staff | 10.72 | 6.97 | -0.115** | 0.168** | -0.025** | 0.057** | 0.295** | 0.665** | 0.616** | 0.717** | 0.832** | 0.602** | 1.000 |

** p<0.01, * p<0.05

†Denotes log-transformed variable.

staff. Adequate and well-trained nursing personnel are known to be associated with better patient outcomes and safer practices, whereas administrative and support staff may facilitate smoother operations and patient coordination [73, 66]. We log-transform select staffing variables to achieve more stable distributions and improve estimation reliability.

Collectively, these controls help ensure that our analyses more accurately isolate the effects of chain affiliation and social disadvantage on clinical quality performance (See, Table 2). By incorporating a diverse set of organizational, financial, and human resource metrics, we acknowledge the complexity of health care service delivery and better account for the multifaceted nature of quality improvement efforts in the dialysis sector.

# 4 Method

## 4.1 Fixed effects models

Our empirical analyses examine how social disadvantage influences clinical quality performance and whether chain affiliation moderates this relationship. We employ fixed effects (FE) regressions to address unobserved, time-invariant facility attributes and year-specific shocks common to all facilities. To verify that the fixed-effects (FE) specification is superior to the alternative estimations, we conduct serial standard statistical tests (See, Table 3). Specifically, we use the Braasch-Pagan Lagrange multiplier and the Hausman test to determine that the random-effects (RE) model is superior to ordinary least squares (OLS) and that the fixed-effects (FE) model is preferable to the RE model. To avoid potential multicollinearity errors, we evaluate the variance inflation factor (VIF). The VIF values for all variables are below 10, with a mean VIF below 2.7 for all models, indicating that collinearity remained within an acceptable range of below 5 (Kutner et al., 2005). Specifically, we estimate the following models (1)–(2).

Here, $i$ indexes facilities and $t$ indexes years. $QualityOutcomes_{it}$ is the clinical quality performance measure for facility $i$ in year $t$. $SD_{it}$ measures social disadvantage, and $Chain_{it}$ indicates chain affiliation. The parameters $\alpha_i$ and $\delta_t$ are facility and year fixed effects, respectively, capturing unobserved, time-invariant facility characteristics and common temporal shocks. $X_{it}$ is a vector of control variables (e.g., profit status, years since certification, facility size, expenditure levels, treatment volume, staffing composition), and $\epsilon_{it}$ is the error term.

## 4.2 Endogeneity

Although we include a range of facility- and community-level controls—such as facility size, profit status, local economic conditions, and regional health system characteristics—to mitigate potential omitted variable bias, three sources of endogeneity may still persist: measurement errors, confounding factors, and reverse causality [74]. Measurement errors are less concerning in this context, given the rigorous data collection protocols of the Centers for Medicare & Medicaid Services (CMS), the Census Bureau, and the Bureau of Labor Statistics (BLS) [75]. However, the Social Vulnerability Index (SVI)—which captures social disadvantage—may not be strictly exogenous due to the remaining two sources of endogeneity.

**Table 3**: Model Selection Tests

| Test | Purpose | Metric |
|---|---|---|
| Breusch–Pagan Lagrange Multiplier | RE model is preferable to pooled OLS model if $p < 0.01$ | $p < 0.001$ |
| Hausman | FE model is preferable to RE model if $p < 0.01$ | $p < 0.01$ |
| Multicollinearity | Evaluates potential multicollinearity if VIF $> 5$ | VIF $= 2.7$ |

$$\text{Quality Outcomes}_{it} = \alpha_i + \delta_t + \beta_1\, SD_{it} + \beta_2\, \text{Chain}_{it} + X_{it}\,\Phi + \epsilon_{it} \tag{1}$$

$$\text{Quality Outcomes}_{it} = \alpha_i + \delta_t + \beta_1\, SD_{it} + \beta_2\, \text{Chain}_{it} + \beta_3\big(\text{Chain}_{it} \times SD_{it}\big) + X_{it}\,\Phi + \epsilon_{it} \tag{2}$$

**Table 4**: Model Selection Tests

| Test | Purpose | Metric |
|---|---|---|
| Under identification | Instruments are relevant if $p < 0.05$ | $p < .001$ |
| Sargan-Hansen (over identification) | Instruments are exogenous if $p > 0.1$ | $p = .31$ |
| Weak identification | Instruments are not weak if $F > 10$ & critical values* | $F = 57$ |

Notes* : critical values = 16.87 (Stock-Yogo weak ID test 10% maximal IV size)

First, confounding factors (e.g., insufficient public infrastructure, limited educational opportunities, and weak social support) can simultaneously influence patient behaviors and provider outcomes [16, 76, 54, 25]. For instance, communities lacking reliable transportation or facing widespread language barriers often exhibit lower adherence to recommended treatments, thereby biasing performance metrics. Second, reverse causality may arise if improvements in local healthcare services attract higher-socioeconomic-status individuals, leading to a decline in a community's SVI and triggering a feedback loop.

To address these concerns, we employ an instrumental variable (IV) regression model [74]. We select two instruments theorized to correlate with social disadvantage yet exert minimal direct influence on facility-level decisions. The first instrument— mean RN hourly salary at the state level — reflects broader economic conditions and resource costs that shape social vulnerability. Because RNs form the core workforce in dialysis centers, higher RN wages often indicate better regional employment opportunities and greater wealth, both of which can affect local socioeconomic conditions [76, 54]. The second instrument—the population aged 16 and over at the county level—captures local demographic characteristics commonly associated with social disadvantages, such as potential workforce size and educational attainment [16]. However, these measures do not present individual facility-level resource allocation or clinical processes, thereby minimizing direct endogeneity with facility performance [74]. In this study, we log-transform the population variable to improve precision and address potential non-linearities.

Interaction effects that include endogenous variables can complicate estimation further. As established by Angrist and Pischke [77] and Wooldridge [78], when interaction terms involve at least one endogenous variable, constructing additional instrumental variables becomes necessary. Specifically, this requires multiplying the original instruments by the second level interacting variable ($Chain$) to form a set of interaction instruments. Therefore, the interaction terms, $Chain \times \overline{RNSalary}$ and $Chain \times \log(Population_{16+})$, are constructed to improve identification by capturing the interaction-driven variation in the endogenous regressor while maintaining exclusion criteria. The approach enhances the robustness of our IV framework.

While fixed-effects modeling helps mitigate time-invariant unobserved heterogeneity, we employ an IV Generalized Method of Moments (GMM) approach for the potential heteroskedasticity and within-group error correlation, thereby further enabling robustness in estimation. Notably, the frequently used IV two-stage least squares (2SLS) estimator is essentially a special case of GMM, relying on assumptions of homoscedastic and serially uncorrelated errors. By contrast, IV-GMM offers a more flexible variance-covariance matrix, potentially yielding greater efficiency. As shown in Table 4, the selected instruments meet both relevance and exclusion criteria, confirming their validity for resolving endogeneity.

# 5 Results

In Model 1, the coefficient on $SD$ is negative and statistically significant (-100.036, p¡0.01), indicating that higher levels of social disadvantage are associated with lower clinical quality scores. The results support Hypothesis 1. This finding aligns with previous studies [18, 25] showing social disadvantage communities pose challenges that inhibit consistent delivery of high-quality care. This finding supports Hypothesis 2, which posited that chain-affiliated facilities, benefiting from economies of scale, standardized clinical protocols, and internal knowledge sharing, achieve

more stable and higher clinical quality levels [61, 23, 49]. In Model 2, the coefficient on the interaction is positive and statistically significant (82.839, $p < 0.05$), indicating that as $SD$ intensifies, chain affiliation mitigates the downward pressure on quality performance. In other words, chain-affiliated facilities do not experience as steep a decline in clinical quality in response to increasing $SD$ as non-chain facilities do. The result validates Hypothesis 2. This finding supports the DCT, which posited that chain-affiliated facilities, benefiting from economies of scale, standardized clinical protocols, and internal knowledge sharing, achieve more stable and higher clinical quality levels [61, 23, 49].

**Table 5**: IV-GMM Estimation Results

| | (1) | (2) |
|---|---|---|
| Social disadvantages | -100.036*** | -157.270*** |
| | (30.420) | (44.984) |
| Chain | -0.057 | 2.604 |
| | (1.025) | (2.106) |
| Social disadvantage × Chain | | 82.839** |
| | | (40.231) |
| Profit status | -0.671 | -0.415 |
| | (1.798) | (1.652) |
| Years certified† | -4.365** | -4.179** |
| | (2.033) | (1.904) |
| Dialysis stations† | -2.033 | -2.331* |
| | (1.446) | (1.410) |
| Laboratory expenses† | 3.062*** | 3.034*** |
| | (0.267) | (0.266) |
| Drug expenses† | 1.910*** | 1.790*** |
| | (0.396) | (0.406) |
| Number of treatments† | -3.399*** | -3.101*** |
| | (0.686) | (0.709) |
| Clinical staff† | 0.779** | 0.892** |
| | (0.358) | (0.374) |
| Nonclinical staff† | 1.728*** | 1.702*** |
| | (0.470) | (0.473) |
| $F$-statistic | 615*** | 598*** |
| $R$-squared (within) | 0.342 | 0.328 |
| State FE | ✓ | ✓ |
| Year FE | ✓ | ✓ |
| $N$ of facilities | 5,748 | |
| $N$ of observations | 25,974 | |

Robust clustered standard errors are reported.
†Denotes log-transformed variable. *$p$ <0.10, **$p$ <0.05, ***$p$ <0.01.

Figure 1, as local social disadvantage deepens; non-chain healthcare facilities experience sharper declines in quality than chain-affiliated facilities. While community-level improvements—such as enhanced education, transportation, and preventive care—take substantial time, chain networks can implement organizational interventions rapidly. Chain affiliation fosters resource reallocation scaled best practices, and staff training, yielding meaningful quality gains even in the face of entrenched social challenges. The evidence suggests that chain networks can offset disadvantages more effectively in the short term than waiting for broader socioeconomic reforms. Rather than viewing local conditions as fixed barriers, supporting collaborative networks and chain structures can serve as a strategic stopgap—if not a long-term solution—to improve healthcare quality amid persistent socioeconomic constraints.

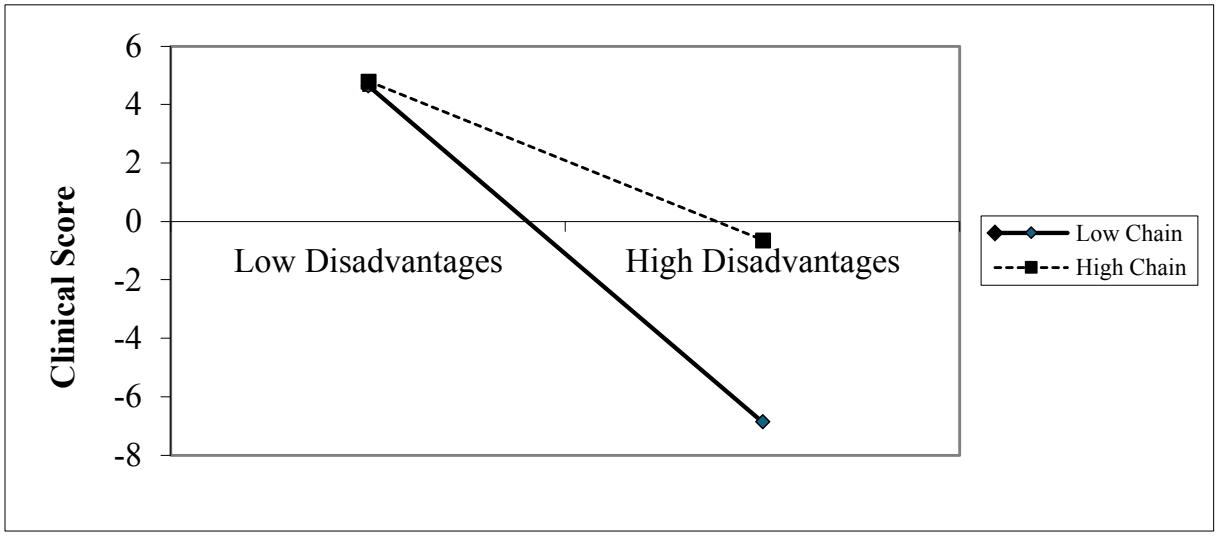
# 6 Robustness

## 6.1 Alternative method approach

To ensure the robustness of the findings obtained using the IV-GMM approach, this study employs two additional IV estimation methods: 2SLS and Limited Information Maximum Likelihood (LIML). These methods effectively address methodological concerns and offer complementary strengths.

First, 2SLS is effective in handling endogeneity through instrumental variables. This method separates the endogenous variable, such as the SVI, from the error term using a two-stage process. In the first stage, instruments predict the endogenous variable, which is then used in the second stage to estimate the outcome. While 2SLS assumes homoscedasticity and can be sensitive to weak instruments, it provides reliable results under appropriate conditions. Second, LIML is

**Fig. 1**: Two-way linear interaction effects estimated via regression analysis




employed as an alternative method to address potential instrument weaknesses, while IVs are not weak in our study. LIML is particularly robust in the presence of weak instruments and produces consistent estimates under more flexible assumptions than 2SLS. This makes LIML a valuable complement to 2SLS, especially in cases of uncertain instrument strength.

The results from these methods, as shown in Table 7, closely align with the statistics from IV-GMM, demonstrating the robustness of the findings. Specifically, 2SLS (Model 3) and LIML (Model 5) both show that higher social disadvantage, as measured by SVI, is associated with lower clinical quality scores. The coefficients for $SD$ are negative and statistically significant (-95.805, $p < 0.01$ in 2SLS; -96.165, $p < 0.01$ in LIML). Similarly, chain affiliation exhibits positive effects in both methods, with slightly smaller coefficients observed in 2SLS (2.162 in Model 4) than in LIML (2.271 in Model 6). Both 2SLS and LIML confirm that chain affiliation mitigates the negative impact of social disadvantage on clinical quality. The interaction term between $SD$ and chain affiliation is positive and statistically significant (62.653, $p < 0.05$ in 2SLS Model 4; 65.188, $p < 0.10$ in LIML Model 6), reinforcing the hypothesis that chain-affiliated facilities better sustain quality performance under challenging socioeconomic conditions. These findings highlight the robustness and reliability of the results.

## 6.2 Alternative subgroup analysis

To further validate the moderating role of chain affiliation in the relationship between social disadvantage and clinical quality performance, we conduct a subgroup analysis based on the Social Vulnerability Index (SVI). Subgroup analysis is widely recognized as a robust method to address heterogeneity across contexts, particularly in studies of socioeconomic disparities (Diez Roux, 2012; Braveman et al., 2011). By categorizing regions into low, medium, and high SVI groups using the mean and $\pm 1$ standard deviation, we capture potential contextual variations that may be masked in aggregate analysis.

The results presented in Table 8 align with our main findings. Among the three subgroups, the coefficient for chain affiliation is highest (7.954, $p < 0.01$) in the high SVI group and lowest (3.395, $p < 0.01$) in the low SVI group. This pattern confirms that the moderating effect of chain affiliation is significantly stronger in regions characterized by higher levels of social disadvantage. These findings reinforce the importance of chain structures in addressing clinical quality disparities, particularly in socioeconomically vulnerable areas.

### 6.3 Alternative independent – the unscaled SVI

The main analysis relies on the Rescaled Percentile Rank (RPL), a normalized version of SVI, widely employed in empirical research to facilitate cross-regional comparability [79, 57]. Bonnett and Heim [80] indicate that the scaling variables may cause inconsistent results and, in this way, validate their main results using the raw measures in the robustness section. To mitigate potential scaling effects, we incorporate the Summed Percentile Rank (SPL), an unscaled version of SVI. Table 6 indicates Model (10)-(11) results. The findings based on SPL align closely with those derived from RPL, with no changes in the direction or significance of the results. The regressions ensure robustness and validate the consistency of the analyses, irrespective of scaling [81].

## 7 Post Hoc Analysis

In the main analysis, we treat chain status as a binary feature, distinguishing between chain and independent facilities. This approach aligns with prior research on integrated delivery systems and LDOs [61, 32]. However, other studies suggest that chain size can significantly influence organizational quality and efficiency, with its impact shaped by the heterogeneity in the chain scale. Based on our preceding analysis, the mitigating effects of chain affiliation should consistently benefit, especially as larger chains possess more substantial dynamic capabilities, including extensive internal learning networks, broader managerial expertise, and more flexible resource pools [44, 45].

To test this extrapolation, we re-estimated our models by grouping chain affiliation into three categories: small chains (fewer than 100 facilities), mid-sized chains (100–1,000 facilities), and large chains (more than 1,000 facilities). This categorization aligns with the observed structure of the U.S. dialysis market, where two dominant organizations each manage more than 1,000 units, while other chains remain smaller (see Table 6). Table 9 (models 7–9), the core patterns persist by comparing the social disadvantage impacts through different chain size groups. Specifically, large chains display the highest coefficient on social disadvantage ($-51.348, p < 0.1$) compared to mid-sized ($-180.694, p < 0.05$) and small ($-209.227, p < 0.1$) chains.

More specifically, these findings broaden our conclusions in two important ways. First, compared with our second hypothesis in the main analysis, which only distinguishes between independent facilities (chain scale $= 1$) and chain-affiliated facilities (chain scale $\neq 1$), these results reveal a more nuanced continuum: of the larger the chain, the more effectively it can mitigate the impact of social disadvantages. This finding extends beyond a simple dichotomy and underscores the importance of chain scale in moderating the relationship between social disadvantages and organizational outcomes. The enhancement of facilities' resilience depends on the scale of chain affiliations, which means a larger scale of chain organization will provide greater capability to against the adverse external conditions. Facilities joining a larger chain absorb best practices, specialized training, and supply chain efficiencies that they could not access independently.

Second, the observed scale-based effects imply *collective* benefits for both newly affiliated sites and the broader chain community. Specifically, the larger chain also gains from the diverse experiences and patient populations at newly integrated sites, enhancing the network's collective capacity for sensing emergent needs and experimenting with culturally tailored interventions [13, 44]. In other words, these newly affiliated sites broaden the chain's overall network capacity and scale, benefiting themselves and existing affiliates. This reciprocal dynamic strengthens the chain's collective ability to sense emergent needs and experiment with culturally tailored interventions, as well as enhances its resilience against adverse socioeconomic pressures.

## 8 Discussion

The findings suggest that chain affiliation can meaningfully moderate the negative relationship between social disadvantage and clinical quality in the dialysis sector. Our empirical results show that, on average, facilities operating in higher-disadvantage communities scored 6–8% lower on core quality measures, reflecting the substantial challenges posed by socioeconomic barriers such as low health literacy, limited transportation,

**Table 6**: Distribution of Chain Sizes

| Chain size | Range of scale | Number of organizations | Approx. % of observations |
|---|---|---|---|
| Small | 1 – 100 | 71 | 10% |
| Medium | 101 – 1000 | 19 | 20% |
| Large | > 1000 | 2 | 70% |

and cultural mistrust. Crucially, however, chain-affiliated facilities maintain higher baseline quality and experience significantly less performance deterioration as social disadvantage intensifies. The results answer the debates about the social and ethical effects of chain organizations in disadvantaged areas, proving that ESRD patients would achieve better care after expansion. Also, our study contributes to three other aspects: theoretical basis, managerial, and policy-making insights.

Initiated from DCT, we demonstrate how chain affiliation provides a structural platform for adaptation, thus mitigating the negative impacts of socially disadvantaged environments. We can conclude that the benefits come from three essential abilities: sensing needs, seizing opportunities, and reconfiguring resources. In disadvantaged contexts, independent facilities often encounter severe constraints in seizing the needs and conditions of patients, which limit their ability to implement new interventions swiftly or sustain continuous improvement. In contrast, chain-owned sites can leverage internal data analytics systems to identify emergent care gaps, mobilize specialized staff from other locations to address resource bottlenecks and replicate successful culturally tailored education campaigns initially tested in a similar low-literacy community. This internal "innovation marketplace," where proven interventions travel quickly through chain networks, effectively amplifies dynamic capabilities—turning a challenging environment from a persistent liability into a scenario where quality improvements are still attainable.

Moreover, the study provides actionable insights for healthcare management, highlighting strategies for optimizing operations in underserved communities. By applying DCT, chain organization managers can better evaluate the risks and opportunities associated with expanding into socially disadvantaged areas and operate their structures to offer essential resources to facilities facing disadvantaged environments. Specifically, LDOs should focus on developing robust internal communication platforms to ensure seamless information sharing, adopting a flexible staffing model to deploy specialized expertise where it is most needed, and implementing advanced resource allocation tools to fully leverage the value chain.

Additionally, the post hoc analysis underscores that *not all chain affiliations are created equal*. Larger chains, with more extensive organizational capabilities, exhibit stronger inter-facility knowledge flows and a more powerful capacity to flexibly allocate resources where needed most. Consequently, if an independent dialysis center located in a highly disadvantaged region is considering acquisition or partnership, alignment with a larger chain may yield more substantial improvements in clinical quality. For the chain side, acquiring or establishing new facilities in underdeveloped areas is not merely a cost or philanthropic gesture; it also enriches the chain's ability to handle diverse challenges and patient populations. The result is a "win-win" dynamic in which new affiliates gain operational resilience, while the entire network benefits from fresh insights into serving marginalized communities.

Lastly, the findings provide policymakers with practical steps to improve the quality of care delivery for underserved populations. Policymakers can draw on this evidence to design incentives that support chain-based solutions or encourage independent providers to form collaborative networks. Consider a chain-affiliated dialysis center located in a predominantly Hispanic, low-income urban neighborhood. Independent facilities might struggle to improve adherence if patients cannot easily attend thrice-weekly sessions or understand dietary recommendations. The local clinic can rapidly adopt these strategies by drawing on another chain facility's successful pilot program—such as using bilingual community health workers, partnering with a nearby food bank for nutrition education, and using a mobile app to coordinate patient transportation. Centralized QI

**Table 7**: Alternative IV estimation - 2SLS and LIML approach

| | 2SLS | | LIML | |
|---|---|---|---|---|
| | (3) | (4) | (5) | (6) |
| Social disadvantage | -95.805*** | -121.582*** | -96.165*** | -127.816*** |
| | (26.708) | (38.974) | (26.816) | (41.497) |
| Chain | -0.082 | 2.162 | -0.081 | 2.271 |
| | (0.886) | (1.573) | (0.886) | (1.639) |
| Social disadvantage × Chain | | 62.653** | | 65.188* |
| | | (31.706) | | (33.818) |
| Profit status | -0.644 | -0.342 | -0.645 | -0.343 |
| | (1.746) | (1.649) | (1.747) | (1.657) |
| Years certified† | -4.592** | -4.151** | -4.595** | -4.183** |
| | (1.859) | (1.735) | (1.861) | (1.758) |
| Dialysis stations† | -1.986 | -2.238* | -1.985 | -2.233* |
| | (1.275) | (1.256) | (1.276) | (1.259) |
| Laboratory expenses† | 3.068*** | 3.078*** | 3.068*** | 3.071*** |
| | (0.261) | (0.261) | (0.261) | (0.263) |
| Drug expenses† | 1.912*** | 1.829*** | 1.912*** | 1.824*** |
| | (0.369) | (0.378) | (0.370) | (0.380) |
| Number of treatments† | -3.389*** | -3.273*** | -3.389*** | -3.271*** |
| | (0.647) | (0.669) | (0.647) | (0.673) |
| Clinical staff† | 0.779** | 0.927*** | 0.778** | 0.923*** |
| | (0.337) | (0.353) | (0.337) | (0.355) |
| Nonclinical staff† | 1.720*** | 1.681*** | 1.721*** | 1.686*** |
| | (0.438) | (0.442) | (0.438) | (0.444) |
| State FE | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | ✓ | ✓ | ✓ |

Robust standard errors are reported. *$p$ <0.10, **$p$ <0.05, ***$p$ <0.01.
†Denotes log-transformed variable.

**Table 8**: Alternative independents — region groups and unscaled SVI

| | Region groups | | | Raw SVI | |
|---|---|---|---|---|---|
| | (7) | (8) | (9) | (10) | (11) |
| Social disadvantage | | | | -8.962*** | -26.645*** |
| | | | | (2.920) | (5.752) |
| Chain | 3.395*** | 5.834*** | 7.954*** | -0.709 | -168.802*** |
| | (1.256) | (0.692) | (1.178) | (0.798) | (47.773) |
| Social disadvantage × Chain | | | | | 21.500*** |
| | | | | | (6.103) |
| Profit status | -2.318** | -0.569 | 1.098 | -0.089 | -0.825 |
| | (0.930) | (0.555) | (0.976) | (1.591) | (1.589) |
| Years certified† | 0.666 | 0.189 | 0.843* | -2.518** | -1.351 |
| | (0.415) | (0.263) | (0.473) | (1.229) | (1.238) |
| Dialysis stations† | -1.442 | -2.101*** | -2.807** | -2.251* | -2.410* |
| | (0.910) | (0.524) | (1.135) | (1.267) | (1.262) |
| Laboratory expenses† | 1.304*** | 2.519*** | 1.924*** | 3.060*** | 2.873*** |
| | (0.480) | (0.299) | (0.428) | (0.245) | (0.252) |
| Drug expenses† | 1.842*** | 0.673* | 2.038*** | 1.847*** | 1.396*** |
| | (0.643) | (0.391) | (0.636) | (0.345) | (0.370) |
| Number of treatments† | -5.224*** | -3.492*** | -3.277*** | -3.322*** | -2.811*** |
| | (1.076) | (0.625) | (1.145) | (0.595) | (0.618) |
| Clinical staff† | 0.105 | 0.029 | 0.520 | 0.497 | 0.644** |
| | (0.471) | (0.308) | (0.577) | (0.321) | (0.325) |
| Nonclinical staff† | 0.067 | -0.048 | -0.941 | 1.727*** | 1.886*** |
| | (0.572) | (0.385) | (0.585) | (0.411) | (0.411) |
| State FE | ✓ | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | ✓ | ✓ | ✓ | ✓ |

Robust standard errors are reported. *$p$ <0.10, **$p$ <0.05, ***$p$ <0.01.
†Denotes log-transformed variable.

**Table 9**: Post Hoc analysis — chain size

| | Chain size | | |
|---|---|---|---|
| | (12) | (13) | (14) |
| Social disadvantage | -209.227* | -180.694** | -51.348* |
| | (111.045) | (83.832) | (28.606) |
| Profit status | 5.917*** | -2.911 | 1.934 |
| | (1.438) | (6.565) | (2.295) |
| Years certified† | 6.247** | -83.567*** | -3.273*** |
| | (2.799) | (5.417) | (1.259) |
| Dialysis stations† | 6.461 | -3.814 | -2.737 |
| | (6.115) | (3.944) | (1.685) |
| Laboratory expenses† | 0.070 | 3.007*** | 5.941*** |
| | (1.504) | (0.972) | (0.488) |
| Drug expenses† | 0.205 | -1.052 | 3.444*** |
| | (1.268) | (1.411) | (0.674) |
| Number of treatments† | -1.280 | 0.276 | -8.204*** |
| | (2.273) | (1.787) | (1.211) |
| Clinical staff† | -0.813 | -0.837 | 1.507** |
| | (1.438) | (0.938) | (0.703) |
| Nonclinical staff† | 0.401 | 0.909 | 3.939** |
| | (1.739) | (1.104) | (1.597) |
| State FE | ✓ | ✓ | ✓ |
| Year FE | ✓ | ✓ | ✓ |

Robust standard errors are reported. *$p$ <0.10, **$p$ <0.05, ***$p$ <0.01.
†Denotes log-transformed variable.

teams and standardized training modules streamline this knowledge transfer, ensuring the disadvantaged site benefits from network-level learning.

The global health landscape, as articulated in the United Nations Sustainable Development Goals and ongoing CMS health equity initiatives, calls for reducing disparities in access and outcomes. The evidence presented here suggests that chain-affiliated organizations can be strategic allies in achieving these goals. In rural dialysis centers with sparse specialist availability, or facilities serving predominantly minority populations that face linguistic and cultural barriers, chain structures support the rapid diffusion of context-specific solutions. By complementing broader public health reforms and targeted policy interventions, chain organizations—through their internal learning networks—can help level the playing field and advance equity in care quality.

# 9 Conclusion

This study demonstrates that chain affiliation plays a moderating role in mitigating the negative effects of social disadvantage on dialysis facility quality. Chain-affiliated facilities exhibit stronger resilience and adaptability in challenging socioeconomic contexts by leveraging dynamic capabilities—namely, enhanced sensing of patient needs, seizing improvement opportunities, and reconfiguring resources. Our findings indicate that chain networks can help overcome socioeconomic barriers in underserved areas by disseminating best practices, reallocating resources, and proactively refining care delivery processes.

Despite these contributions, several limitations warrant caution. First, our study relies on secondary data compiled from CMS sources and other publicly available datasets. Although these sources are standardized and widely used, we cannot entirely exclude potential coding errors or biases inherent in large administrative databases. Second, our measurement of social disadvantage employs composite indices (e.g., SVI), while capturing the multi-dimensional of social adversity—do not distinguish among specific barriers, such as linguistic isolation or transportation insecurity. Future research could use more granular data (e.g., household-level socioeconomic measures) to better capture localized nuances. Third, although we used multiple robustness checks and an instrumental variables approach, endogeneity issues may persist if unobserved factors (e.g., local policy interventions, unique community assets) systematically affect both social disadvantage and facility performance. Finally, this study focuses exclusively on dialysis facilities in the U.S.; thus, the generalizability of our findings to other healthcare contexts or countries with different regulatory and reimbursement frameworks may be limited.

Future studies can build on our findings by examining how chain affiliation operates in other healthcare domains—particularly in chronic care settings where patient engagement is critical but socioeconomic constraints are pervasive. Incorporating finer-grained data, such as patient-level adherence metrics and localized social determinants of health, could shed light on the underlying mechanisms through which organizational capabilities specifically address different types of disadvantages. Comparative analyses of multiple health system structures (e.g., accountable care organizations and regional health cooperatives) may also clarify whether these governance forms exhibit similar advantages—or face similar constraints—as large chain organizations. Further, researchers could explore the interplay between chain affiliation and emerging management science techniques (e.g., simulation, optimization, machine learning) to determine which interventions most effectively enhance dynamic capabilities in the face of variable socioeconomic risks. Ultimately, extending these lines of inquiry will refine our understanding of how organizational strategies and network-based structures can promote health equity across an even wider range of healthcare settings.

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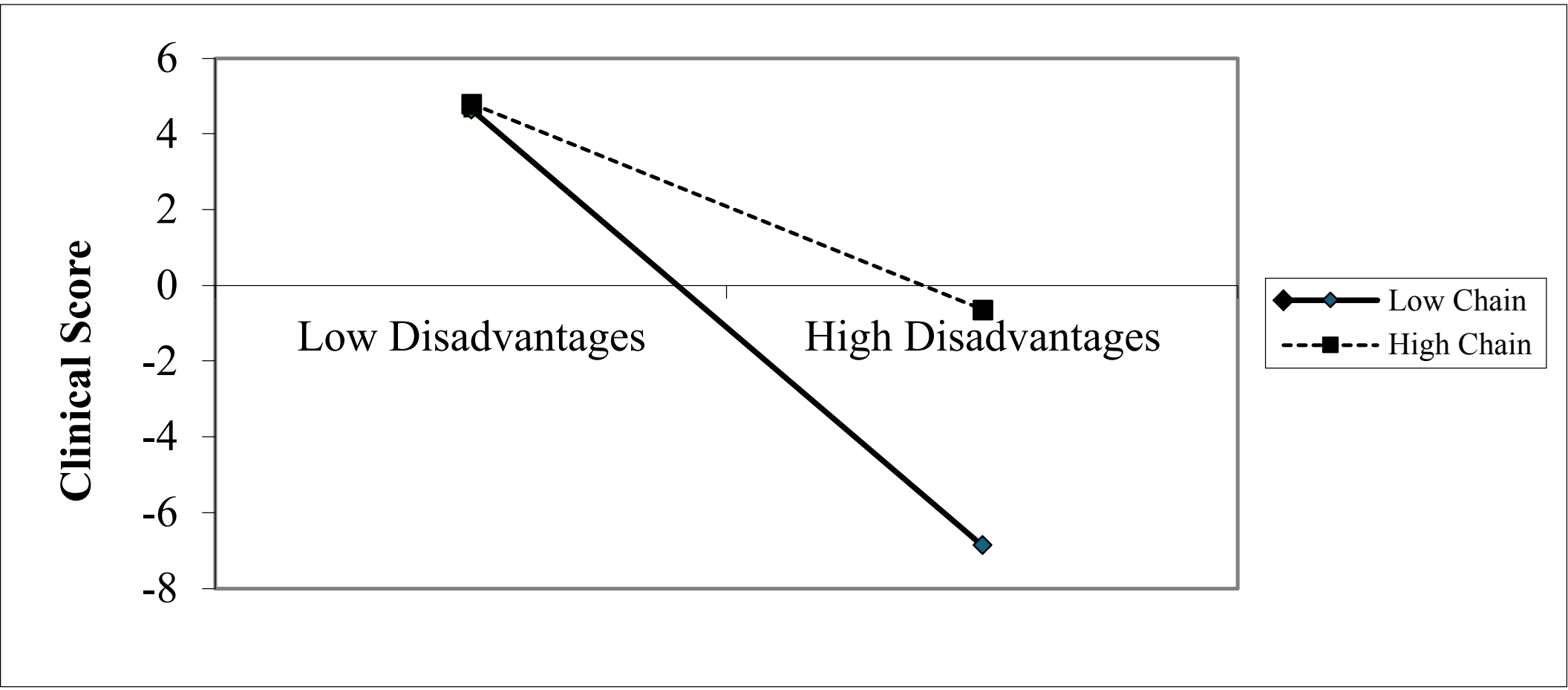
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Fig1.eps


Clinical Score
6
4
2
0
-2
-4
-6
-8
Low Disadvantages
High Disadvantages
Low Chain
High Chain