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Antecedents and Outcomes Associated with Hospital Participation in a Clinically Integrated Network

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Antecedents and Outcomes Associated with Hospital Participation in a Clinically Integrated Network

by

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Abstract

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Health care delivery and payment reform have intended to redesign care in a manner that is higher quality, better coordinated, and more efficient. As part of this shift, delivery systems are increasingly organizing in new ways, often moving toward greater organizational integration. One model that has emerged is the Clinically Integrated Network, or CIN, a set of independent provider organizations such as hospitals and physician groups that collaborate to provide high-value care. This dissertation examines antecedents and outcomes associated with hospital participation in a CIN.

The first study uses national survey data to identify the organizational characteristics and other foundational collaboration arrangements associated with hospital participation in a CIN. The second study evaluates CIN processes, using a survey of hospital activities to ask whether CIN-affiliated hospitals offer more integrated care delivery than hospitals not affiliated with CINs. The third study uses inpatient hospitalization data to evaluate care coordination outcomes associated with hospital participation in a CIN by testing for an association between CINs and potentially preventable inpatient utilization. Taken together, these studies provide the first national empirical evidence describing CIN activities, and the findings can help inform decisions of CIN leadership and regulatory authorities.

For my family – by birth, marriage, and choice – who made this possible

And especially for my Omi, the first doctor in the family

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Conceptual Framework and Aims

As payment reform aims to shift the US healthcare system from volume to value, the organization of the delivery system has also been called into focus. Coordination and information exchange across care settings are critical to clinical goals, such as the ongoing management of chronic diseases and prevention of complications, as well as to financial goals, such as alignment of provider incentives and success in capitated reimbursement models. But federal regulatory and antitrust authorities must balance this push for efficiencies from collaboration with market protections to maintain competition and preserve patient choice (Figure 1).

Figure 1: A fundamental tension in the way healthcare providers organize to deliver optimal care

Integration of organizations is one way to pursue cross-setting coordination and collaboration. This often manifests as hospitals acquiring physicians that provide preventive or ambulatory care. Changes to Medicare reimbursement in the 1980s were predicted to lead to tighter integration between hospitals and physicians,[1] and this played out in the form of accelerated hospital acquisitions of physician practices over the next few decades.[2,3] But these changes have led to higher utilization and spending[4,5] without corresponding improvements in outcomes.[6]

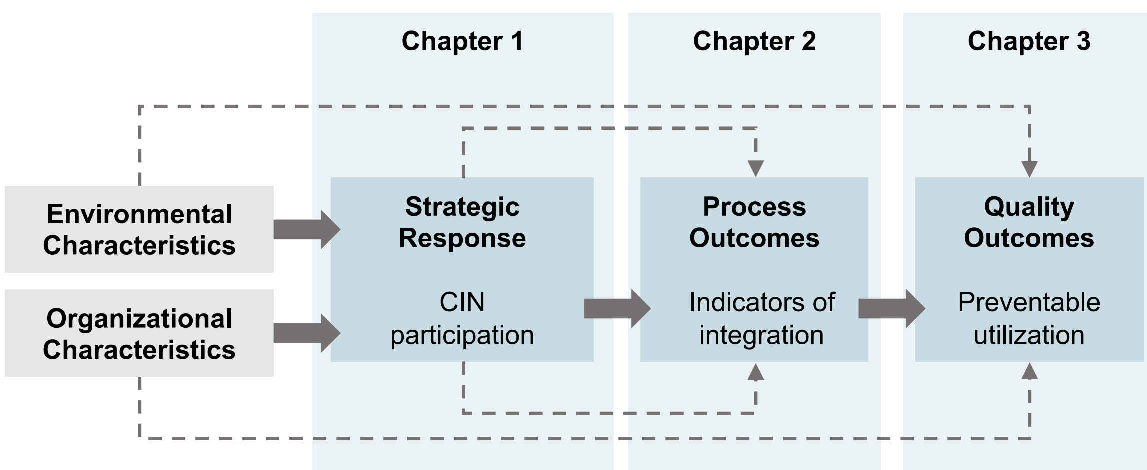
Another type of integration is "virtual" integration through contracting networks, which does not require merging of assets or physician employment. While truly integrated organizations are characterized by a "unity of purpose and performance" and may be better able to negotiate and enforce agreements with external entities such as payers[7], there are also high costs to maintaining internal organization which make virtual options attractive or in some cases even preferable.[8] For example, the virtual organizational structure allows organizations to more nimbly adapt to environmental changes.[7] In determining how to integrate, an organization must weigh the transaction costs of internal coordination against those of establishing and monitoring relationships in virtual networks.[9,10]

The Federal Trade Commission (FTC) and Department of Justice (DOJ), the agencies responsible for antitrust enforcement, initially took the perspective that true integration was preferable to virtual integration because it required financial integration, preserving an incentive structure that would benefit consumers.[11] However, in 1996 FTC/DOJ-permitted integration was expanded to virtual networks, including networks of competitors, that were "clinically integrated".[11,12] Delivery system and payment reform programs run by the Centers for Medicare and Medicaid Services now explicitly promote virtual integration in various forms. Perhaps most visibly, Accountable Care Organizations were developed to create more formal organizational relationships for the "extended hospital medical staff" and align incentives within these virtual organizations.[13] Policies also support provider-initiated virtual integration of physician groups with health systems and hospitals. For example, reforms to modernize Stark Law and the Anti-Kickback Statute permit resource-sharing and more innovative collaboration between providers in shared risk contracts and value-based care arrangements.[14,15]

Clinically Integrated Networks (CINs) are a type of virtual integration that can align incentives and resources between otherwise independent hospitals and physician groups in the absence of full-on integration or employment. CINs may contract with multiple payers for financial risk and are permitted to collectively negotiate fee-for-service contracts. CINs have been cited as a strategic mechanism used by hospitals to coordinate care across settings and align with independent physicians to retain or grow market share.[16,17] In exchange, physician groups benefit from access to hospital resources such as IT infrastructure, as well as administrative support or practice management services.[17,18]

Consulting firm McKinsey & Company states that CINs are "in vogue"[19] and Bloomberg notes that they have "jumped to the forefront of industry transformation".[20] But despite this attention from industry media, CINs have been underexplored in academic literature. This dissertation studies antecedents and outcomes of Clinically Integrated Networks through three aims, summarized in the conceptual framework (Figure 2).

Figure 2: Conceptual framework for antecedents and outcomes of Clinically Integrated Networks



The first aim is to assess the environmental and organizational characteristics associated with hospital participation in a Clinically Integrated Network (Aim 1). Hospital participation in a CIN may be a rational decision influenced by the transaction costs of virtual versus "true" integration, though this requires acceptance of the argument that organizations are fully rational rather than "intendedly rational".[10,21] Organizational and market forces may also drive CIN participation decisions through hospitals' pursuit of legitimacy (as predicted by Institutional Theory)[22,23], via hospital leadership's bounded rationality, "problematic preferences",[24] and the trendiness of the networks, or through a natural selection process wherein organizations that cannot adapt to their environment do not survive.[25] While this research does not attempt to identify a mechanism for decision-making, understanding factors associated with hospital participation in a CIN is an important first step in CIN research.

Second, we examine process outcomes associated with hospital participation in a CIN to determine whether CINs deliver care through differential means, and whether regulatory requirements are being met (Aim 2). The FTC and DOJ have issued favorable advisory opinions for Clinically Integrated Networks, provided they meet certain criteria.[26,27] But there is a gap in empirical evidence around CIN activities, and some legal experts have argued that CINs may more closely resemble anticompetitive organizations than truly integrated care networks.[11,28] There is also limited evidence that macro-level structural or financial integration will translate to clinical or functional integration, or more meso- or micro-level alignment attitudes. Research on physician-hospital alignment, including beliefs about clinical integration, found no improvement with virtual network-style "alliance" models over fully independent physicians.[29]

Lastly, we evaluate the association between hospital participation in a CIN and clinical quality outcomes, to see whether hospitalizations at CIN-affiliated hospitals are less likely to be potentially preventable and more indicative of coordinated care (Aim 3). Antitrust permissions are granted based on the argument that tipping the balance further away from competition and toward collaboration can provide higher-quality care at a lower cost.[30,31] However, aside from case studies,[32] little is known about whether CINs are achieving these successes. There is a dearth of evidence linking CIN participation to performance at the national level, and our research aims to help fill this gap.

Chapter 1: Hospital Characteristics Associated with Clinically Integrated Network Participation

Introduction

Vertical integration of organizations into health care systems is one way to pursue cross-setting coordination and alignment between hospitals and physicians, and hospital and health care system acquisition of physician practices has accelerated in recent decades.[2,3] These acquisitions have historically been motivated by hospitals' desire to increase referrals and negotiate higher rates,[2] and research has shown that they often led to increased profitability for hospitals.[33] Such consolidation can help stabilize shared patient networks, which may facilitate more coordinated care delivery.[34] However, organizational integration into health care systems has not necessarily generated improvements in clinical integration or patient outcomes.[35–37] Evidence indicates that system-owned practices may be more likely to implement care management practices,[38] use advanced health information technology,[39] and perform well on process measures compared to independent practices.[40,41] But in many cases vertical integration is linked to higher utilization and spending[4,5] without any positive effect on health care quality and outcomes.[6]

In spite of mixed evidence in support of integration, the Federal Trade Commission (FTC) and Department of Justice (DOJ) have issued favorable antitrust advisory opinions for virtual networks, including networks of competitors, that are "clinically integrated", provided they meet certain criteria.[11,12] Clinically Integrated Networks (CINs) are a type of virtually integrated organization that can align resources and incentives – such as financial rewards for performance on specific quality or utilization measures – between otherwise independent hospitals and physician groups in the absence of vertical integration or employment. To meet FTC and DOJ requirements, provider organizations participating in a CIN – such as hospitals, medical groups, Independent Practice Associations (IPAs), or physician practices – must cooperate to collectively invest in processes and resources such as technology or care management staff, and may collectively contract with health care payers for risk or on fee-for-service contracts that promote higher-quality care at a lower cost. This is in contrast to Accountable Care Organization (ACO) contracts, which are typically shared savings or risk-based arrangements, although CINs may have ACO contracts in addition to other fee-for-service or value-based contracts.[42]

CINs are similar to Physician-Hospital Organizations (PHOs),[43] but unlike PHOs, CINs can involve multi-hospital partnerships and collective negotiation of payer contracts. The FTC and DOJ define collective negotiation as when "the network's physician participants collectively agree on prices or price-related terms and jointly market their services".[12] CINs use collective negotiation in contrast to the "messenger-model contracting" typical of PHOs, where the organization negotiates general terms for payor contracts and individual physicians can opt in or out.[44–46] In addition, CINs are often intentionally more selective than other types of physician-hospital relationships; for example, they may be a subset of an existing PHO.[47]

CINs have not been examined in the empirical literature despite receiving substantial attention in the healthcare industry and the media. McKinsey &

Company noted in 2016 that CINs were "in vogue"[19] and Bloomberg claimed that they had "jumped to the forefront of industry transformation".[20] But CINs are understudied by regulators and researchers.[17,28] The limited research on CINs describes them as a strategic mechanism used by hospitals to coordinate care across settings and align with independent physicians to retain or grow market share.[16,17] Because of this, more evidence is needed to understand CINs as a unique organizational arrangement and how CIN formation relates to market consolidation, an area of interest for policymakers considering price implications. Accordingly, we sought to understand what types of health care organizations, in what circumstances, have formed CINs, and to examine pathways to CIN participation.

To advance evidence about the role of CINs, we examine hospital characteristics associated with CIN participation. We draw on institutional theory, which highlights the importance of social context and organizations' needs for legitimacy on organizational decision-making,[22,23] positing that hospitals with more active collaboration with independent physicians have norms, values, and social expectations more conducive to clinical integration and CIN participation. We therefore hypothesize that hospitals with IPAs, PHO affiliations, and/or ACO contracts would be more likely to participate in CINs, controlling for hospital characteristics. Because CINs could be a mechanism for hospitals and health systems to respond to pressures from payers and to attempt to stabilize resources in the form of financial flows, referrals, or access to data, we also assess for potential confounding from indicators of resource availability.

These hypotheses are also consistent with evidence that IPAs and PHOs often serve as the foundation for a CIN,[18,48] and that CINs may serve as a contracting entity for ACO contracts.[49] Given that hospitals may opt to have multiple organizational affiliations, we implement a Mokken scale analysis. The Mokken scale is a way to reduce data to a unidimensional latent scale based on the probability of each affirmative response. We do this to assess whether IPAs, PHOs, and ACOs represent a common underlying latent trait – affinity for virtual organizational affiliations – and to identify whether a natural ordering of hospital participation in an IPA, PHO, or ACO exists. Should regression analyses indicate that multiple organizational affiliations are associated with hospital participation in CINs, the Mokken scale can help elucidate the hierarchical ordering of "difficulty" of these affiliations.

Methods

This study analyzes data on CIN participation and hospital characteristics from the 2019 American Hospital Association (AHA) annual survey, as well as lagged CIN participation data from the 2017 AHA survey. The AHA annual survey is administered to over six thousand hospitals, with a response rate of 80% in 2019. The data is integrated with data on 2019 Medicare Advantage penetration from the Area Health Resource File, compiled by the Health Services and Resources Administration.[50] Data on standard economic measures of hospital market competition is calculated by an outside vendor using 2016 AHA data.[51] Insurance market competition comes from the American Medical Association (AMA), published for 382 Metropolitan Statistical Areas and current as of January 1, 2018.[52]

While hospital and insurance market competition data are not available for 2019, we expect any measurement error to be minimal due to the small time difference.

Our study focuses on a sample of 4,405 general medical and surgical hospitals responding to the 2019 AHA survey for which 2017 and 2019 CIN participation data, 2019 AHRF data, and recent hospital and insurance concentration data were also available. The sample contains a diverse mix of non-profit, for-profit, and public hospitals distributed in all 50 states and the District of Columbia, and includes representation from academic medical centers and critical access hospitals.

The primary outcome measure is a binary indicator of CIN participation at the hospital or health system level, sourced from the AHA survey. The AHA survey defines a clinically integrated network for respondents as "a collection of healthcare providers, such as physicians, hospitals, and post-acute care treatment providers, that come together to improve patient care and reduce overall healthcare costs".[53] The question is positioned in the survey section that asks about alternative payment models, immediately following questions about ACO participation and risk arrangements. We opt to define this measure to include both hospital- and system-level CIN participation because health care systems often centralize CIN participation and contracting but still engage hospital locations in their efforts.[48,54,55]

The measures for IPA relationship and PHO participation are binary indicators of whether the hospital reports participation in an Independent Practice Association or any Physician-Hospital Organization at the hospital or system level. The measure for ACO participation is a binary indicator or whether the hospital or health system has established an ACO. Each of these measures is collected in the AHA survey.

We include several variables to control for hospital structural characteristics. Bed size collapses AHA bed size categories into small (under 100 beds), medium (100-299 beds), or large (300 beds or more). Hospital control describes government, non-profit non-government, or for-profit ownership. An indicator variable flags whether the hospital is an Academic Medical Center (AMC). Urbanicity uses Census Bureau-defined metro, micro, or rural Core Based Statistical Areas. Hospital market concentration uses the 2016 Herfindahl-Hirschman Index (HHI), a measure of market competition, for each hospital at the Metropolitan Statistical Area (MSA) level.[51] Models also use state fixed effects to capture effects of state-level market and regulatory variation such as rate review, corporate practice of medicine laws, and certificate of need legislation.

Mimetic pressures and resource dependencies may also drive hospital CIN adoption. Therefore, we control for lagged CIN penetration, the percentage of other hospitals in each hospital's Hospital Referral Region that reported having a CIN in the 2017 AHA data. We control for market managed care, quantified as Medicare Advantage (MA) penetration, to account for integrative pressure from purchasers and payers.[56] We construct a variable for Medicare and Medicaid share by summing Medicare and Medicaid days as a percentage of total reported inpatient days; this accounts for financial strain for hospitals with greater shares of reimbursement from government relative to commercial payers.[57,58] We include physician employment in our models because prior evidence suggests that CINs have been described as an alternative to employment for physicians,[59,60] and hospitals which employ a lesser share of their medical staff may have greater incentive to pursue a CIN strategy. We quantify physician employment as the physicians (both primary care and specialists) employed by the hospital as a percentage of all privileged physicians on the medical staff, converted to tertiles. Because there is high missingness for this variable, we supplement with data from adjacent years of the AHA survey and use imputation for the remainder.[61]

We calculate bivariate descriptive analyses for hospitals with and without CINs. We next analyze correlations of our measures to ensure continuous variables are not correlated at a level greater than 0.5. To identify factors associated with CIN participation, we estimate a multivariate logistic regression model. Model 1.0 includes the measures of IPA, PHO, and ACO participation described in the main hypotheses, along with organizational control variables and state fixed effects:

$$\begin{aligned} log\ odds(CIN) = {} & \beta_0 + \beta_1(IPA) + \beta_2(PHO) + \beta_3(ACO) + \\ & \beta_4(MA\ penetration) + \beta_5(CIN\ penetration) + \\ & \beta_6(Medicare\ and\ Medicaid\ share) + \beta_7(physician\ employment) + \\ & \beta_8(hospital\ HHI) + \beta_9(bed\ size) + \beta_{10}(control) + \beta_{11}(AMC) + \\ & \beta_{12}(urbanicity) + \alpha_{state} + \epsilon \end{aligned}$$

In the above, β_1 through β_3 are the coefficients of interest, while β_4 through β_{12} correspond to our control variables, α_{state} represents state-level fixed effects, and ϵ is a hospital-level error term. Due to the use of state fixed effects, observations in states with no within-state variation drop out of the models. Results of the main model are presented as average marginal effects (AME) to aid interpretation.

We assess multicollinearity for the regression models by calculating variance inflation factors (VIFs) with all model variables included; ideally, the all VIF values should be below 2.5, with VIF values above 10 indicating significant multicollinearity.[62,63]

To assess the potential ordering of hospital organizational affiliations, we use Mokken scaling, a non-parametric item response theory model, to assess the hierarchical ordering of organizational affiliations (IPA, PHO, and ACO).[64,65] We first calculate Loevinger's H coefficient of scalability to determine whether the hospital affiliations are "scalable", or measuring the same latent trait.[66] We then test for monotonicity and double monotonicity (non-intersecting item response functions), which can establish the order of "difficulty" of adoption or implementation[67,68] – here, of each of the hospital affiliations.

We conduct several sensitivity analyses. First, we remove highly multicollinear variables to yield a final model for analysis (Model 1.1). Next, we examine whether the results from Model 1.1 are consistent with the inclusion of payer concentration in Model 2.1, because integration may be motivated by a desire to increase bargaining power with payers.[69,70] This is an MSA-level measure of total insurance product market share sourced from the American Medical Association.[52] This variable is not included in primary analyses because it is not available for non-MSA geographies, yielding a smaller sample of 2,425 hospitals. (To facilitate comparison we also generate a Model 2.0, which is equivalent to Model 1.1 but constrained to the metro-area observations used in Model 2.1.) In Model 2.2, we adapt the measure of CIN participation used as our dependent variable to omit hospitals which indicate CIN participation has occurred at the system level (focusing only on hospitals that indicate having themselves formed a CIN). In Model 2.3, we use multiple imputation rather than single imputation for the physician employment variable.[61] Finally, Model 2.4 uses complete cases only, eliminating observations with imputed employment.

Results

In our analytic sample of 4,405 hospitals, 1,526 (34.6%) participate in a CIN. Descriptive analyses show statistically significant differences between hospitals with CINs and hospitals without CINs across every variable (Table 1).

A test of pairwise correlations among all continuous variables does not identify any values greater than 0.5. Preliminary analyses find that variance inflation factors (VIF) are moderate (mean=3.27), suggesting collinearity among some variables in the regression models.[62,63] Medicare and Medicaid share is highly collinear (VIF=12.17), so it is removed from the main model; all other variables were retained. This results in a reduction of the mean VIF from 3.27 to 2.49 (Table 2.) This modification to the model does not result in organizationally important changes to any coefficient (Table 3).

In the regression analysis with controls and the final set of variables (Model 1.1), all hospital affiliations are significantly associated with CIN participation. Hospitals are significantly more likely to participate in a CIN if they have a relationship with an IPA (AME: 9.5%; 95% CI: 6.1%, 12.9%), participate in a PHO (AME: 6.1%; 95% CI: 3.4%, 8.9%), or participate in an ACO (AME: 19.3%; 95% CI: 13.4%, 25.1%) compared to hospitals without these affiliations. MA penetration is significantly associated with CIN participation (AME: 0.2%; 95% CI: 0.1%, 0.2%), as is lagged CIN penetration (AME: 0.1%; 95% CI: 0.1%, 0.2%).

In Model 1.1, hospitals that participate in CINs are significantly larger than non-CIN hospitals (AME: 3.5%; 95% CI: 1.2%, 5.9% for hospitals with 100-299 beds compared with a reference category of fewer than 100 beds; AME: 4.6%; 95% CI: 1.5%, 7.6% for hospitals with 300 or more beds). CIN hospitals are significantly more likely to be non-profit (AME: 11.2%; 95% CI: 7.9%, 14.6%, compared with a reference category of hospitals under city, county, state, or federal control) and less likely to be for-profit (AME: -11.8%; 95% CI: -18.1%, -58.6%, using the same government reference category). Finally, CIN hospitals are significantly more likely to be located in metropolitan areas (AME for micropolitan areas: -4.4%; 95% CI: -7.8%, -1.1%; AME for rural areas: -5.8%; 95% CI: -9.7%, -1.8%). Physician employment, hospital concentration, and AMC status are not significantly associated with CIN participation. Results of Model 1.1 are summarized in Figure 1.

Results are directionally similar across the four sensitivity analyses with some exceptions. CIN penetration is significantly associated with CIN participation in all models where the outcome is measured at both the system and hospital level, but not significant when looking only at hospital-level affiliation (Model 2.2). The top tertile of physician employment is found to be significantly associated with CIN participation in the models using hospital-level affiliation (Model 2.2), multiple imputation (Model 2.3), and complete cases only (Model 2.4). In Model 2.1, which looks at metro areas only, we find that hospital concentration is statistically significant, but bed size is not. Payer concentration is not found to be significantly associated with CIN participation in Model 2.1. All results, presented as exponentiated odds ratios, are detailed in Table 3.

Mokken analyses indicate that the PHO and ACO variables are highly scalable to a single scale (Loevinger's H: 0.508 and 0.508, respectively). The IPA variable is not scalable. Given that the single scale consists of two items, we cannot assess monotonicity or ordering.

Discussion

We find that hospitals are significantly more likely to participate in a CIN if they have a relationship with an IPA or participate in a PHO or ACO. This is consistent with reports that an IPA or PHO often forms the chassis for a CIN,[18,48] which then serves as the contracting entity for joint negotiation across multiple contracts such as ACOs.[49] Hospitals are also significantly more likely to participate in a CIN if they are located in a region with high Medicare Advantage penetration or a higher concentration of CINs, though the magnitude of the association suggests that these factors may not be policy-relevant. Taken together, however, these results lend support to the idea that participation in these types of organizations may be driven in part by market and network-level norms and expectations.

Notably, CIN participation seems less motivated by regulative forces or resource dependencies. Hospital concentration was not found to be significant in our main model, and a sensitivity analysis found no association between CIN participation and payer concentration. Similarly, physician employment was not found to be significant in our main model – that is, CIN participation does not appear to be driven by hospitals with largely independent medical staffs attempting to increase alignment. In fact, higher levels of physician employment were significantly associated with CIN participation in sensitivity analyses; this is again suggestive of norms-motivated adoption.

Given the overlap between CINs and other types of affiliation organizations, it will be critical to further disentangle these relationships and understand the effects of each type of organization, and we believe this is a rich area for further study. Our study serves as a preliminary attempt, suggesting two pathways to CIN formation: hospital or health-system led efforts via a PHO or ACO, and independently led efforts via an IPA. The former pathway may be the health system's attempt to manage transaction costs through formalized virtual affiliations. The latter may be more suited to serving the needs of independent physicians. These types of organizations may also look different, given the heterogeneity that exists across IPAs – with some led by health systems to attempt to control independent physicians, and others led by independent physicians with a goal of maintaining autonomy.

Future research should consider other social and integrative forces such as market-level ACO penetration. Research should attempt to describe whether CINs serve as a pathway to ACO formation or vice versa, potential synergies between dual participation in ACOs and CINs, and how CINs may be related to ACO contracting and performance. Finally, future research should aim to understand heterogeneity of CIN activities and outcomes such as quality performance, cost, and utilization.

In recent years, federal regulators have implicitly supported virtual integration models over traditional brick-and-mortar integration. In 2021, the FTC announced that it would renew scrutiny of health care system and hospital acquisitions of physician practices.[71] But that same year saw the introduction of reforms to modernize Stark Law and the Anti-Kickback Statute by permitting resource-sharing and more innovative collaboration between providers in shared risk contracts and value-based care arrangements,[14] and the Centers for Medicare and Medicaid Services promotes virtual integration through models such as the Medicare Shared Savings Program. Because of this, our research to understand what types of organizations are taking advantage of antitrust flexibilities is especially important.

Our findings should be considered in light of some limitations. First, causal relationships between organizational affiliations and CIN participation are not assessed due to the cross-sectional data analyzed. However, this study is the first to assess CIN participation nationally. Additionally, the Mokken scale analysis helps us gain some insight into potential ordering of hospital affiliations that support CIN participation, identifying two distinct pathways. Second, there is potential for measurement error with the AHA's definition of a CIN. We use the AHA measure because this survey is the first source to assess hospital participation in CINs; however, we advocate for a "gold standard" definition to reliably disentangle the effects of CINs compared to other potential interpretations or affiliations. Third, the AHA survey uses a single respondent and does not allow for an assessment of reliability. However, survey responses are carefully validated by the AHA for consistency across hospital types and within hospitals over time. Fourth, the physician employment variable has high missingness; however, the results of our hypothesized relationships are consistent between single imputations, multiple imputations, and the complete case analysis. Fifth, our data sets match 2019 survey data to 2016 and 2018 market data. This generates some measurement error, but we expect this error to be small due to the short time difference; furthermore, while the error may affect the magnitude of associations, it is unlikely to change the qualitative findings of our research. Finally, the AHA survey does not assess whether the formation of CINs were led by hospitals, or if hospitals participate in CINs in response to demand from physicians, and the physician perspective is missing from this study. Findings from qualitative research, however, suggest that hospitals and health care systems are driving this trend.[17]

Conclusion

This national study, the first to empirically assess hospital participation in CINs, paints a picture of a pervasive but poorly understood organizational phenomenon. We find that slightly over one-third of hospitals participate in a CIN, in spite of limited evidence about the effectiveness of virtual integration in improving care or reducing costs. We also find a significant association between IPA, PHO, and ACO affiliations and CIN participation, suggesting CIN hospitals are responding to integrative norms from developments in their markets and/or from members of their provider network. It remains unclear whether CINs provide value to hospitals or consumers. This movement may be motivated by mimetic pressures and reflective of symbolic compliance rather than a transformational model to coordinate care among hospitals, physicians, and other healthcare organizations. Collectively, these findings contribute to evidence about the spectrum of hospital integration models and factors associated with virtual integration. Future research should strive to elucidate what activities CINs engage in, whether CINs are effectively deliver more integrated care, and what factors are associated with CIN effectiveness. Such evidence can inform regulatory decisions that aim to balance competition and collaboration to support high-value health care.

Tables

Table 1: Hospital characteristics by Clinically Integrated Network (CIN) participation status

Hospital Characteristic	Total (of 4,405)	Without CIN (n=2,879)	With CIN (n=1,526)	P-Value[5]
Independent Variables				
Independent Practice Association (IPA) relationship[1]	–	–	–	<0.001***
Without IPA	93.7%	96.8%	87.9%	
With IPA	6.2%	3.2%	12.1%	
Physician Hospital Organization (PHO) participation[1]	–	–	–	<0.001***
Without PHO	85.4%	91.0%	74.7%	
With PHO	14.6%	9.0%	25.3%	
Accountable Care Organization (ACO) participation[1]	–	–	–	<0.001***
Without ACO	61.5%	80.2%	26.1%	
With ACO	38.5%	19.8%	73.9%	
Control Variables				
Medicare Advantage penetration (county-level)[2]	32.5 (15.3)	30.6 (15.5)	36.1 (14.2)	<0.001***
Clinically Integrated Network penetration (county-level)[2]	33.1 (21.9)	29.1 (19.9)	40.7 (23.5)	<0.001***
Medicare & Medicaid share[2]	69.5 (20.4)	68.0 (22.4)	72.4 (15.5)	<0.001***
Physician employment (reported)[1,3]	–	–	–	<0.001***
Low (bottom tertile)	25.5%	24.4%	28.1%	
Moderate (middle tertile)	25.5%	23.0%	30.1%	
High (top tertile)	25.4%	19.3%	36.8%	
Not reported	23.6%	33.5%	4.9%	
Physician employment (imputed)[1]	–	–	–	<0.001***
Low (bottom tertile)	34.0%	36.1%	30.0%	
Moderate (middle tertile)	33.0%	34.0%	31.7%	
High (top tertile)	33.0%	29.9%	38.3%	
Hospital concentration (MSA-level)[2,4]	6656.7 (3197.6)	7032.8 (3137.2)	5947.0 (3190.9)	<0.001***
Bed size[1]	–	–	–	<0.001***
<100 beds	49.9%	58.5%	33.8%	

Hospital Characteristic	Total (of 4,405)	Without CIN (n=2,879)	With CIN (n=1,526)	P-Value[5]
100-299 beds	32.3%	29.4%	37.7%	
300+ beds	17.8%	12.2%	28.4%	
Hospital control[1]	–	–	–	<0.001***
Government	24.9%	32.1%	11.3%	
Not-for-profit (non-government)	60.9%	48.4%	84.4%	
For-profit	14.3%	19.5%	4.3%	
Academic Medical Center[1]	–	–	–	<0.001***
No	94.0%	96.3%	89.7%	
Yes	6.0%	3.7%	10.3%	
Urbanicity[1]	–	–	–	<0.001***
Metro	60.0%	51.8%	75.5%	
Micro	17.3%	19.4%	13.2%	
Rural	22.7%	28.8%	11.3%	
Census region[1] (descriptive purposes only)	–	–	–	<0.001***
Northeast	12.3%	8.5%	19.5%	
Midwest	30.0%	29.9%	30.2%	
South	37.3%	39.8%	32.5%	
West	20.4%	21.8%	17.8%	
Hospital Characteristic	**Total (of 2,445)**	**Without CIN (n=1,374)**	**With CIN (n=1,071)**	**P-Value[3]**
Additional Control Variables (used for sensitivity analyses)				
Payer concentration (MSA-level)[2,4]	2990.1 (1209.6)	3065.1 (1270.8)	2893.9 (1119.7)	<0.001***

Notes:
[1]Represents physicians employed by the hospital as a share of total hospital medical staff
[2]Reported as mean (standard deviation)
[3]Excludes imputed values
[4]MSA = Metropolitan Statistical Area
[5]Significance levels: <0.05* <0.01** <0.001***

Table 2: Variance inflation factors (VIF) for the main regression model

Variable	VIF with all variables included (Model 1.0)	VIF after removing *Medicare & Medicaid share* variable (Model 1.1)
Independent Practice Association relationship (ref: no)	1.11	1.10
Physician-Hospital Organization participation (ref: no)	1.29	1.29
Accountable Care Organization participation (ref: no)	2.02	2.00
Medicare Advantage penetration	5.87	5.13
Clinically Integrated Network penetration	3.42	3.37
Medicare & Medicaid share	12.17	n/a
Physician employment (ref: low)	–	–
Moderate	1.94	1.92
High	1.99	1.99
Hospital concentration	6.72	5.82
Bed size (ref: Up to 99 beds)	–	–
100-299 beds	2.11	2.06
300+ beds	2.18	2.14
Hospital control (ref: government)	–	–
Not-for-profit (non-gov't)	4.30	3.72
For-profit	1.78	1.60
Academic Medical Center (ref: no)	1.38	1.38
Urbanicity (ref: metro)	–	–
Micro	1.74	1.70
Rural	2.32	2.16
Mean VIF	**3.27**	**2.49**

Note: 2.5<VIF<10 shaded light gray. VIF≥10 shaded deeper gray.

Table 3: Regression results including sensitivity analyses presented as exponentiated odds ratios (OR) with standard errors (SE)

Hospital Characteristic	Main Specifications				Sensitivity Analyses									
	Model 1.0 (n=4,360)[1]		Model 1.1 (n=4,360)[1]		Model 2.0 (n=2,377)[2]		Model 2.1 (n=2,377)[2]		Model 2.2 (n=4,300)[3]		Model 2.3 (n=4,360)[4]		Model 2.4 (n=2,706)[5]	
	OR (SE)	P-value[6]	OR (SE)	P-value[6]	OR (SE)	P-value[6]	OR (SE)	P-value[6]	OR (SE)	P-value[6]	OR (SE)	P-value[6]	OR (SE)	P-value[6]
Independent Practice Association relationship	2.799 (0.510)	<0.001 ***	2.799 (0.510)	<0.001 ***	2.729 (0.635)	<0.001 ***	2.738 (0.638)	<0.001 ***	1.519 (0.240)	0.008**	2.796 (0.510)	<0.001 ***	1.842 (0.353)	0.001**
Physician Hospital Organization participation	1.815 (0.243)	<0.001 ***	1.813 (0.243)	<0.001 ***	1.845 (0.319)	<0.001 ***	1.838 (0.318)	<0.001 ***	1.385 (0.167)	0.007**	1.817 (0.243)	<0.001 ***	1.428 (0.199)	0.011*
Accountable Care Organization participation	9.443 (0.878)	<0.001 ***	9.401 (0.863)	<0.001 ***	11.92 (1.466)	<0.001 ***	11.97 (1.475)	<0.001 ***	4.271 (0.403)	<0.001 ***	9.365 (0.860)	<0.001 ***	3.897 (0.406)	<0.001 ***
Medicare Advantage penetration	1.015 (0.004)	<0.001 ***	1.015 (0.004)	<0.001 ***	1.013 (0.006)	0.031*	1.014 (0.006)	0.025*	1.011 (0.004)	0.009**	1.015 (0.004)	<0.001 ***	1.010 (0.005)	0.036*
Clinically Integrated Network penetration	1.010 (0.003)	<0.001 ***	1.010 (0.003)	<0.001 ***	1.010 (0.003)	0.003**	1.010 (0.003)	0.002**	1.001 (0.002)	0.656	1.010 (0.003)	<0.001 ***	1.011 (0.003)	<0.001 ***
Medicare & Medicaid share	0.999 (0.003)	0.760	–	–	–	–	–	–	–	–	–	–	–	–
Physician employment (ref: low)	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Moderate	0.905 (0.098)	0.358	0.905 (0.098)	0.361	0.929 (0.133)	0.607	0.928 (0.133)	0.601	0.943 (0.104)	0.595	0.951 (0.110)	0.662	1.015 (0.128)	0.907
High	1.211 (0.134)	0.083	1.214 (0.134)	0.079	1.264 (0.189)	0.117	1.265 (0.189)	0.115	1.288 (0.142)	0.021*	1.316 (0.151)	0.017*	1.441 (0.191)	0.006**
Hospital concentration	1.000 (0.000)	0.914	1.000 (0.000)	0.889	1.000 (0.000)	0.020*	1.000 (0.000)	0.016*	1.000 (0.000)	0.372	1.000 (0.000)	0.868	1.000 (0.000)	0.525
Bed size (ref: <100 beds)	–	–	–	–	–	–	–	–	–	–	–	–	–	–
100-299 beds	1.365 (0.151)	0.005**	1.364 (0.151)	0.005**	1.271 (0.191)	0.110	1.265 (0.190)	0.117	1.411 (0.161)	0.002**	1.362 (0.151)	0.005**	1.371 (0.173)	0.013*

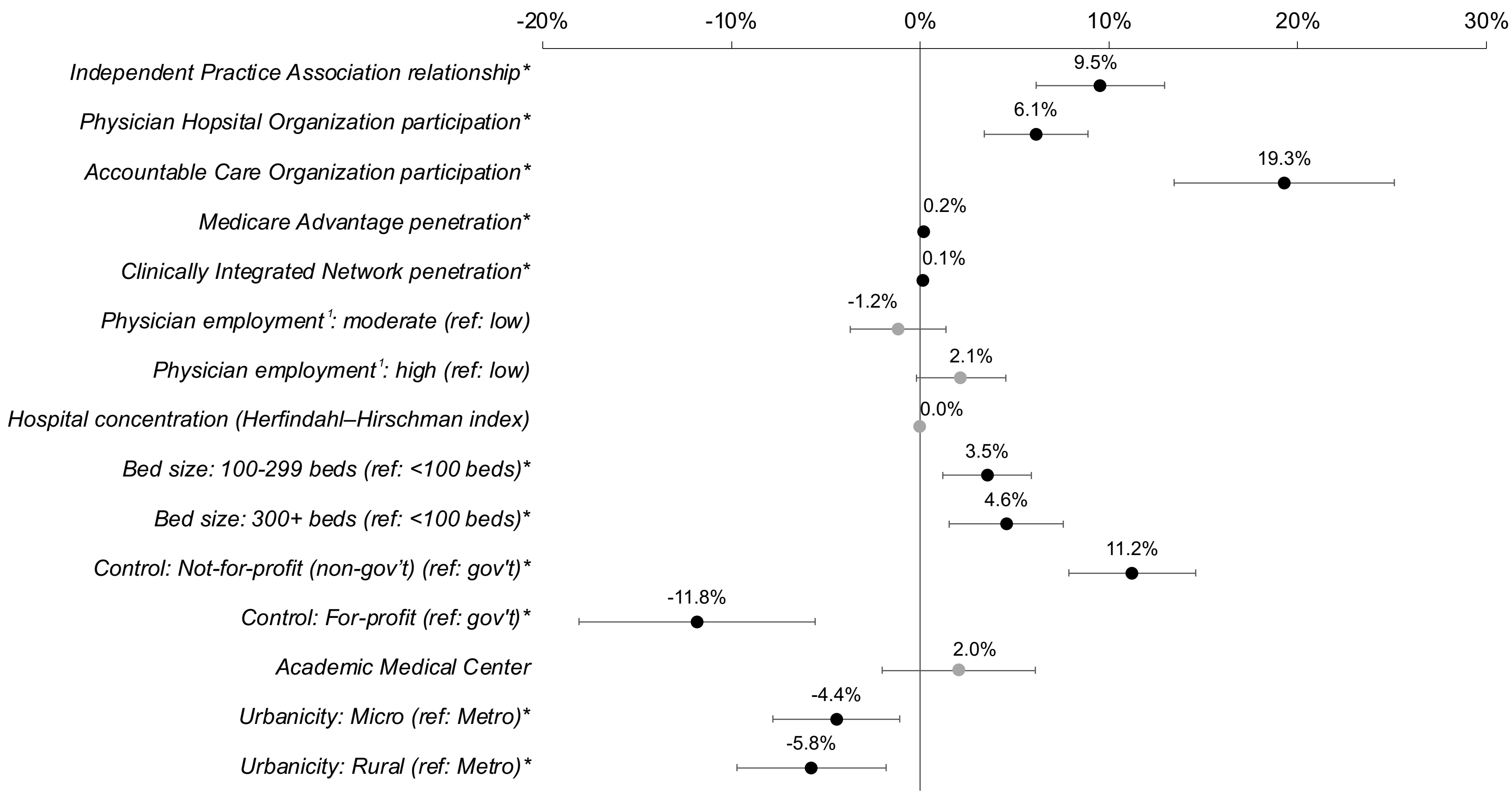
Hospital Characteristic	Main Specifications				Sensitivity Analyses									
	Model 1.0 (n=4,360)[1]		Model 1.1 (n=4,360)[1]		Model 2.0 (n=2,377)[2]		Model 2.1 (n=2,377)[2]		Model 2.2 (n=4,300)[3]		Model 2.3 (n=4,360)[4]		Model 2.4 (n=2,706)[5]	
	OR (SE)	P-value[6]	OR (SE)	P-value[6]	OR (SE)	P-value[6]	OR (SE)	P-value[6]	OR (SE)	P-value[6]	OR (SE)	P-value[6]	OR (SE)	P-value[6]
300+ beds	1.506 (0.222)	0.006**	1.504 (0.222)	0.006**	1.214 (0.212)	0.268	1.213 (0.212)	0.269	1.447 (0.211)	0.011*	1.488 (0.220)	0.007**	1.390 (0.238)	0.054
Hospital control (ref: government)	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Not-for-profit (non-gov't)	2.786 (0.340)	<0.001 ***	2.754 (0.321)	<0.001 ***	2.528 (0.412)	<0.001 ***	2.515 (0.410)	<0.001 ***	1.610 (0.195)	<0.001 ***	2.787 (0.325)	<0.001 ***	2.511 (0.336)	<0.001 ***
For-profit	0.467 (0.090)	<0.001 ***	0.462 (0.087)	<0.001 ***	0.380 (0.089)	<0.001 ***	0.378 (0.089)	<0.001 ***	0.387 (0.084)	<0.001 ***	0.474 (0.090)	<0.001 ***	0.540 (0.116)	0.004**
Academic Medical Center	1.199 (0.234)	0.352	1.204 (0.234)	0.341	1.245 (0.259)	0.294	1.238 (0.258)	0.306	1.396 (0.241)	0.054	1.200 (0.234)	0.349	1.010 (0.223)	0.964
Urbanicity (ref: Metro)	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Micro	0.678 (0.091)	0.004**	0.677 (0.091)	0.004**	–	–	–	–	0.793 (0.111)	0.098	0.676 (0.091)	0.004**	0.622 (0.093)	0.002**
Rural	0.611 (0.090)	<0.001 ***	0.608 (0.089)	<0.001 ***	–	–	–	–	0.741 (0.113)	0.051	0.611 (0.090)	0.001**	0.595 (0.097)	0.001**
Payer concentration	–	–	–	–	–	–	1.000 (0.000)	0.523	–	–	–	–	–	–

Notes:

[1]All observations; 45 Utah hospitals drop out due to use of state fixed effects (no Utah hospitals have Clinically Integrated Networks (CINs))
[2]Metro-area observations only; 48 metro-area hospitals drop out due to use of state fixed effect (no metro-area hospitals in Alaska Delaware, South Dakota, or Utah have CINs and all metro-area hospitals in Vermont have CINs)
[3]All observations, using hospital-level CIN participation only; 105 Utah and South Carolina hospitals drop out due to use of state fixed effects (no Utah or South Carolina hospitals have hospital-level CINs)
[4]All observations, using multiple imputation for physician employment; 45 Utah hospitals drop out due to use of state fixed effects (no Utah hospitals have CINs)
[5]Complete cases only; 22 Utah hospitals drop out due to use of state fixed effects (no Utah hospitals have CINs)
[6]Significance levels: <0.05* <0.01** <0.001***

Figures

Figure 1: Results of main multivariable regression specification presented as average marginal effects on the predicted probability of CIN participation. Whiskers around point estimates represent 95% confidence intervals.



*Statistically significant at $p<0.05$; variables that are not statistically significant are shaded gray
[1]Represents physicians employed by the hospital as a share of total hospital medical staff

Chapter 2: Are Hospitals with Clinically Integrated Networks Actually Clinically Integrated?

Introduction

Federal policy continues to encourage the health system's shift from volume to value, and regulatory agencies aim to strike a balance between provider competition and collaboration that is most beneficial to consumers. For example, recent reforms permit more innovative collaboration between providers through modernized Stark and Anti-Kickback regulations,[14,15] and the Department of Justice (DOJ) and Federal Trade Commission (FTC) have issued favorable advisory opinions around Clinically Integrated Networks (CINs).[11,12] CINs are groups of independent providers that meet standards of cooperation and integration intended to promote higher-quality care at a lower cost. Organizations that meet these standards have historically been granted an antitrust "safety zone", allowing joint negotiation of fee-for-service and value-based contracts that would otherwise be illegal; however, the DOJ recently withdrew this guidance,[72] shifting enforcement emphasis to a set of criteria that can help determine whether a CIN is "sufficiently clinically integrated to avoid summary condemnation".[73]

Some argue that CIN collaboration may approach de facto consolidation or anticompetitive behavior.[28] Similar "soft consolidation" arrangements may lead to price increases as health system market power is extended to independent providers in the network.[74] And while qualitative research suggests that CINs are being used by hospitals to align with independent physicians, coordinate care across settings, and share resources, they are also being used as a vehicle to negotiate contracts and grow market share.[17,54] These findings, coupled with the FTC's renewed scrutiny around hospital acquisitions of physician practices,[71] highlight the need for a better understanding of how CINs organize to deliver care.

This study is the first empirical assessment of CIN activities at a national level. It aims to assess the relationship between hospital participation in a Clinically Integrated Network and how effectively the organization has integrated to deliver high-value care. We use national survey data to operationalize indicators of integration put forth by the FTC and DOJ. These represent the agencies' most concrete guidance on how to determine whether a CIN is "sufficiently clinically integrated to avoid summary condemnation".[73] These indicators include 1) "the use of common information technology to ensure exchange of all relevant patient data, 2) the development and adoption of clinical protocols; and 3) mechanisms to ensure adherence to protocols." Based on the FTC/DOJ requirements, we hypothesize that hospitals in CINs will be more likely to use shared information technology, adopt clinical protocols, and use mechanisms to monitor physician adherence to protocols compared to hospitals not in CINs.

These three indicators require hospitals to make substantive organizational changes to how they implement care delivery. Integrated information technology requires both boundary spanning capabilities and sufficient resources for implementation.[75,76] The adoption of clinical protocols requires both agreement on guidelines and infrastructure such as decision support tools to promote uptake.[77]

Finally, the use of mechanisms for protocol adherence requires a cultural shift toward accountability.[78,79]

We simultaneously examine other types of virtual affiliations of hospitals such as Independent Practice Associations (IPAs), Physician-Hospital Organizations (PHOs), and Accountable Care Organizations (ACOs). Participants in CINs can also participate in these other virtual affiliations, but IPAs, PHOs, and ACOs may offer distinct integration benefits.

Methods

This study uses cross-sectional data from the 2017 American Hospital Association (AHA) annual survey and data from the 2017-2018 National Survey of Healthcare Organizations and Systems (NSHOS). The AHA survey is an annual survey sent to nearly all hospitals in the United States, with a response rate of greater than 80%.[80] The NSHOS survey, approved by the Dartmouth College Institutional Review Board, uses a special design to sample from the full population of health systems in a two-stage process, first sampling health system or owner-subsidiary clusters, then individual hospital units. Hospital surveys were completed by C-suite leaders (such as a Chief Executive Officer or Chief Medical Officer), and resulted in a 45% response rate.[81] Analysis of nonresponse to the hospital NSHOS survey can be found in Table 1, and details have been published in other research.[82,83] NSHOS and AHA data are also linked to data from the IQVIA OneKey database, which includes data from the American Medical Association, public sources, and proprietary data collection to characterize hospitals.[84]

Our study focuses on a final sample of 693 representative non-federal acute-care hospitals across the United States which are available in both the AHA and NSHOS data, allowing a comprehensive analysis of CIN participation as well as hospital characteristics. Hospitals in the sample are of diverse ownership and geographies, with representation from Critical Access Hospitals and Academic Medical Centers (AMCs).

We examine three composite measures from the NSHOS survey to represent FTC/DOJ indicators of integration, all scored on a scale of 0 to 100. Information technology is a composite of two items about the extent of electronic health record (EHR) use and integration, including interoperability of EHRs with community physicians (Cronbach's α, a measure of internal consistency or scale reliability for the measure, was 0.60 for these two items). Clinical protocols summarizes the use of evidence-based protocols and clinical decision support, as well as approaches to disseminate best practices (21 items, α=0.89). Protocol adherence mechanisms is a measure summarizing the use of physician performance data for feedback (7 items, α=0.85). Detail on the items comprising these measures can be found in Table 2 and Table 3.

Our main independent variable is CIN participation, which is based on responses to the AHA survey questions about whether either the hospital or health system formed a CIN. The survey includes language defining a CIN as "a collection of healthcare providers, such as physicians, hospitals, and post-acute care treatment providers, that come together to improve patient care and reduce overall healthcare costs". The question is positioned after separate questions about IPA and PHO arrangements and ACO participation, in a survey section titled "Insurance and Alternative Payment Models".[53]

We also use several measures to control for relevant hospital affiliations and characteristics that may be related to both a hospital's participation in a CIN and/or its level of integration. Measures for IPA relationship and PHO participation are binary indicators of whether the hospital reports participation in an Independent Practice Association or any Physician-Hospital Organization. The measure for ACO participation is a binary indicator of whether the hospital or health system has established an ACO. Physician employment is quantified as the percentage of physicians employed by the hospital as a percentage of all privileged physicians on the hospital's medical staff, categorized into tertiles. Missing variables are imputed using hotdeck single imputation (see Sensitivity Analyses).[61,85] Medicaid share is a binary indicator of whether a hospital has a high (≥30%) share of days paid by Medicaid, serving as a proxy for hospital financial resources. Hospital payment reform revenue is a dichotomous measure (low: <30%, high: ≥30%) of the self-reported percentage of hospital revenue from arrangements other than traditional fee-for-service, including shared savings, pay-for-performance, episodic payment, or capitation. Hospital structural characteristics include bed size (categorized as small with under 100 beds, medium with 100-299 beds, or large with 300 beds or more); hospital control (operation or ownership including government, non-profit non-government, or for-profit); a binary indicator for whether the hospital is an Academic Medical Center or AMC; and urbanicity (Census Bureau-defined metro, micro, or rural Core Based Statistical Areas).

We conduct descriptive analyses of each outcome and control variable for hospitals with and without CINs. We examine the relationship between a hospital's CIN participation and each of the indicators of integration. For this step, we estimate a set of multivariable linear regressions using cluster-robust standard errors to allow for correlation of observations of different hospitals within the same health system. Models also use state fixed effects to capture effects of state-level market and regulatory variation. All models are weighted based on sampling probability at the hospital and system levels, and weighted for non-response using data from the IQVIA OneKey database on all hospitals in the sampling frame.

Model 1.1 regresses information technology on CIN participation, with a vector of control variables W:

$$Information\ technology = \beta_0 + \beta_1(CIN\ indicator) + \beta_2 W + \alpha_{state} + \epsilon$$

Model 1.2 is similar to 1.1, but with the clinical protocol measure as the outcome variable:

$$Clinical\ protocols = \gamma_0 + \gamma_1(CIN\ indicator) + \gamma_2 W + \alpha_{state} + \epsilon$$

And finally, Model 1.3 uses the protocol adherence mechanisms measure as the outcome:

$$Protocol\ adherence\ mechanisms = \delta_0 + \delta_1(CIN\ indicator) + \delta_2 W + \alpha_{state} + \epsilon$$

In the above equations, β_1, γ_1, and δ_1 respectively are the coefficients of interest. W is a vector of hospital-level covariates that includes IPA relationship, PHO participation, ACO participation, physician employment, Medicaid share, payment reform revenue, bed size, control, AMC status, and urbanicity. ϵ is a hospital-level error term. We analyze correlations of our covariates to check for strong correlations among variables (>0.50) and a conservative threshold for potential collinearity (VIF>2.5).

We perform three sensitivity analyses to assess the consistency of our results to alternative regression model specification decisions. Model 2.1 is a sensitivity analysis that removes participation in other organizational affiliation organizations (IPA, PHO, and ACO) from the main regression models to determine whether CIN-affiliated hospitals perform better overall on our measures of integration, when potential confounding effects from other hospital affiliations are not considered. Model 2.2 is equivalent to the main model but uses complete cases only (n=523). Model 2.3 uses multiple imputation for the physician employment variable in the main regression model, although this method does not permit us to incorporate the survey weights in the analysis.[61]

Results

In unadjusted analyses, hospitals participating in CINs have significantly higher use of integrated information technology and clinical protocols (72.0 for hospitals with CINs versus 65.3 out of 100 hospitals without CINs for information technology, p=0.002; 69.5 versus 62.7 for clinical protocols, p<0.001). The difference in use of protocol adherence mechanisms for CIN versus non-CIN hospitals is not significant (51.6 and 50.8, respectively; p=0.780). Full unadjusted comparisons are detailed in Table 4. Unadjusted performance on measures for other organizational affiliations is shown in Figure 1.

In unadjusted analyses, hospitals with CINs are significantly more likely to have IPA, PHO, or ACO affiliations, to be larger, to be not-for-profit, to be an Academic Medical Center, to be located in a metropolitan area, and in the northeast or Midwest than hospitals without CINs. There is no difference between hospitals with and without CINs with regard to Medicaid revenue, revenues from payment reform, or physician employment, though hospitals with CINs are more likely to report physician employment data than hospitals without CINs. Unadjusted pairwise correlations between the three indicators of integration are all below 0.5.

In multivariable regression analyses (Table 5), we find that hospital CIN participation is positively associated with information technology (β=5.54, p=0.047). We do not find evidence that hospital CIN participation is positively associated with clinical protocols (β=3.30, p=0.174) or protocol adherence mechanisms (β=-5.59, p=0.132). Correlations between all model variables are also all below 0.5.

The regression-adjusted mean score for information technology across all hospitals is 42.70 (SD=12.37); see Figure 2 for a comparison of adjusted indicator scores for hospitals with and without CINs, at sample means. High revenue from payment reform is significantly associated with greater information technology (β=9.52, p=0.015) and for-profit status is significantly associated with less robust information technology (β=-14.38, p=0.031).

The regression-adjusted mean score for clinical protocols across all hospitals is 53.40 (SD=9.03). In adjusted analyses, there are no differences between CIN and non-CIN hospitals for clinical protocols, but PHO participation is significantly associated with more extensive use of clinical protocols (β=5.44, p=0.027). Of the other control variables, hospitals with high Medicaid concentration have significantly lower use of clinical protocols (β=-8.70, p=0.002), while larger hospitals have significantly greater use of clinical protocols measure (β=6.37, p=0.039 for hospitals with 100-299 beds and β=9.25 p=0.005 for hospitals with 300+ beds).

The regression-adjusted mean score for protocol adherence mechanisms across all hospitals is 23.94 (SD=11.76). In the adjusted analysis, CIN and non-CIN hospitals do not differ in use of mechanisms for protocol adherence. IPA participation and moderate physician employment, however, are significantly associated with use of mechanisms for protocol adherence (β=14.82, p=0.004 and β=10.50, p=0.018, respectively).

Variance inflation factors indicate potential collinearity (mean VIF=3.51) (Table 6), though we do not believe this biases our model results.[63] Collinearity is largely limited to categorical control variables with multiple categories: hospital bed size (VIF=3.18 for 200-299 beds and 2.81 for 300+ beds) and hospital control (VIF=6.73 for non-profit and VIF=2.93 for for-profit hospitals). The VIF for CIN participation, our coefficient of interest, is 2.63, and the VIF on ACO participation is 2.59.

Results of sensitivity analyses (Table 7) are largely consistent with the main results with one exception: Model 2.1 finds the association between CIN participation and information technology to be only marginally significant (β=5.32, p=0.062) when the potential confounding of other hospital affiliations is not considered. Consistent with the main model, there is no association between CIN participation and other indicators of integration in Model 2.1. In Models 2.2 and 2.3, we find significant association between CIN participation and information technology but not the other two indicators of integration.

Discussion

Hospital participation in a CIN is positively associated with more robustly integrated information technology in multivariable regression analyses that control for other organizational affiliations and hospital characteristics. The positive association between CIN participation and information technology suggests that CINs may be a useful organization structure for improving integration of health information across care settings. Hospitals may also be pursuing a strategy of value-based CIN contracting supported by integrated information technology capabilities, consistent with the positive association between revenue from payment reform and information technology.

We do not find evidence, however, that CIN hospitals have greater use of clinical protocols or more mechanisms for protocol adherence than hospitals without CINs. The lack of statistically significant positive associations may be because clinical integration is complex and can take years to develop.[86,87] However, the results could also suggest that some hospitals may be forming CINs as a mechanism of signaling legitimacy to the market or for managing public perceptions.[88–90] This signaling without actual clinical integration could raise concerns if CINs use their status to help hospitals and health care systems jointly negotiate contracts without investing in integrated care delivery.

PHO affiliations are significantly associated with greater use of clinical protocols, and IPA affiliations are significantly associated with protocol adherence mechanisms. The results suggest that, despite overlap of organizational affiliations, specific affiliations may support the development of distinct hospital infrastructure capabilities. It is possible that physician-hospital alignment supported by PHOs enables the use of evidence-based guidelines and decision support functionality. The robust clinical protocols defined by our study require agreement on clinical guidelines and the resources and capabilities to integrate decision support reminders into EHR systems.[91] While limited research exists around PHOs, it is known that they can help physician groups implement evidence-based guidelines;[92] this physician-led effort combined with hospital resources may lead to greater implementation at hospitals with PHOs as well. Regarding physician performance management, the physician-led nature of IPAs may be particularly beneficial[93] because physician buy-in around measures and the monitoring process are critical components of the use of individual-level data for audit and feedback.[94] This is consistent with evidence showing that physician practices associated with IPAs have more robust performance management systems.[95]

Hospital ACO affiliation is also not associated with any of the three indicators of integration, despite other research suggesting that ACO-affiliated hospitals and physician groups are more integrated than their non-ACO peers.[96–99] The incentive structure of ACOs may lead them to exert control over spending in ways that are not captured in our indicators of integration. It is also possible that we do not see ACO effects because our models include other types of organizational affiliations that predate ACOs, such as IPAs or PHOs. It is known that ACO participant perceptions about the function of the ACO and the desired approach to integration are shaped by pre-existing organizational structures and attitudes about organizational identity;[100] therefore, integration in ACOs may be partially attributable to historical influences of other hospital affiliations.

Our study results should be considered in light of some limitations. First, NSHOS and/or AHA survey non-response could bias the results, though analyses are weighted to account for sampling design and non-response. Second, the cross-sectional analyses did not assess the temporal relationship of CIN participation and information technology, and causal relationships cannot be established. Third, we operationalize the FTC/DOJ indicia of integration using data collected for a survey designed to characterize hospital structure and capabilities, which was not designed to measure CINs. Although the survey measures align well with the indicia of integration, CINs may also engage in additional activities that support integration that are not captured by the surveys. Additionally, use of clinical protocols and protocol adherence mechanisms may be more reflective of an organizational commitment to quality or efficiency than integrated care delivery; even so, these measures assess criteria that CINs must meet to maintain regulatory compliance. Finally, power analyses (Table 8) suggest that the analyses may be underpowered. The small magnitude of effects of CIN participation on integration indicators, however, indicates that these effects are not large enough to be meaningful for policy or practice even if statistically significant. Finally, while CIN participation permits joint negotiation, joint negotiation is not a CIN requirement, and we cannot draw conclusions from this data about a hospital's negotiating activities. Nor should the findings from this study suggest that any antitrust violations are taking place; however, more research should be done to investigate whether collective negotiation is a concern in specific cases.

This research is an important first step in understanding whether CINs are achieving organizational integration. Future research should delve further into CIN activities such as what payer contracts are held by CINs (and, for example, which patient populations their integration activities may prioritize), or whether CIN hospitals are engaging in joint negotiation. In addition, researchers should attempt to disentangle the effects of CINs and other types of organizational affiliations to clarify which affiliations are most effective at accelerating integration.

Conclusion

Our study, the first empirical analysis of activities of CINs, helps shed light on whether hospital participation in a CIN is affiliated with organizational integration. Hospital leaders should ensure that CIN participation translates into integrated information technology capabilities, clinical protocols and decision support, and implementing mechanisms for protocol adherence in order to achieve the goals of clinical integration and maintain regulatory compliance.[73] Future research should examine CIN activities such as the various payer contracts held by CINs, which patient populations are the focus of CIN integration activities, and the extent to which hospitals with CINs engage in joint negotiation. Moreover, researchers should attempt to disentangle the effects of CINs and other organizational affiliations to clarify which affiliations are most effective at accelerating integrated care delivery. Our findings also have implications for policymakers across the federal government as they work to balance market protections with regulatory flexibility for new payment and care delivery models, supporting the decision to use specific indicators of integration over a blanket antitrust safety zone.

Tables

Table 1: Characteristics of hospital-level survey respondents and non-respondents

	Respondents (n=753)	Non-Respondents (n=884)	Sample Frame[3] (n=4,534)
Organizational Characteristics			
Non-Profit[1]	83.5% (629)	79.2% (700)	71.8% (3,255)
General Acute[1]	73.7% (555)	82.5% (729)	74% (3,352)
Critical Access[1]	26.2% (197)	17.5% (154)	26% (1,180)
Teaching Hospital[1]	25.9% (195)	26.2% (232)	21.1% (957)
Community Hospital[1]	73.8% (556)	82.5% (729)	73.9% (3,352)
Size			
Physicians[2]	116.0 (188.9)	128.5 (198.6)	87.1 (151.2)
Associate Providers[2]	16.7 (30.3)	16.8 (28.6)	12.6 (22.8)
Beds[2]	184.6 (191.1)	192.1 (179.4)	160.4 (166.2)
Geography			
Urban[1]	52.5% (395)	61.8% (546)	48.5% (2,200)
Suburban[1]	20.3% (153)	20.3% (153)	21.0% (950)
Rural[1]	27.2% (205)	27.2% (205)	30.5% (1,384)
Midwest[1]	33.2% (250)	27.9% (247)	28.8% (1,304)
Northeast[1]	15.0% (113)	18.8% (166)	13.5% (613)
South[1]	32.0% (241)	32.8% (290)	38.4% (1,740)
West[1]	19.8% (149)	20.5% (181)	19.3% (877)
System Characteristic			
Independent[1]	6.9% (52)	3.2% (28)	18.5% (840)
Simple System[1]	34.9% (263)	31.5% (278)	28.7% (1,301)
Complex System[1]	58.2 % (438)	65.4% (578)	52.8% (2,393)
Owner Subsidiaries[2]	4.4 (7.4)	4.9 (7.8)	6.0 (8.5)
Acute Care Hospitals[2]	26.2 (48.1)	30.8 (53.7)	48.3 (79.2)
Medical Groups[2]	126.0 (175.3)	132.3 (176.9)	157.7 (196.0)
States operating in[2]	5.1 (7.8)	5.9 (8.7)	8.7 (12.0)
Part of ACO[1]	22.5% (158)	22.3% (191)	20.5% (758)

Notes:

[1]Reported as mean (standard deviation)

[2]Reported as percent of total (count)

[3]Includes surveyed and non-surveyed organizations

Table 2: Survey questions used to generate indicators of integration

Measure	Survey Questions Included in Composite
Information Technology (2 items, α*=0.597)	q30: How many electronic health record (EHR) systems do you have in place across your hospital and any owned or managed physician practices? A single EHR across all facilities/ Multiple EHRs/ A mixture of EHR and paper systems/ No EHR capabilities at present q31: Does your hospital's EHR connect directly to the EHR at the primary care practices your patients use? Yes, single HER/ Yes, different EHR, but one that is fully interoperable/ Yes, partially interoperable/ No, not connected
Clinical Protocols (21 items, α*=0.888)	q27: Does your hospital use any of the following approaches on a routine basis to disseminate best patient care practices: ● q27d: An electronic database of practice or system endorsed guidelines ● q27e: Decision supports tools embedded in the EHR ● q27f: Performance improvement events (e.g. LEAN Kaizen training) q28: Does your hospital use evidence based guidelines that have been written down and approved as the preferred protocols for treatment of: ● q28a: Congestive heart failure ● q28b: Acute Coronary Syndrome ● q28c: Hip fracture treatment ● q28d: Community acquired pneumonia ● q28e: Sepsis ● q28f: Pre-eclampsia ● q28g: Neutropenic fever ● q28h: Inpatient radiology ● q28i: Serious mental illness q29: Does your hospital currently use any EHR-based clinical decision-support tools (e.g. embedded order sets) to improve adherence to evidence-based care for: ● q29a: Congestive heart failure ● q29b: Acute Coronary Syndrome ● q29c: Hip fracture treatment ● q29d: Community acquired pneumonia ● q29e: Sepsis ● q29f: Pre-eclampsia ● q29g: Neutropenic fever ● q29h: Inpatient radiology ● q29i: Serious mental illness

Measure	Survey Questions Included in Composite
Protocol Adherence Mechanisms (7 items, α*=0.851)	q32: Management of information about individual clinician performance for: ● q32a: Preventive services (e.g. immunizations, screening) ○ q32a1: Use for feedback ● q32b: Patient experiences (e.g. patient satisfaction or CAHPS scores) ○ q32b1: Use for feedback ● q32c: Overuse of medical tests or procedures (e.g. high cost imaging) ○ q32c1: Use for feedback ● q32d: Underuse of medical test or procedures (e.g. HEDIS) ○ q32d1: Use for feedback ● q32e: Use of acute care services (e.g. readmissions, emergency room use) ○ q32e1: Use for feedback ● q32f: Clinical quality (e.g. blood pressure control, diabetes control, complication rates) ○ q32f1: Use for feedback ● q32g: Total inpatient cost of care ○ q32g1: Use for feedback
*Refers to Cronbach's α, a measure of internal consistency or scale reliability.	

Table 3: Item non-response rates for composite measures

Measure	Survey item	Missing (of 693)*	Percent missing
Information Technology	q30	6	0.87%
	q31	16	2.31%
Clinical Protocols	q27d	10	1.44%
	q27e	10	1.44%
	q27f	12	1.73%
	q28a	10	1.44%
	q28b	12	1.73%
	q28c	16	2.31%
	q28d	10	1.44%
	q28e	8	1.15%
	q28f	27	3.9%
	q28g	22	3.17%
	q28h	19	2.74%
	q28i	27	3.9%
	q29a	13	1.88%
	q29b	19	2.74%
	q29c	23	3.32%
	q29d	15	2.16%
	q29e	11	1.59%
	q29f	35	5.05%
	q29g	28	4.04%
	q29h	25	3.61%
	q29i	30	4.33%
Measure (continued)	**Survey item**	**Missing (of 693)***	**Percent missing**
Protocol Adherence Mechanisms	q32a1	0	0%
	q32b1	0	0%
	q32c1	0	0%
	q32d1	0	0%
	q32e1	0	0%
	q32f1	0	0%
	q32g1	0	0%

*Missing responses coded as “no” or the lowest level of capability.

Table 4: Hospital characteristics by Clinically Integrated Network (CIN) participation status

Hospital Characteristic	Total (of 693)	Without CIN (n=380)	With CIN (n=313)	P-Value[3]
Outcomes				
Information technology[1]	68.3 (28.3)	65.3 (29.5)	72.0 (26.4)	0.002**
Clinical protocols[1]	65.8 (23.9)	62.7(24.7)	69.5 (22.4)	<0.001***
Protocol adherence mechanisms[1]	51.5 (36.3)	50.8 (35.7)	51.6 (37.0)	0.780
Control Variables				
IPA relationship[2]	–	–	–	<0.001***
Without IPA	86.7%	91.8%	80.5%	
With IPA	13.3%	8.2%	19.5%	
PHO participation[2]	–	–	–	<0.001***
Without PHO	78.2%	84.2%	70.9%	
With PHO	21.8%	15.8%	29.1%	
ACO participation[2]	–	–	–	<0.001***
Without ACO	56.9%	74.2%	35.8%	
With ACO	43.1%	25.8%	64.2%	
Physician employment (reported)[2]	–	–	–	<0.001***
Low (bottom tertile)	25.4%	21.6%	30.0%	
Moderate (middle tertile)	25.0%	20.0%	31.0%	
High (top tertile)	25.1%	20.0%	31.3%	
Not reported	24.5%	38.4%	7.7%	
Physician employment (imputed)[2]	–	–	–	
Low (bottom tertile)	34.3%	35.0%	33.5%	0.860
Moderate (middle tertile)	33.8%	33.9%	33.5%	
High (top tertile)	31.9%	31.1%	32.9%	
Medicaid share[2]	–	–	–	0.970
Low (<30%)	83.1%	83.2%	83.1%	
High (≥30%)	16.9%	16.8%	16.9%	
Revenues from payment reform[2]	–	–	–	0.570
Low (<30%)	82.7%	83.4%	81.8%	
High (≥30%)	17.3%	16.6%	18.2%	

Hospital Characteristic	Total (of 693)	Without CIN (n=380)	With CIN (n=313)	P-Value[3]
Bed size[2]	–	–	–	<0.001***
Up to 99 beds	43.1%	51.6%	32.9%	
100-299 beds	32.5%	30.8%	34.5%	
300+ beds	24.4%	17.6%	32.6%	
Hospital control[2]	–	–	–	<0.001***
Government	16.9%	21.6%	11.2%	
Not-for-profit (non-government)	75.8%	65.8%	87.9%	
For-profit	7.4%	12.6%	1.0%	
Academic Medical Center[2]	–	–	–	<0.001***
No	90.8%	94.2%	86.6%	
Yes	9.2%	5.8%	13.4%	
Urbanicity[2]	–	–	–	<0.001***
Metro	61.0%	52.9%	70.9%	
Micro	18.6%	22.4%	14.1%	
Rural	20.3%	24.7%	15.0%	
Census region[2] (descriptive purposes only)	–	–	–	0.072
Northeast	15.2%	13.9%	16.6%	
Midwest	33.8%	30.5%	37.7%	
South	31.6%	33.7%	29.1%	
West	19.5%	21.8%	16.6%	

Notes:
[1]Reported as mean (standard deviation)
[2]Reported as percent of total
[3]Significance levels: <0.05* <0.01** <0.001***

Table 5: Results of multivariate regression of hospital participation in a Clinically Integrated Network on indicators of integration

Hospital Characteristic	Information Technology		Clinical Protocols		Protocol Adherence Mechanisms	
	Coefficient (SE[1])	P-value[2]	Coefficient (SE[1])	P-value[2]	Coefficient (SE[1])	P-value[2]
Clinically Integrated Network participation	5.54 (2.78)	0.047*	3.30 (2.42)	0.174	-5.59 (3.7)	0.132
Independent Practice Association relationship	2.85 (4.19)	0.496	1.78 (3.26)	0.586	14.82 (5.14)	0.004**
Physician Hospital Organization participation	0.54 (3.77)	0.885	5.44 (2.44)	0.027*	5.73 (4.02)	0.155
Accountable Care Organization participation	-1.66 (3.12)	0.594	1.09 (2.35)	0.644	0.56 (3.57)	0.875
Physician employment (ref: low)	–	–	–	–	–	–
Moderate	0.14 (3.40)	0.968	2.25 (2.86)	0.432	10.50 (4.40)	0.018*
High	3.39 (3.25)	0.298	2.45 (2.66)	0.357	2.35 (4.68)	0.617
Medicaid share (ref: low)	1.67 (3.49)	0.633	-8.70 (2.74)	0.002**	-0.97 (4.79)	0.840
Revenues from payment reform (ref: low)	9.52 (3.89)	0.015*	4.33 (2.76)	0.118	-4.59 (4.29)	0.285
Bed size (ref: <100 beds)	–	–	–	–	–	–
100-299 beds	-1.37 (3.96)	0.729	6.37 (3.07)	0.039*	-4.04 (4.64)	0.384
300+ beds	4.69 (4.58)	0.306	9.25 (3.27)	0.005**	1.01 (5.58)	0.857
Hospital control (ref: government)	–	–	–	–	–	–
Not-for-profit (non-gov't)	-0.81 (3.86)	0.834	3.15 (3.2)	0.325	1.27 (4.73)	0.789
For-profit	-14.38 (6.62)	0.031*	0.80 (4.57)	0.862	-2.83 (7.01)	0.687
Academic Medical Center	3.41 (4.59)	0.458	6.64 (3.55)	0.062	-4.78 (6.12)	0.435
Urbanicity (ref: Metro)	–	–	–	–	–	–
Micro	-0.97 (3.67)	0.791	0.57 (3.07)	0.852	-4.69 (4.83)	0.332
Rural	-6.12 (4.27)	0.153	-5.87 (3.69)	0.113	-9.33 (5.46)	0.088
Intercept (adjusted mean score 0-100)	42.70 (12.37)	<0.001***	53.40 (9.03)	<0.001***	23.95 (11.76)	0.042*

Notes:

[1]SE = standard error

[2]Significance levels: <0.05* <0.01** <0.001***

Table 6: Variance inflation factors (VIF) for the main regression model

Variable	VIF
CIN participation (ref: no)	2.63
IPA relationship (ref: no)	1.45
PHO participation (ref: no)	1.68
ACO participation (ref: no)	2.59
Physician employment (ref: low)	–
Moderate	2.43
High	2.29
Medicaid share (ref: low)	1.59
Revenues from payment reform (ref: low)	1.57
Bed size (ref: Up to 99 beds)	–
100-299 beds	3.18
300+ beds	2.81
Hospital control (ref: Government)	–
Not-for-profit (non-gov't)	6.73
For-profit	2.93
AMC (ref: no)	1.61
Urbanicity (ref: Metro)	–
Micro	2.32
Rural	3.15
Mean VIF	***3.51***

Notes: VIF≥2.5 shaded gray. Inflated VIFs are largely limited to categorical control variables with more than two categories, suggesting that this is not a cause for concern.

Table 7: Results of sensitivity analyses regressing Clinically Integrated Network participation on indicators of integration

Hospital Characteristic	Information Technology		Clinical Protocols		Protocol Adherence Mechanisms	
	Coefficient (SE[1])	P-value[2]	Coefficient (SE[1])	P-value[2]	Coefficient (SE[1])	P-value[2]
Model 2.1 (removing other organizational affiliations; n=693)						
Clinically Integrated Network participation	5.32 (2.84)	0.062	4.08 (2.37)	0.086	-3.54 (3.62)	0.329
Physician employment (ref: low)	–	–	–	–	–	–
Moderate	-0.11 (3.40)	0.974	2.36 (2.87)	0.411	9.86 (4.37)	0.025*
High	3.23 (3.26)	0.323	2.42 (2.66)	0.363	1.82 (4.63)	0.695
Medicaid share (ref: low)	1.45 (3.47)	0.676	-9.13 (2.75)	0.001**	-2.16 (4.83)	0.656
Revenues from payment reform (ref: low)	9.47 (3.99)	0.018*	3.85 (2.78)	0.166	-5.59 (4.34)	0.199
Bed size (ref: <100 beds)	–	–	–	–	–	–
100-299 beds	-1.16 (3.81)	0.762	7.19 (3.01)	0.017*	-2.47 (4.59)	0.591
300+ beds	5.06 (4.44)	0.255	10.00 (3.23)	0.002**	3.26 (5.58)	0.559
Hospital control (ref: government)	–	–	–	–	–	–
Not-for-profit (non-gov't)	-1.17 (3.85)	0.761	3.83 (3.22)	0.235	1.77 (4.65)	0.704
For-profit	-14.70 (6.63)	0.027*	0.79 (4.66)	0.865	-4.72 (6.92)	0.495
Academic Medical Center	2.63 (4.44)	0.554	7.03 (3.46)	0.043*	-5.56 (6.00)	0.355
Urbanicity (ref: Metro)	–	–	–	–	–	–
Micro	-0.89 (3.68)	0.808	0.13 (3.11)	0.966	-4.98 (4.94)	0.314
Rural	-6.12 (4.22)	0.148	-6.35 (3.68)	0.085	-9.90 (5.56)	0.076
Intercept (adjusted mean score 0-100)	43.12 (12.31)	<0.001***	53.79 (9.01)	<0.001***	26.44 (11.80)	0.026*
Model 2.2 (complete cases only; n=523)						
Clinically Integrated Network participation	7.38 (3.14)	0.019*	4.25 (2.78)	0.127	-4.02 (4.09)	0.327
Independent Practice Association relationship	4.49 (3.98)	0.260	3.14 (3.40)	0.356	21.36 (5.64)	<0.001***
Physician Hospital Organization participation	4.30 (3.40)	0.206	5.43 (2.55)	0.034*	8.75 (4.60)	0.058
Accountable Care Organization participation	0.59 (3.32)	0.860	3.27 (2.62)	0.214	1.63 (4.15)	0.695
Physician employment (ref: low)	–	–	–	–	–	–
Moderate	2.59 (3.76)	0.492	4.52 (3.15)	0.152	10.39 (5.39)	0.055
High	8.90 (3.81)	0.020*	7.23 (3.24)	0.026*	2.25 (5.52)	0.683
Medicaid share (ref: low)	4.89 (3.80)	0.199	-8.44 (2.93)	0.004**	-1.49 (5.10)	0.771
Revenues from payment reform (ref: low)	6.78 (3.92)	0.085	4.32 (3.41)	0.206	0.59 (5.42)	0.914
Bed size (ref: <100 beds)	–	–	–	–	–	–
100-299 beds	-5.59 (4.45)	0.210	7.69 (3.43)	0.026*	-8.49 (5.10)	0.097

Hospital Characteristic	Information Technology		Clinical Protocols		Protocol Adherence Mechanisms	
	Coefficient (SE[1])	P-value[2]	Coefficient (SE[1])	P-value[2]	Coefficient (SE[1])	P-value[2]
300+ beds	3.01 (5.22)	0.565	10.22 (3.61)	0.005**	-0.86 (6.72)	0.899
Hospital control (ref: government)	–	–	–	–	–	–
Not-for-profit (non-gov't)	-4.86 (4.19)	0.247	5.12 (3.50)	0.145	2.69 (5.21)	0.605
For-profit	-28.17 (10.26)	0.006**	8.10 (5.56)	0.147	3.86 (8.52)	0.651
Academic Medical Center	2.064 (5.13)	0.688	7.65 (3.91)	0.052	-1.93 (7.22)	0.79
Urbanicity (ref: Metro)	–	–	–	–	–	–
Micro	-1.88 (4.21)	0.656	2.70 (3.40)	0.428	-4.10 (5.86)	0.484
Rural	-7.97 (4.74)	0.094	-1.66 (3.97)	0.677	-7.97 (6.12)	0.194
Intercept (adjusted mean score 0-100)	24.71 (12.75)	0.054	48.55 (5.97)	<0.001***	25.49 (19.74)	0.198
Model 2.3 (multiple imputation for physician employment; n=693)						
Clinically Integrated Network participation	5.62 (2.62)	0.032*	2.92 (2.17)	0.178	-2.22 (3.45)	0.519
Independent Practice Association relationship	0.38 (3.56)	0.914	-0.40 (2.90)	0.889	11.97 (4.54)	0.008**
Physician Hospital Organization participation	3.72 (2.86)	0.193	2.15 (2.35)	0.362	4.23 (3.71)	0.255
Accountable Care Organization participation	0.33 (2.66)	0.902	1.73 (2.19)	0.429	-1.56 (3.43)	0.649
Physician employment (ref: low)	–	–	–	–	–	–
Moderate	0.42 (2.64)	0.872	0.58 (2.22)	0.794	5.31 (3.59)	0.139
High	4.41 (2.70)	0.102	2.14 (2.26)	0.344	-0.36 (3.64)	0.922
Medicaid share (ref: low)	0.11 (2.97)	0.969	-6.90 (2.50)	0.006**	-0.45 (4.04)	0.912
Revenues from payment reform (ref: low)	3.53 (2.77)	0.203	5.09 (2.35)	0.030*	-3.18 (3.81)	0.404
Bed size (ref: <100 beds)	–	–	–	–	–	–
100-299 beds	-0.08 (3.02)	0.979	5.19 (2.54)	0.041*	-0.42 (4.1)	0.918
300+ beds	5.56 (3.67)	0.130	8.84 (3.12)	0.005**	3.73 (5.07)	0.462
Hospital control (ref: government)	–	–	–	–	–	–
Not-for-profit (non-gov't)	-0.92 (3.26)	0.778	1.67 (2.72)	0.540	0.72 (4.37)	0.869
For-profit	-6.23 (5.84)	0.287	-3.87 (4.65)	0.405	-7.58 (6.96)	0.276
Academic Medical Center	-0.41 (4.36)	0.925	4.16 (3.68)	0.258	-3.43 (5.96)	0.565
Urbanicity (ref: Metro)	–	–	–	–	–	–
Micro	-1.95 (3.40)	0.566	-3.06 (2.86)	0.286	-3.24 (4.62)	0.484
Rural	-3.8 (3.69)	0.304	-7.03 (3.09)	0.023*	-9.83 (4.97)	0.048*
Intercept (adjusted mean score 0-100)	52.21 (10.05)	<0.001***	54.84 (8.34)	<0.001***	32.43 (13.44)	0.016*

Notes: [1]Significance levels: <0.05* <0.01** <0.001***

Table S6: Power analyses to detect sample size for a test of all coefficients

	Information Technology	Clinical Protocols	Protocol Adherence Mechanisms
Model R^2	0.2295	0.2493	0.1476
Model R^2 without CIN variable	0.2244	0.2465	0.1440
R^2 attributable to CIN variable	0.0051	0.0028	0.0036
Sample size required to detect	***1,534***	***2,798***	***2,175***

Figures

Figure 1: Indicators of integration by organizational affiliation (unadjusted)

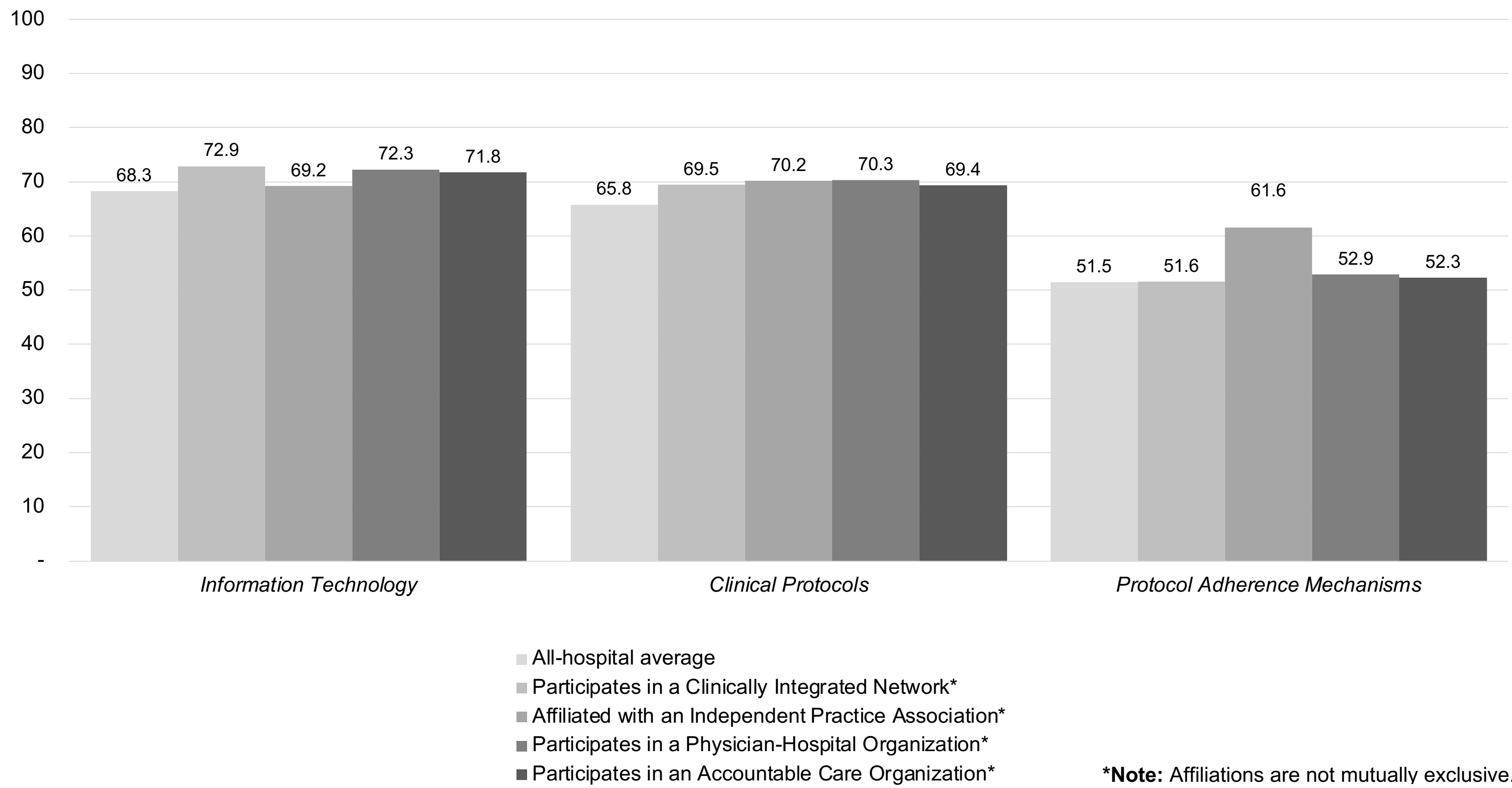
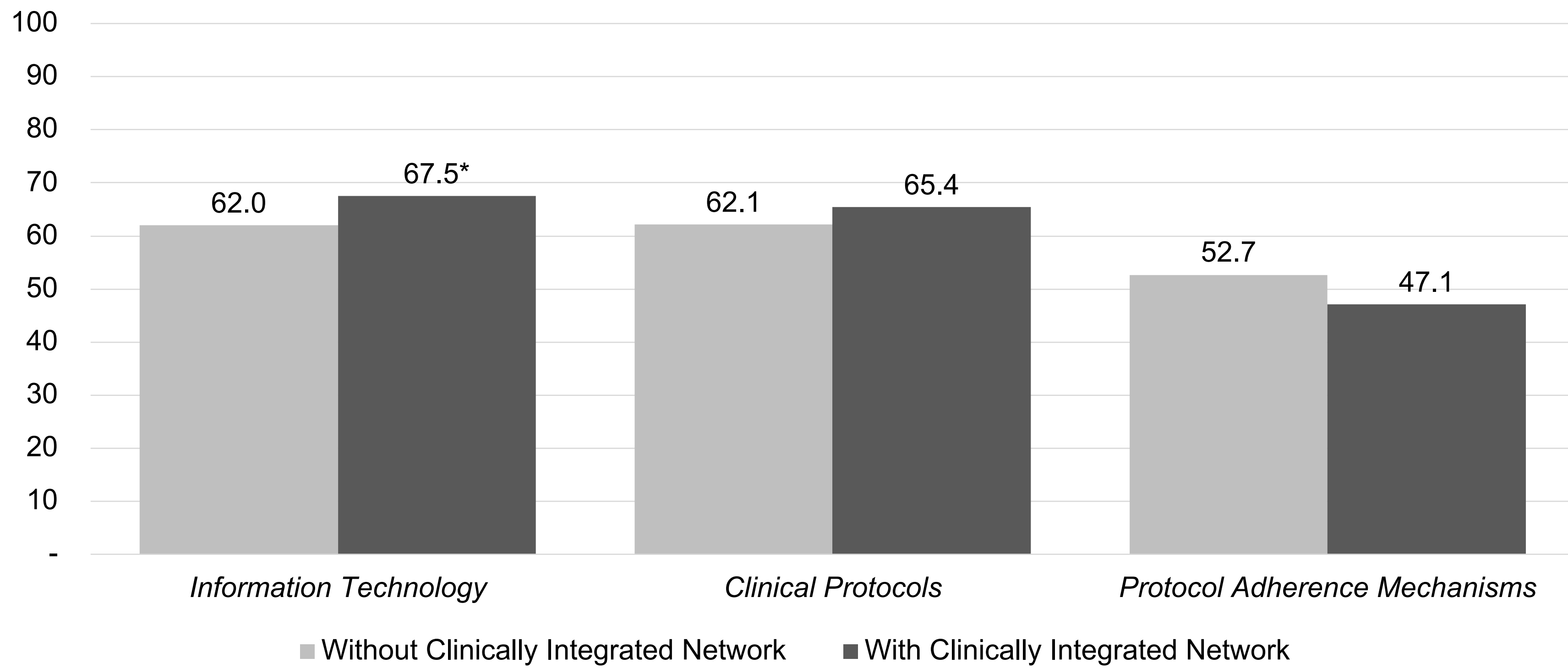


Figure 2: Indicators of organizational integration, by hospital CIN affiliation (adjusted predicted values from the main regression model at variable means)



*Indicates statistically significant at $p<0.05$

Chapter 3: Potentially Preventable Hospitalization in Clinically Integrated Networks

Introduction

As health reform aims to shift incentives from volume to value, provider organizations are using new models to collaborate and coordinate care across the continuum. One organizational form that has arisen in response to reform efforts in recent decades is the Clinically Integrated Network (CIN), which has become especially prominent since the 2010 passage of the Affordable Care Act (ACA).[17,20] A CIN is a network of independent providers – often hospitals and physician practices – that cooperate to control costs and promote quality. CINs provide regulatory flexibility enabling independent providers to jointly negotiate fee-for-service prices with payers that would otherwise violate antitrust price-fixing laws, provided they make financial and human capital investments toward infrastructure that supports higher-quality, more efficient care delivery.[11,12] CINs are similar to Accountable Care Organizations (ACOs), but ACOs require a greater level of financial integration such as shared savings contracts or the assumption of risk.[42] In the absence of financial integration (i.e., an ACO contract), CINs must demonstrate clinical integration through the use of integrated information technology, the adoption of clinical protocols or guidelines, and mechanisms to ensure adherence to those guidelines. [73]

ACA reforms emphasize preventive care and attempt to shift incentives toward population health, away from the historical fee-for-service model that incentivized utilization. CINs that demonstrate integration according to the criteria described above are given special antitrust consideration by the Department of Justice (DOJ) and Federal Trade Commission (FTC) with the expectation that this collaboration between independent providers will generate efficiencies such as improved coordination of care. The delivery of timely, appropriate, well-coordinated ambulatory care should decrease potentially preventable inpatient utilization,[101] a major driver of avoidable spending.[102,103]

Despite the potential for improved care coordination, little evidence exists linking CINs to improved patient outcomes.[17] Our study aims to help fill this gap, examining the association between hospital participation in a CIN and the odds of an inpatient hospitalization at that hospital being potentially preventable. Prevention Quality Indicators (PQIs) are a validated measure for identifying hospitalizations that are potentially preventable through timely, effective, and coordinated care.[104,105] Odds of a PQI have been linked to hospital characteristics,[106,107] and reforms intended to promote more integrated, higher-value care delivery have been found to reduce potentially preventable PQIs.[108,109] Given the expected benefits of Clinically Integrated Networks we hypothesize that, controlling for other factors, hospitals with CINs will demonstrate lower potentially preventable hospitalizations.

Further, we expect to find synergies for hospitals with both a CIN and ACO. CINs and ACOs are similar conceptually, but hospitals with an ACO have, by definition, a contract for financial accountability for a given population beyond traditional fee-for-service.[42] The ACO contract model is designed to incentivize coordinated primary and ambulatory care, and to interact positively with other reform models.[110] Thus, we hypothesize that the magnitude of the inverse association between CIN participation and potentially preventable inpatient utilization will be even greater for hospitals that have an ACO in addition to a CIN.

Furthermore, increasing recognition is being paid to the idea that health equity must be a goal in the design and implementation of health reform efforts.[111,112] Racial and ethnic disparities have long existed with regard to healthcare access and outcomes, including potentially preventable hospitalization,[113,114] and these disparities persist in the post-reform era.[115] There is some concern that organizational arrangements such as CINs or ACOs may perpetuate or exacerbate disparities, for example by selection into participation or cherry-picking of patients,[116] and contract incentives could reinforce documented disparities in care pathways linked to utilization.[117] To address these concerns, our study examines the relationship between hospital CIN participation and differential avoidable utilization outcomes by race/ethnicity and socioeconomic indicators to determine whether CINs are associated with a change in health disparities.

Methods

We analyze CIN participation and hospital characteristics from the 2017 American Hospital Association (AHA) survey linked to all-payer hospitalization-level information sourced from the 2017 Healthcare Cost and Utilization Project (HCUP) State Inpatient Databases (SID) for 14 states (available at the time of analysis) and county-level provider supply data from the 2017 Area Health Resources File. The AHA survey profiles over 6,200 hospitals with a response rate of over 75%.[118] The HCUP-SID data available includes all inpatient discharges from Arkansas, Arizona, Colorado, Florida, Kentucky, Maryland, New Jersey, Nevada, New York, Oregon, Rhode Island, Vermont, Washington, and Wyoming, totaling 7,605,594 hospitalizations across 1,064 hospitals (see Table 1 for details).

The outcome variable is a binary indicator of potentially preventable inpatient utilization, following the Agency for Healthcare Quality and Research method to define an overall composite Prevention Quality Indicator (PQI 90), which identifies ambulatory care sensitive conditions that may be preventable through timely, effective, and coordinated primary and outpatient care.[104,105] Detail on the items comprising the PQI measure can be found in Table 2.

The independent variable of interest is a binary indicator of CIN participation sourced from the AHA survey. The survey asks whether the hospital or health system has formed a CIN, defining a CIN as “a collection of healthcare providers, such as physicians, hospitals, and post-acute care treatment providers, that come together to improve patient care and reduce overall healthcare costs”. The survey question is positioned in a section titled “Insurance and Alternative Payment Models”, and follows questions asking about other affiliation organizations including ACOs, Independent Practice Associations, and Physician-Hospital Organizations.[53]

We control for potentially confounding hospitalization and hospital characteristics that may be related to both a hospital’s participation in a CIN and to potentially preventable utilization. At the hospital level we control for participation in an ACO and an interaction between CIN and ACO participation, in an attempt to disentangle associations between these related and often-overlapping organizational structures and utilization. We control for hospital financial resources by including a dichotomous variable for Medicaid share (high: ≥30%; low: <30%) and for county-level ratio of primary care physicians to 10,000 population (PCP ratio), available from the AHRF, as a measure of access to ambulatory preventive care.[119] Hospital structural characteristics included as control variables include hospital size (up to 99 beds, 100-299 beds, or 300+ beds); ownership (government, non-profit non-government, or for-profit); type (acute care, Critical Access Hospital (CAH), or Academic Medical Center (AMC)); and urbanicity (Census Bureau-defined metro, micro, or rural Core Based Statistical Area). At the hospitalization level we control for patient sex, primary payer, race/ethnicity, ZIP code income quartile, and age sourced from the HCUP-SID data.[120] We also control for the count of comorbid conditions using the Elixhauser comorbidity index, a validated predictor of inpatient utilization.[121,122]

We calculate unadjusted descriptive statistics for hospitalizations and of all hospitals in the data set, by hospital CIN status. We test pairwise correlations between all included variables, then conduct a single-level multivariate logistic regression with hospital-clustered standard errors (Model 1.0) to test for potential multicollinearity, calculating variance inflation factors (VIFs) with all variables included. A VIF of 2.5 or greater indicates some multicollinearity, and VIFs above 10 indicate significant multicollinearity.[62,63] Variables with significant multicollinearity (VIF>10) are typically removed, as are variables of interest with some multicollinearity (2.5≥VIF>10); however, variables are retained if they are of theoretical importance.[123]

Next, multilevel multivariate logistic regression models with random effects for hospitals are specified, where the outcome is the log odds of a potentially preventable hospitalization, and the main predictor is hospital participation in a CIN.[101] The level-1 (unit) variable is the patient hospitalization and the level-2 (cluster) variable is the hospital. We use state fixed effects, hospital clustered standard errors, and an unstructured covariance matrix. The model regresses inpatient hospitalizations on CIN participation, and includes a vector of variables W to adjust for hospital-level characteristics and a vector of variables X to adjust for hospitalization-level characteristics, following the form:

$$log\ odds(PQI_{ij}) = \beta_0 + \beta_1(CIN_j) + \beta_2(W_j) + \beta_3(X_{ij}) + \alpha_{state} + \zeta_{0j} + \epsilon_{ij}$$

In the above, β_1 is the coefficient of interest. W_j is a vector of hospital-level covariates, X_{ij} is a vector of hospitalization-level covariates, α_{state} represents the state fixed effects, ζ_{0j} is the hospital-level error term, and ϵ_{ij} is a hospitalization-level error term. Our use of a multilevel model assumes that any omitted level-2 variables are uncorrelated with the variables in the model.[124] Model 2.0 includes all variables (analogous to Model 1.0). Our main model, Model 2.1, is the reduced model with variables removed to reduce multicollinearity (analogous to Model 1.1).

To examine heterogeneity of outcomes among different patient populations and test for an association between hospital participation in a CIN and disparities in potentially preventable hospitalization, Model 2.2 introduces interactions between the CIN indicator variable and the hospitalization-level variables for payer, race/ethnicity, and ZIP code income quartile (building on the main model).[125]

We also conduct a sensitivity analysis with the main model, using a chronic PQI composite (PQI 92) rather than the overall PQI composite as the outcome of interest (Model 3.1). The chronic condition measure excludes PQIs for acute conditions (community-acquired pneumonia and urinary tract infections), limiting the outcome only to chronic conditions which may reflect the care coordination expected of a CIN.[126]

Results

Just over one-third (35%) of hospitals participate in a CIN, and a minority (13%) of hospitalizations are potentially preventable. In unadjusted analyses, CIN hospitals have significantly fewer potentially preventable hospitalizations than non-CIN hospitals (12.8% compared with 14.0%, p<0.001). Hospitals with CINs differ significantly from non-CIN hospitals across every variable we consider, and hospitalizations vary significantly between CIN and non-CIN hospitals across every measure except patient sex. See Table 3 for full descriptive statistics of hospitals in the sample and Table 4 for full descriptive statistics of hospitalizations.

In the preliminary model with all covariates included (Model 1.0), we find moderately high correlations between some variables: the correlation between payer and patient age is 0.52, and the correlation between CIN and ACO participation is 0.50 (see Table 5). We find moderate multicollinearity of the CIN variable of interest (VIF=6.38) with other model variables and a moderate overall VIF (mean VIF=3.81). To address these collinearity issues, we remove the ACO variable (VIF=7.02) and the interaction between CIN and ACO participation (VIF=9.32). We also remove PCP to population ratio (VIF=12.72), and combine the Medicare and Medicaid payer categories to a Medicare/caid category to reduce multicollinearity with age (VIF=16.59). Age is maintained due to theoretical motivations (i.e., we wish to model the association between CIN participation and potentially preventable utilization, controlling for patient age among other characteristics; VIF=12.01).[123] This yields a reduced model (Model 1.1) with mean VIF=3.04 and less concern about multicollinearity on the CIN variable of interest (VIF=2.97). See Table 6 for details.

In the main analysis, which uses multilevel regression modeling with the reduced set of covariates (Model 2.1), Clinically Integrated Network status is not significantly associated with the log odds of a hospitalization being a potentially preventable admission (OR=0.98, p=0.533), controlling for other hospital and hospitalization characteristics. See Figure 1.

Of hospital-level control variables, hospitalizations at larger hospitals have significantly lower odds of being potentially preventable than those at smaller hospitals (for hospitals with 100-299 beds OR=0.77, p<0.001 and for 300+ beds OR=0.64, p<0.001, both compared with a reference group of hospitals with 99 or fewer beds). Compared with acute care hospitals, hospitalizations at critical access hospitals have significantly higher odds of being potentially preventable (OR=1.87, p<0.001) and those at academic medical centers have significantly lower odds

(OR=0.77 p<0.001). Hospitalizations at micropolitan and rural area hospitals also have greater odds of being potentially preventable (OR=1.13, p=0.006 and OR=1.43, p<0.001, respectively). Controlling for all else, results of the main model find no significant difference in the odds of a potentially preventable hospitalization by hospital ownership or Medicaid share.

Of hospitalization-level control variables, female patients have greater odds of a potentially preventable hospitalization than male patients (OR=1.07, p<0.001), controlling for other factors. Patients with Medicare/caid and other primary payers also have greater odds of a potentially preventable hospitalization (OR=1.32, p<0.001 for Medicare/caid; OR=1.24, p<0.001 for other payers). Odds of a potentially preventable hospitalization are also higher for Black (OR=1.44, p<0.001), Hispanic (OR=1.23, p<0.001), Asian/Pacific Islander (OR=1.07, p=0.001), Native American patients (OR=1.08, p=0.002), and patients categorized as "other" race/ethnicities (OR=1.05, p=0.005) compared with a reference group of non-Hispanic white patients. The odds of a potentially preventable hospitalization decrease as the median income in a patient's ZIP code increases (OR=0.93, p<0.001 for patients living in ZIPs with income in the second versus the first quartile; OR=0.88, p<0.001 for patients in ZIPs in the third quartile; and OR=0.82, p<0.001 for patients in the top quartile). Considering comorbidities, a 1-point increase in Elixhauser comorbidity index is associated with 1.24 times the odds of a potentially preventable hospitalization (p<0.001). A one-year increase in patient age is associated with an increase of 1.01 times the odds of a potentially preventable hospitalization (p<0.001).

In heterogeneity analyses (Model 2.2), we find that Black patients at CIN hospitals have significantly greater odds of a potentially preventable admission than non-Hispanic white patients at CIN hospitals (OR=1.05, p=0.020), controlling for other characteristics. All else equal, patients at CIN-affiliated hospitals with race/ethnicity categorized as "other" also have significantly greater odds of potentially preventable admission compared with non-Hispanic white patients at CIN-affiliated hospitals (OR=1.07, p=0.028). Coefficients for the interaction terms for other race/ethnicities are not significant. Coefficients for the interaction terms on payer and ZIP code income quartile are also not significant; that is, we find no significant interaction between CIN participation and payer and between CIN participation and patient ZIP income quartile with regard to potentially preventable hospitalization, controlling for all else.

When including all control variables (Model 2.0), we find results consistent with the main model (Model 2.1); there is no significant association between hospital CIN status and the odds of a potentially preventable admission (OR=1.00, p=0.929). Similarly, we find no significant association between ACO participation (OR=0.98, p=0.599) or CINs with ACO contracts (OR=1.02, p=0.750) and the odds of a hospitalization being potentially preventable. Results are also consistent for all control variables. These results are also consistent with the single-level models (Model 1.0 and Model 1.1). Complete results are found in Table 7.

In the sensitivity analysis using the alternative PQI specification with only chronic conditions included, the results are consistent with the main model; we find no association between hospital CIN participation and the odds of a hospitalization for a chronic condition being potentially preventable (OR=1.01, p=0.807; see Table 8).

Discussion

Our study, the first to examine the association between hospital CIN participation and quality of care, finds that hospital participation in a CIN is not significantly associated with the odds of a potentially preventable admission when accounting for other hospital and hospitalization-level characteristics. While CINs have been described as a way to improve cross-setting care coordination and quality of care,[17] this does not appear to translate to a measurable decrease in unnecessary hospitalization.

There are several potential explanations for the lack of association between CINs and quality. The lack of association may be due to the complex challenges inherent to efforts to reduce potentially preventable utilization. While care continuity and coordination can be effective tools,[127,128] hospitalization is a relatively downstream outcome. Utilization is impacted by broad environmental factors including social and economic determinants of health,[129,130] and more research is needed to identify the best way to organize care delivery to reduce potentially preventable utilization. Even activities currently required of CINs by regulatory authorities, such as the implementation of clinical guidelines,[73] may not directly impact potentially preventable utilization.[131]

Complex incentive and reimbursement structures can also make inpatient utilization difficult to influence. Alignment of financial incentives is critical to care coordination,[132] and CINs can be a mechanism for aligning incentives across independent provider organizations.[18] However, hospitals paid per admission by diagnosis related groups do not have incentive to reduce inpatient utilization, and pay-for-performance programs may not be enough to drive a reduction in potentially preventable utilization.[131] We find no association between the CIN-ACO interaction and odds of a potentially preventable hospitalization in the full model, meaning that even CINs with ACO contracts do not have lower potentially preventable utilization. These patterns are consistent with the mixed results of research examining the impact of ACO participation on potentially preventable hospitalization.[133,134] More information about reimbursement models and the level of risk (i.e., upside-only or downside) could help to further elucidate which organizational models are truly effective at shifting utilization patterns.

Finally, it is possible that hospital participation in a CIN is not associated with potentially preventable hospitalization because CINs do not integrate care in a way that would lead to reduced downstream utilization. For example, a CIN may serve more as a signal of legitimacy to patients, payers, or independent providers.[88–90]

Our results also raise important questions about health equity in CINs. Consistent with other research,[135] we find increased odds of a potentially preventable hospitalization for all racial/ethnic categories compared with non-Hispanic white patients. However, the interaction between hospital CIN participation and patient race/ethnicity also indicates that CIN participation is associated with significantly higher odds of a potentially preventable hospitalization for Black patients and patients with "other" race/ethnicity compared to patients at hospitals that do not participate in a CIN. This gives further voice to concerns that CIN activities or contracts may be exacerbating pre-existing disparities.[116,117] This finding is consistent with evidence that health system affiliation of physician practices may potentially increase disparities;[136] however, evidence on the relationship between racial/ethnic disparities and other affiliation organizations such as ACOs is mixed.[137–140] Further study is required to understand whether hospitals are more likely to form CINs in areas with greater racial/ethnic disparities, or if activities associated with CIN participation are contributing to increased disparities in outcomes.

Our findings lead to several recommendations for CINs leadership to support reduction of potentially preventable hospitalizations, and for policymakers to ensure CINs are delivering on the promise of improved outcomes in exchange for regulatory flexibility. First, CINs must prioritize care coordination and continuity with efforts that go above and beyond the minimum activities required by current regulatory guidelines in order to improve quality of care. Second, CINs should take advantage of the permitted joint contracting flexibilities to contract in novel ways; this could further align incentives around preventive and ambulatory care, and support a shift away from unnecessary inpatient utilization. This may better support care coordination with ambulatory care practices, leading to improved quality. Regulatory agencies should consider placing increased emphasis on the assumption of shared financial risk for CINs to maintain compliance. Third, payment and delivery reforms for all CIN contracts should be designed with equity, not just efficiency, in mind; the ACO Realizing Equity, Access, and Community Health model, which evolved from the Medicare Shared Savings Program, is an example of this; it requires implementation of a health equity plan, mandates data collection on social determinants of health, and provides additional support to ACOs with disadvantaged populations.[141] Integrating equity into contracts could support targeted interventions to improve care coordination for racial/ethnic groups with high potentially preventable hospitalizations.

Our study results should be considered in the context of some limitations. First, the HCUP-SID data is only available for a subset of states, and results may not generalize to all U.S. states. Despite this, we opt to use outcomes from the available HCUP-SID data rather than national outcomes data because the hospitalization-level adjustments permitted with HCUP-SID data are critical to disentangling hospital and patient effects. Second, our analyses are limited to potentially preventable inpatient utilization, and we cannot examine outcomes such as readmissions or patient experience or the activities that may contribute to such outcomes. There are still significant gaps in our understanding of how CINs organize to deliver care, and whether care delivery processes at CIN-affiliated providers differ meaningfully from those at providers without CINs. We focus on potentially preventable hospitalizations as an outcome because these are an accepted measure of care coordination that is an expected efficiency of a CIN, but future research should attempt to describe the care coordination activities of hospitals with and without CINs. Finally, the cross-sectional nature of the data does not allow us to examine directionality or a mechanism for the identified racial/ethnic disparities in potentially preventable utilization for CIN-affiliated hospitals; the AHA survey only collected CIN participation data between 2017 and 2019, limiting our ability to look longitudinally. More research is necessary to delineate potential causes of this finding.

Conclusion

Our study, the first to empirically examine patient outcomes associated with hospital participation in a Clinically Integrated Network, raises questions about whether CINs are an effective model of collaboration in pursuit of population health goals, and whether federal regulators should continue to support virtual integration. CIN leadership must prioritize care coordination and continuity permitted by the CIN structure, and capitalize on opportunities to contract in a way that aligns incentives to support this work. Policymakers should consider whether current payment models and antitrust requirements for CINs are sufficient to improve care coordination and quality of care.

Tables

Table 1: List of states available in 2017 Healthcare Cost and Utilization Project (HCUP) State Inpatient Database (SID) data and corresponding American Hospital Association survey hospital count and HCUP-SID hospitalizations

State	Hospitals	Hospitals with a Clinically Integrated Network	Hospitalizations	Hospitalizations in a Clinically Integrated Network
Arkansas	71	32 (45%)	255,690	177,011 (69%)
Arizona	54	7 (13%)	417,177	62,133 (15%)
Colorado	76	21 (28%)	304,567	145,573 (48%)
Florida	178	52 (29%)	2,046,399	901,653 (44%)
Kentucky	95	28 (29%)	386,642	169,738 (44%)
Maryland	46	20 (43%)	458,685	263,302 (57%)
New Jersey	63	47 (75%)	679,975	554,677 (82%)
Nevada	32	5 (16%)	220,887	49,521 (22%)
New York	159	77 (48%)	1,677,786	1,053,293 (63%)
Oregon	59	43 (73%)	252,692	203,737 (81%)
Rhode Island	9	4 (44%)	85,285	56,098 (66%)
Vermont	14	3 (21%)	35,581	16,863 (47%)
Washington	86	28 (33%)	408,747	239,041 (58%)
Wyoming	122	1 (1%)	375,481	9,079 (2%)
Total	***1,064***	***368 (35%)***	***7,605,594***	***3,901,719 (51%)***

Table 2: Summary of diagnosis and procedure codes used to define Prevention Quality Indicators (PQIs)

Measure	Summary of Criteria
PQI 01 Diabetes Short-Term Complications	Discharges, for patients ages 18 years and older, with a principal ICD-10-CM diagnosis code for diabetes short-term complications (ketoacidosis, hyperosmolarity, or coma) (ACDIASD*).
PQI 03 Diabetes Long-Term Complications	Discharges, for patients ages 18 years and older, with a principal ICD-10-CM diagnosis code for diabetes with long-term complications (renal, eye, neurological, circulatory, or complications not otherwise specified) (ACDIALD*).
PQI 05 Chronic Obstructive Pulmonary Disease (COPD) or Asthma in Older Adults	Discharges, for patients ages 40 years and older, with either a principal ICD-10-CM diagnosis code for Chronic obstructive pulmonary disorder – COPD (excluding acute bronchitis) (ACCOPDD*) or a principal ICD-10-CM diagnosis code for asthma (ACSASTD*). Excludes cases with an ICD-10-CM diagnosis code for cystic fibrosis and anomalies of the respiratory system (RESPAN*).
PQI 07 Hypertension	Discharges, for patients ages 18 years and older, with a principal ICD-10-CM diagnosis code for hypertension (ACSHYPD*). Excludes cases with an ICD-10-PCS procedure code for cardiac procedure or an ICD-10-CM diagnosis code of Stage I-IV kidney disease (ACSHY2D*) if the kidney disease code is accompanied by an ICD-10-PCS procedure code for dialysis access (DIALY2P*).
PQI 08 Heart Failure	Discharges, for patients ages 18 years and older, with a principal ICD-10-CM diagnosis code for heart failure (MRTCHFD*). Excludes cases with an ICD-10-PCS procedure code for cardiac procedure.
PQI 11 Community-Acquired Pneumonia	Discharges, for patients ages 18 years and older, with a principal ICD-10-CM diagnosis code for community acquired pneumonia (ACSBACD*). Excludes cases with an ICD-10-CM diagnosis code for sickle cell anemia or HB-S disease (ACSBA2D*), an ICD-10-CM diagnosis code for immunocompromised state, or an ICD-10-PCS procedure code for immunocompromised state.
PQI 12 Urinary Tract Infections	Discharges, for patients ages 18 years and older, with a principal ICD-10-CM diagnosis code for urinary tract infection (ACSUTID*). Excludes cases with an ICD-10-CM diagnosis code for kidney or urinary tract disorder (KIDNEY*), an ICD-10-CM diagnosis code for immunocompromised state, or an ICD-10-PCS procedure code for immunocompromised state.
PQI 14 Uncontrolled Diabetes	Discharges, for patients ages 18 years and older, with a principal ICD-10-CM diagnosis code for uncontrolled diabetes without mention of a short-term or long-term complication (ACDIAUD *).
PQI 15 Asthma in Younger Adults	Discharges, for patients ages 18 through 39 years, with a principal ICD-10-CM diagnosis code for asthma (ACSASTD*). Excludes cases with an ICD-10-CM diagnosis codes for cystic fibrosis and anomalies of the respiratory system (RESPAN*).
PQI 16 Lower-Extremity Amputation among Patients with Diabetes	Discharges, for patients ages 18 years and older, with an ICD-10-PCS procedure code for lower extremity amputation (ACSLEAP*) and an ICD-10-CM diagnosis code for diabetes (ACSLEAD *). Excludes cases with an ICD-10-CM diagnosis code for traumatic amputation of the lower extremity (ACLEA2D*).
PQI 90 Overall Composite	Includes PQI 01, PQI 03, PQI 05, PQI 07, PQI 08, PQI 11, PQI 12, PQI 14, PQI 15, and PQI 16
PQI 92 Chronic Composite	Includes PQI 01, PQI 03, PQI 05, PQI 07, PQI 08, PQI 14, PQI 15, and PQI 16

Table 3: Descriptive statistics of hospitals in the sample, by Clinically Integrated Network status

Variable	All hospitals (n=1,064)	Non-CIN hospitals (n=696)	CIN hospitals (n=368)	p-value[2]
Accountable Care Organization	–	–	–	<0.001***
No	33.8%	15.5%	68.5%	–
Yes	66.2%	84.5%	31.5%	–
Bed size	–	–	–	<0.001***
Up to 99 beds	41.3%	50.4%	23.9%	–
100 to 299 beds	36.2%	35.1%	38.3%	–
300+ beds	22.6%	14.5%	37.8%	–
Ownership	–	–	–	<0.001***
Government	14.8%	17.2%	10.1%	–
Not-for-profit (non-government)	69.3%	60.1%	86.7%	–
For-profit	16.0%	22.7%	3.3%	–
Hospital type	–	–	–	<0.001***
Acute care hospital	68.8%	66.1%	73.9%	–
Critical access hospital	25.0%	30.9%	13.9%	–
Academic medical center	6.2%	3.0%	12.2%	–
Medicaid share of days	–	–	–	0.024*
Low (<30%)	82.4%	84.3%	78.8%	–
High (≥30%)	17.6%	15.7%	21.2%	–
Urbanicity	–	–	–	<0.001***
Metro	66.7%	58.6%	82.1%	–
Micro	15.5%	18.7%	9.5%	–
Rural	17.8%	22.7%	8.4%	–
Ratio of primary care physicians to 10k population[1]	7.3 (3.0)	6.8 (2.9)	8.2 (3.1)	<0.001***

Notes:
[1]Reported as mean (standard deviation)
[2]Significance levels: <0.05* <0.01** <0.001***

Table 4: Descriptive statistics of hospitalizations in the sample, by hospital Clinically Integrated Network status, hospital-level characteristics

Variable	All hospitalizations (n=7,605,594)	Non-CIN hospitalizations (n=3,703,875)	CIN hospitalizations (n=3,901,719)	p-value[2]
Hospital-level characteristics				
Accountable Care Organization	–	–	–	<0.001***
No	51.0%	76.9%	26.4%	–
Yes	49.0%	23.1%	73.6%	–
Bed size	–	–	–	<0.001***
Up to 99 beds	6.8%	10.7%	3.2%	–
100 to 299 beds	34.3%	43.5%	25.6%	–
300+ beds	58.8%	45.8%	71.2%	–
Ownership	–	–	–	<0.001***
Government	10.8%	10.2%	11.4%	–
Not-for-profit (non-government)	73.7%	60.0%	86.6%	–
For-profit	15.5%	29.8%	1.9%	–
Hospital type	–	–	–	<0.001***
Acute care hospital	76.1%	84.7%	67.9%	–
Critical access hospital	1.7%	2.8%	0.7%	–
Academic medical center	22.2%	12.6%	31.4%	–
Medicaid share of days	–	–	–	<0.001***
Low (<30%)	78.4%	79.8%	77.1%	–
High (≥30%)	21.6%	20.2%	22.9%	–
Urbanicity	–	–	–	<0.001***
Metro	93.6%	90.2%	96.8%	–
Micro	4.5%	6.4%	2.7%	–
Rural	1.9%	3.4%	0.5%	–
Ratio of primary care physicians to 10k population[1]	8.5 (2.8)	8.0 (2.8)	9.0 (2.8)	<0.001***
Hospitalization-level characteristics				
Prevention quality indicator hospitalization	–	–	–	<0.001***
No	86.7%	86.0%	87.2%	–
Yes	13.3%	14.0%	12.8%	–
Sex	–	–	–	0.092
Male	48.9%	48.9%	48.9%	–
Female	51.1%	51.1%	51.1%	–

Variable	All hospitalizations (n=7,605,594)	Non-CIN hospitalizations (n=3,703,875)	CIN hospitalizations (n=3,901,719)	p-value[2]
Primary payer	–	–	–	<0.001***
Private	23.0%	21.0%	24.8%	–
Medicare	52.4%	54.4%	50.6%	–
Medicaid	17.9%	17.7%	18.1%	–
Other	6.7%	6.9%	6.5%	–
Race/ethnicity	–	–	–	<0.001***
White	67.4%	69.7%	65.2%	–
Black	14.5%	13.2%	15.7%	–
Hispanic	10.9%	10.8%	11.1%	–
Asian or Pacific Islander	2.1%	1.6%	2.6%	–
Native American	0.5%	0.6%	0.4%	–
Other	4.6%	4.1%	5.1%	–
ZIP income quartile	–	–	–	<0.001***
$1-$43,999	29.6%	32.6%	26.7%	–
$44k-$55,999	25.7%	28.7%	22.8%	–
$56k-73,999	23.7%	22.5%	24.9%	–
$74k+	21.0%	16.2%	25.6%	–
Age[1]	60.4 (20.9)	60.8 (20.6)	60.0 (21.2)	<0.001***
Elixhauser comorbidity index[1]	3.4 (2.3)	3.5 (2.3)	3.4 (2.3)	<0.001***

Notes:
[1]Reported as mean (standard deviation)
[2]Significance levels: <0.05* <0.01** <0.001***

Table 5: Correlations between variables in the full regression model

	Clinically Integrated Network	Accountable Care Organization	Bed size	Ownership	Hospital type	Medicaid share	Urbanicity	Primary care physicians to 10k population	Sex	Payer	Race/ethnicity	ZIP income quartile	Elixhauser comorbidity index	Age
Clinically Integrated Network	1.00													
Accountable Care Organization	0.50	1.00												
Bed size	0.26	0.21	1.00											
Ownership	-0.29	-0.23	-0.16	1.00										
Hospital type	0.21	0.23	0.33	-0.23	1.00									
Medicaid share	0.03	0.08	0.20	-0.30	0.20	1.00								
Urbanicity	-0.14	-0.14	-0.40	-0.03	-0.05	-0.01	1.00							
Primary care physicians to 10k population	0.18	0.23	0.23	-0.13	0.29	0.07	-0.16	1.00						
Sex	0.00	0.00	-0.02	0.02	-0.01	-0.02	0.01	-0.01	1.00					
Payer	0.03	0.02	0.06	-0.03	0.05	0.04	-0.05	0.04	-0.07	1.00				
Race/ethnicity	0.04	0.07	0.12	-0.04	0.12	0.17	-0.09	0.06	-0.01	0.09	1.00			
ZIP income quartile	0.12	0.14	0.03	-0.07	0.06	-0.06	-0.17	0.22	0.00	0.02	-0.07	1.00		
Elixhauser comorbidity index	-0.02	-0.02	-0.02	0.03	-0.04	-0.04	0.00	-0.04	0.00	-0.31	-0.07	-0.03	1.00	
Age	-0.02	-0.02	-0.11	0.07	-0.10	-0.13	0.04	-0.04	0.06	-0.52	-0.16	0.07	0.39	1.00

Table 6: Variance inflation factors (VIF) for the full and reduced regression models

Variable	VIF[1]	
	Model 1.0: Single-level full model	Model 1.1: Single-level reduced model
Clinically Integrated Network (CIN)	6.38	2.97
Accountable Care Organization (ACO)	7.02	removed
CIN x ACO	9.32	removed
Bed size (ref: up to 99)	–	–
100 to 299	6.82	6.24
300+	12.58	11.21
Ownership (ref: gov't)	–	–
Not-for-profit (non-gov't)	8.43	8.11
For-profit	2.92	2.83
Hospital type (ref: acute care)	–	–
Critical access hospital (CAH)	1.51	1.51
Academic medical center (AMC)	1.83	1.74
Medicaid share (ref: <30%)	1.83	1.77
Urbanicity (ref: metro)	–	–
Micro	1.26	1.26
Rural	1.49	1.48
Primary care physicians to 10k population	12.72	removed
Sex (ref: male)	2.04	2.04
Payer (ref: commercial)	–	–
Medicare	4.68	combined
Medicaid	1.87	combined
Medicare/caid	–	4.72
Other	1.31	1.31

Variable (continued)	VIF[1]	
	Model 1.0: Single-level full model	Model 1.1: Single-level reduced model
Race/ethnicity (ref: white)	–	–
Black	1.42	1.40
Hispanic	1.29	1.28
Asian or Pacific Islander	1.06	1.05
Native American	1.02	1.02
Other	1.13	1.13
ZIP income (ref: <$44k)	–	–
$44k-$55,999	1.97	1.96
$56k-73,999	2.05	2.03
$74k+	2.32	2.25
Elixhauser comorbidity index	3.99	3.99
Age	16.59	12.01
Mean VIF	***3.81***	***3.04***

[1] 2.5<VIF<10 shaded light gray. VIF≥10 shaded deeper gray.

Table 7: Exponentiated odds ratios (OR) with standard errors (SE) for all models using the Prevention Quality Indicator Overall Composite outcome (PQI 90)

Variable	Model 1.0: Single-level full model		Model 1.1: Single-level reduced model		Model 2.0: Multi-level full model		Model 2.1 (main results): Multi-level reduced model		Model 2.2: Multi-level reduced model with interactions	
	OR (SE)	p-value[1]	OR (SE)	p-value[1]	OR (SE)	p-value[1]	OR (SE)	p-value[1]	OR (SE)	p-value[1]
Hospital-level characteristics										
Clinically Integrated Network (CIN)	0.99 (0.03)	0.826	1.00 (0.03)	0.848	1.00 (0.04)	0.929	0.98 (0.03)	0.533	0.98 (0.03)	0.574
Accountable Care Organization (ACO)	0.99 (0.03)	0.821	–	–	0.98 (0.04)	0.599	–	–	–	–
CIN x ACO	1.01 (0.05)	0.797	–	–	1.02 (0.05)	0.750	–	–	–	–
Bed size (ref: up to 99)	–	–	–	–	–	–	–	–	–	–
100 to 299	0.81 (0.03)	<0.001***	0.79 (0.03)	<0.001***	0.81 (0.04)	<0.001***	0.77 (0.03)	<0.001***	0.77 (0.03)	<0.001***
300+	0.71 (0.03)	<0.001***	0.68 (0.03)	<0.001***	0.69 (0.03)	<0.001***	0.64 (0.03)	<0.001***	0.64 (0.03)	<0.001***
Ownership (ref: gov't)	–	–	–	–	–	–	–	–	–	–
Not-for-profit (non-gov't)	1.03 (0.04)	0.407	1.01 (0.04)	0.702	0.99 (0.04)	0.858	0.99 (0.04)	0.864	0.99 (0.04)	0.892
For-profit	0.99 (0.04)	0.773	0.98 (0.04)	0.623	0.94 (0.05)	0.245	0.95 (0.05)	0.355	0.95 (0.05)	0.373
Hospital type (ref: acute)	–	–	–	–	–	–	–	–	–	–
Critical access hospital	1.66 (0.08)	<0.001***	1.70 (0.09)	<0.001***	1.79 (0.08)	<0.001***	1.87 (0.09)	<0.001***	1.87 (0.09)	<0.001***
Academic medical center	0.84 (0.03)	<0.001***	0.80 (0.03)	<0.001***	0.82 (0.03)	<0.001***	0.77 (0.03)	<0.001***	0.77 (0.03)	<0.001***
Medicaid share (ref: <30%)	0.97 (0.03)	0.237	0.98 (0.03)	0.418	0.97 (0.03)	0.403	0.99 (0.04)	0.786	0.99 (0.04)	0.802
Urbanicity (ref: metro)	–	–	–	–	–	–	–	–	–	–
Micro	1.08 (0.04)	0.034*	1.13 (0.04)	0.002**	1.08 (0.05)	0.079	1.13 (0.05)	0.005**	1.13 (0.05)	0.006**
Rural	1.46 (0.11)	<0.001***	1.50 (0.11)	<0.001***	1.38 (0.07)	<0.001***	1.43 (0.08)	<0.001***	1.43 (0.08)	<0.001***
Primary care physicians to 10k population	0.97 (0.00)	<0.001***	–	–	0.96 (0.00)	<0.001***	–	–	–	–
Hospitalization-level characteristics										
Sex (ref: male)	1.08 (0.00)	<0.001***	1.08 (0.01)	<0.001***	1.07 (0.00)	<0.001***	1.07 (0.00)	<0.001***	1.07 (0.00)	<0.001***
Payer (ref: commercial)	–	–	–	–	–	–	–	–	–	–
Medicare	1.29 (0.01)	<0.001***	–	–	1.29 (0.01)	<0.001***	–	–	–	–
Medicaid	1.38 (0.02)	<0.001***	–	–	1.38 (0.02)	<0.001***	–	–	–	–
Medicare/caid	–	–	1.33 (0.01)	<0.001***	–	–	1.32 (0.01)	<0.001***	1.33 (0.02)	<0.001***
Other	1.23 (0.02)	<0.001***	1.24 (0.02)	<0.001***	1.24 (0.02)	<0.001***	1.24 (0.02)	<0.001***	1.23 (0.02)	<0.001***
Race/ethnicity (ref: white)	–	–	–	–	–	–	–	–	–	–
Black	1.45 (0.02)	<0.001***	1.44 (0.02)	<0.001***	1.44 (0.02)	<0.001***	1.44 (0.02)	<0.001***	1.40 (0.02)	<0.001***
Hispanic	1.26 (0.02)	<0.001***	1.26 (0.03)	<0.001***	1.23 (0.01)	<0.001***	1.23 (0.01)	<0.001***	1.22 (0.02)	<0.001***

Variable	Model 1.0: Single-level full model		Model 1.1: Single-level reduced model		Model 2.0: Multi-level full model		Model 2.1 (main results): Multi-level reduced model		Model 2.2: Multi-level reduced model with interactions	
	OR (SE)	p-value[1]	OR (SE)	p-value[1]	OR (SE)	p-value[1]	OR (SE)	p-value[1]	OR (SE)	p-value[1]
Asian or Pacific Islander	1.11 (0.05)	0.021*	1.10 (0.04)	0.021*	1.06 (0.02)	0.001**	1.07 (0.02)	0.001**	1.05 (0.04)	0.143
Native American	1.07 (0.03)	0.007**	1.07 (0.03)	0.014*	1.07 (0.03)	0.004**	1.08 (0.03)	0.002**	1.08 (0.03)	0.020
Other	1.06 (0.02)	0.009**	1.06 (0.02)	0.030*	1.04 (0.02)	0.009**	1.05 (0.02)	0.005**	1.01 (0.02)	0.721
ZIP income (ref: <$44k)	–	–	–	–	–	–	–	–	–	–
$44k-$55,999	0.93 (0.01)	<0.001***	0.93 (0.01)	<0.001***	0.93 (0.01)	<0.001***	0.93 (0.01)	<0.001***	0.93 (0.01)	<0.001***
$56k-73,999	0.89 (0.01)	<0.001***	0.88 (0.02)	<0.001***	0.88 (0.01)	<0.001***	0.88 (0.01)	<0.001***	0.86 (0.01)	<0.001***
$74k+	0.85 (0.02)	<0.001***	0.82 (0.02)	<0.001***	0.82 (0.01)	<0.001***	0.82 (0.01)	<0.001***	0.81 (0.02)	<0.001***
Elixhauser comorbidity index	1.23 (0.00)	<0.001***	1.23 (0.00)	<0.001***	1.24 (0.00)	<0.001***	1.24 (0.00)	<0.001***	1.24 (0.00)	<0.001***
Age	1.01 (0.00)	<0.001***	1.01 (0.00)	<0.001***	1.01 (0.00)	<0.001***	1.01 (0.00)	<0.001***	1.01 (0.00)	<0.001***
Heterogeneity analyses										
Payer x CIN (ref: commercial)	–	–	–	–	–	–	–	–	–	–
Medicare/caid x CIN	–	–	–	–	–	–	–	–	0.99 (0.02)	0.585
Other x CIN	–	–	–	–	–	–	–	–	1.02 (0.03)	0.374
Race/ethnicity x CIN (ref: white)	–	–	–	–	–	–	–	–	–	–
Black x CIN	–	–	–	–	–	–	–	–	1.05 (0.02)	0.020*
Hispanic x CIN	–	–	–	–	–	–	–	–	1.03 (0.02)	0.199
Asian or Pacific Islander x CIN	–	–	–	–	–	–	–	–	1.02 (0.04)	0.581
Native American x CIN	–	–	–	–	–	–	–	–	1.01 (0.05)	0.882
Other x CIN	–	–	–	–	–	–	–	–	1.07 (0.03)	0.028*
ZIP income x CIN (ref: <$44k)	–	–	–	–	–	–	–	–	–	–
$44k-$55,999 x CIN	–	–	–	–	–	–	–	–	0.98 (0.02)	0.306
$56k-73,999 x CIN	–	–	–	–	–	–	–	–	0.99 (0.02)	0.678
$74k+ x CIN	–	–	–	–	–	–	–	–	1.02 (0.03)	0.486
Baseline odds	0.06 (0.01)	<0.001***	0.05 (0.00)	<0.001***	0.07 (0.01)	<0.001***	0.06 (0.01)	<0.001***	0.06 (0.01)	<0.001***

Note: [1]Significance levels: <0.05* <0.01** <0.001***

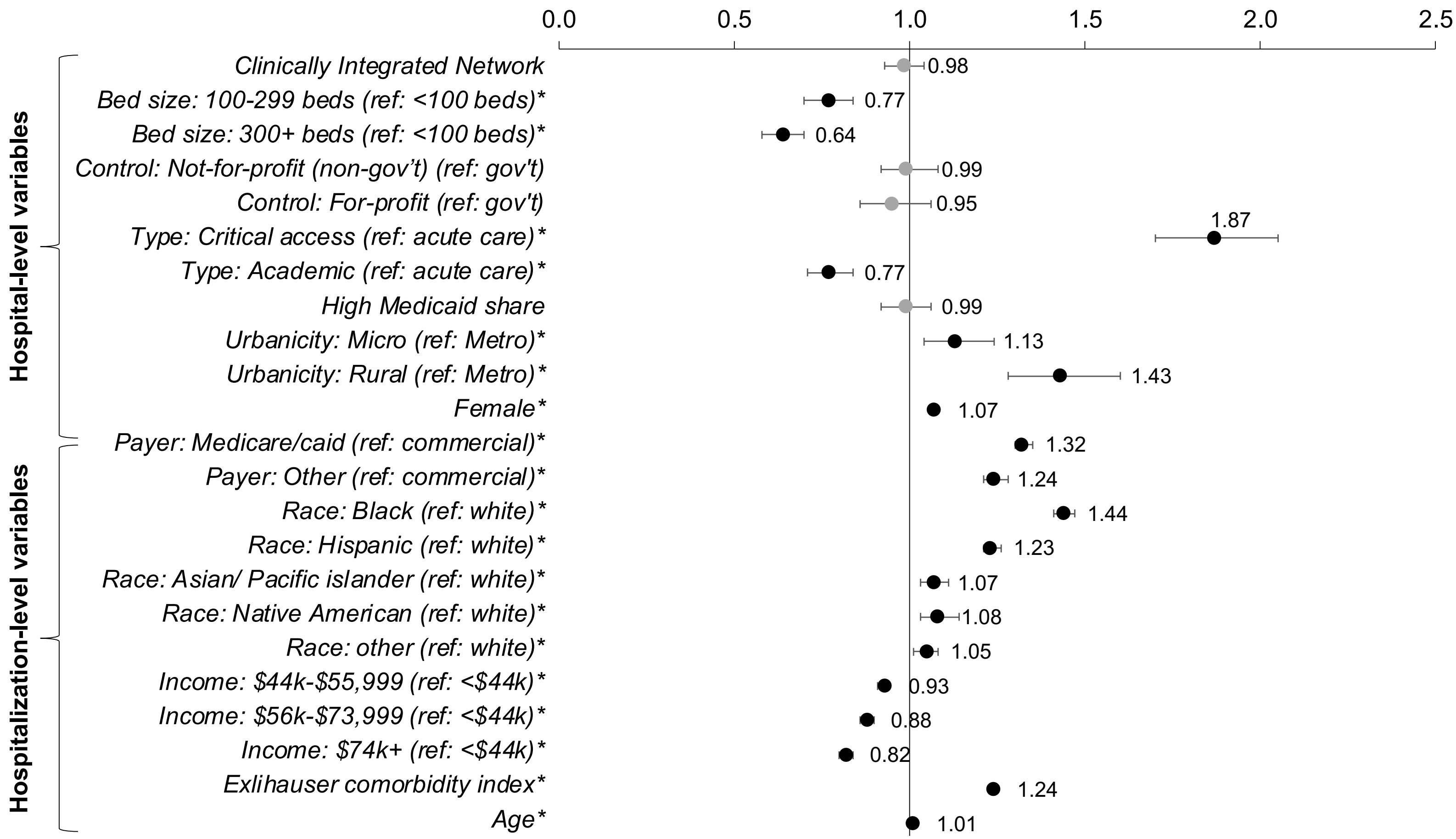
Table 8: Exponentiated odds ratios (OR) with standard errors (SE) for sensitivity analysis using the Prevention Quality Indicator Chronic Composite outcome (PQI 92)

Variable	OR (SE)	p-value[1]
Hospital-level characteristics		
Clinically Integrated Network	1.01 (0.03)	0.807
Bed size (ref: up to 99)	–	–
100 to 299	0.80 (0.03)	<0.001***
300+	0.68 (0.03)	<0.001***
Ownership (ref: gov't)	–	–
Not-for-profit (non-gov't)	1.08 (0.04)	0.042*
For-profit	1.07 (0.05)	0.211
Hospital type (ref: acute care)	–	–
Critical access hospital (CAH)	1.41 (0.06)	<0.001***
Academic medical center (AMC)	0.80 (0.03)	<0.001***
Medicaid share (ref: <30%)	1.01 (0.03)	0.811
Urbanicity (ref: metro)	–	–
Micro	1.13 (0.05)	<0.002**
Rural	1.31 (0.07)	<0.001***
Hospitalization-level characteristics		
Sex (ref: male)	0.95 (0.00)	<0.001***
Payer (ref: commercial)	–	–
Medicare/caid	1.26 (0.01)	<0.001***
Other	1.30 (0.02)	<0.001***
Variable (continued)	**OR (SE)**	**p-value[1]**
Race/ethnicity (ref: white)	–	–
Black	1.61 (0.02)	<0.001***
Hispanic	1.24 (0.02)	<0.001***
Asian or Pacific Islander	1.06 (0.03)	0.020*
Native American	1.12 (0.03)	<0.001***
Other	1.05 (0.02)	0.009**
Elixhauser comorbidity index	1.33 (0.00)	<0.001***
Age	1.01 (0.00)	<0.001***
Baseline odds	0.03 (0.00)	<0.001***

Note: [1]Significance levels: <0.05* <0.01** <0.001***

Figures

Figure 1: Results of main model regressing a hospitalization-level indicator of a potentially preventable admission on hospital participation in a Clinically Integrated Network



*Statistically significant at $p<0.05$; variables that are not statistically significant are shaded gray

Conclusion

Clinically Integrated Networks (CINs) are a common but underexplored organizational structure that has emerged to promote high-value healthcare.[17,19,20] CINs are permitted by antitrust regulatory agencies with the expectation that increased collaboration between independent providers will lead to improvements in value, such as higher quality at a lower cost;[11,12] however, theoretical benefits of provider integration in other cases have not necessarily borne out in practice.[35–37] This dissertation outlines a conceptual framework with three aims to study antecedents and outcomes of hospital participation in a CIN. The three studies in this dissertation are the first empirical assessments of CIN participation and activities, providing new insights into virtually integrated care delivery models.

The first aim of this dissertation is to understand the factors associated with hospital participation in a CIN. National hospital survey data (n=4,045) are analyzed to quantify hospital CIN participation. Multivariable logistic regression models are estimated to examine whether IPA, PHO, and ACO affiliations were associated with CIN participation, controlling for market factors and hospital characteristics. We find that hospital participation in a CIN is common, with just over one-third of hospitals reporting that they participate in a Clinically Integrated Network. Hospitals participating in CINs are more likely to have an Independent Practice Association affiliation, a Physician-Hospital Organization Affiliation, or an Accountable Care Organization contract compared to hospitals not participating in CINs. Market penetration of Medicare Advantage and penetration of CINs at other hospitals in the market are also both significantly associated with CIN participation. Overall, the results suggest that CIN participation may be a response to integrative norms.

The second aim of this dissertation is to assess the relationship between hospital participation in a CIN and three indicators of clinical integration put forth by antitrust authorities: information technology, clinical protocols, and protocol adherence mechanisms. We analyze a national survey of hospitals (n=693) about their activities, and perform three multivariable linear regressions to separately estimate the association of hospital CIN participation with integrated information technology, the use of clinical protocols, and mechanisms to promote protocol adherence, controlling for other hospital affiliations and hospital characteristics. We find that hospital CIN participation is significantly associated with increased health information technology, but there is no association between CIN participation and the use of clinical protocols or protocol adherence mechanisms. These results underscore that CINs do not inherently promote integrated care delivery. Hospital leaders must ensure that CINs meet requirements for antitrust compliance, and regulatory agencies should assess whether CINs are achieving integrated care delivery.

The third and final aim of this dissertation is to evaluate the association between hospital participation in a CIN and potentially preventable inpatient hospitalizations, an indicator of more coordinated care. To do this we use hospital inpatient hospitalization data (n=7,605,594) for 1,064 in 14 states, employing a multilevel multivariable regression model to adjust for hospital-level and hospitalization-level confounders. We find no association between CIN participation and the overall odds of an admission being potentially preventable inpatient. However, we find increased odds of a potentially preventable admission for Black patients compared to white patients at CIN-affiliated hospitals. These findings highlight the difficulties of reducing potentially preventable utilization, raise questions about whether CINs are achieving goals of integration, and raise concerns about health equity in CINs.

Taken together, the results from this dissertation suggest that virtual integration through Clinically Integrated Networks will not be a panacea for achieving quality and efficiency. The path outlined in our conceptual model from CIN participation to activities and then to outcomes is complex. Hospital participation in a CIN may be influenced by normative pressures and function more as a signal of legitimacy to the market than a desire to integrate.[88–90] Furthermore, integrated organizational affiliations do not necessarily translate to more integrated processes or outcomes.[29]

Future research should build on these initial findings about CIN participation, activities, and outcomes. More investigation is needed to create a standardized CIN definition, understand the effects of hospital participation in a CIN, and disentangle CIN effects from those of other organizational affiliations. Additionally, future research should study CIN activities beyond those mandated by antitrust agencies, including what contracts are held by CINs and whether joint negotiation is common, and study outcomes directly linked to these activities.

In conclusion, this dissertation provides the first empirical evidence to describe hospital participation in Clinically Integrated Networks. We find that CIN participation is largely norms-driven, with little evidence of differential process and quality outcomes at CIN-affiliated hospitals.

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