

OPTIMIZING SOCIAL-AFFILIATION NETWORKS OF THE PLAYERS IN A HEALTH CARE GAME

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The U.S. Supreme Court's June 2012 decision to uphold the Patient Protection and Affordable Care Act of 2010 has sparked an intense domestic policy debate over health care reform, including the forthcoming expansion of health care coverage to millions of Americans. Despite partisan gridlock at the national policy level, opportunities exist within the current health care system to coordinate resources, slow the rise of public health care expenditures, and expand access to care. This paper explores one such opportunity by introducing a simple game-theoretic model of patient interaction to show how the constraints on a network structure of health care provider organizations and the flow of information between providers and patients within that network generated a socially suboptimal level of care in Cuyahoga County, Ohio, in 2008. Specifically, the paper will focus on the evolving social-affiliation network of both health care provider organizations and the indigent and uninsured patient populations within a three-city interest area of Cuyahoga County. The primary challenge for charity care in Cuyahoga County is shown to be structural (in the network-theoretic sense), revealing an insidious geographical paradox: despite the spatial proximity of several viable charity care providers, many patients over-rely on select health care organizations and underuse other available resources. Ultimately, the model illustrates how local government-initiated coordination among health care providers and geographical expansion of the health care providers available to patients should remedy the socially suboptimal uncompensated care consumption problem and promote the attainment of a socially optimal consumption level.

This analysis will lead to a discussion of coordination among health care providers and the role of local government as drivers

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of improved care and reduced costs. While both federal and state government agencies currently subsidize uncompensated care, county governments and local policymakers have clear opportunities to have a tangible and proactive influence on the issue of rising health care costs. Health care expenditures in the United States now consume roughly 17 percent of the country's entire economic output and appear to be rising at an unsustainable rate.¹ It is the local government, however, that has the capacity to directly foster coordination among health care providers, lower system-wide health care costs, and improve health care access and quality, all from the bottom up. Although local government does not have the direct financial incentives that federal and state governments have to reduce public health care expenditures, all of society stands to benefit from increased coordination among providers, more optimal care consumption by patients, and lower costs.

CUYAHOGA COUNTY IN 2008: UNINSURED PATIENTS AND THE DISJOINTED HEALTH CARE PROVIDERS

The latest assessment by the Ohio Department of Health reports that roughly 33 percent of Cuyahoga County's nearly 1.3 million residents live at or below 200 percent of the Federal Poverty Line (FPL).² While the same report notes that nearly 18 percent of the county's population is uninsured, 2007 Census Bureau data shows that at least fifty thousand people living in the county are both uninsured and living at or below 200 percent of the FPL.³

At first glance, one might presume that the uninsured population living at or below 200 percent of the FPL (hereafter "uninsured population") was unimpeded in its search for quality, low-cost health care options. Indeed, the Greater Cleveland area is home to one of the most acclaimed and comprehensive health care systems in the United States, including top-ranked organizations like the University Hospitals Case Medical Center and the Cleveland Clinic Health System.⁴ Like their counterparts in many regional health care systems, these hospitals provide uncompensated care, colloquially referred to as "charity care." Although they administer

care either for free or at significantly reduced prices for qualified low-income patients, the hospitals are only partially reimbursed by government funds.⁵

The provision of charity care in Greater Cleveland is limited by the same factors that restrict providers across the United States. First, not all health care providers have the same financial capacity to take on charity cases, and upper limits to the provision, and subsequent consumption, of charity care exist.⁶ Second, the lack of meaningful coordination among the health care providers promotes duplicate and overlapping patient visits, unnecessary billing, needless coverage by the hospitals, systematic inefficiency, higher medical outlays, and lower quality of care.⁷ As a result of this lack of coordination, many uninsured patients forego primary and preventive care and instead resort to Emergency Department visits (ED care) whenever they believe they require medical attention.

This poses a significant cost challenge to hospitals that provide charity care to the uninsured and indigent. When these patients seek ED care, they often require expensive treatments for serious ailments that may be preventable through regular visits to primary care practitioners, or they require medical attention for non-urgent, low acuity problems.⁸ In Cuyahoga County, the MetroHealth Medical Center, a public safety-net hospital, assumes much of this charity ED care burden. According to county government estimates, 74,480 of 98,000 MetroHealth emergency department visits were either uninsured or Medicaid covered patients.⁹ MetroHealth was the hospital of choice for “frequent flyer” uninsured patients (those that visited an emergency room at least five times) in 2008.¹⁰

Despite its ostensible might, the Greater Cleveland health care community faced a serious dilemma in 2008: what could be done to reduce the charity ED care burden at certain provider sites while also promoting higher quality care for the region’s uninsured and indigent demographic? As Cuyahoga County government administrators would realize, and as this paper illustrates, other types of providers (such as smaller primary care clinics) existed in the greater health care system. However, the uninsured population sig-

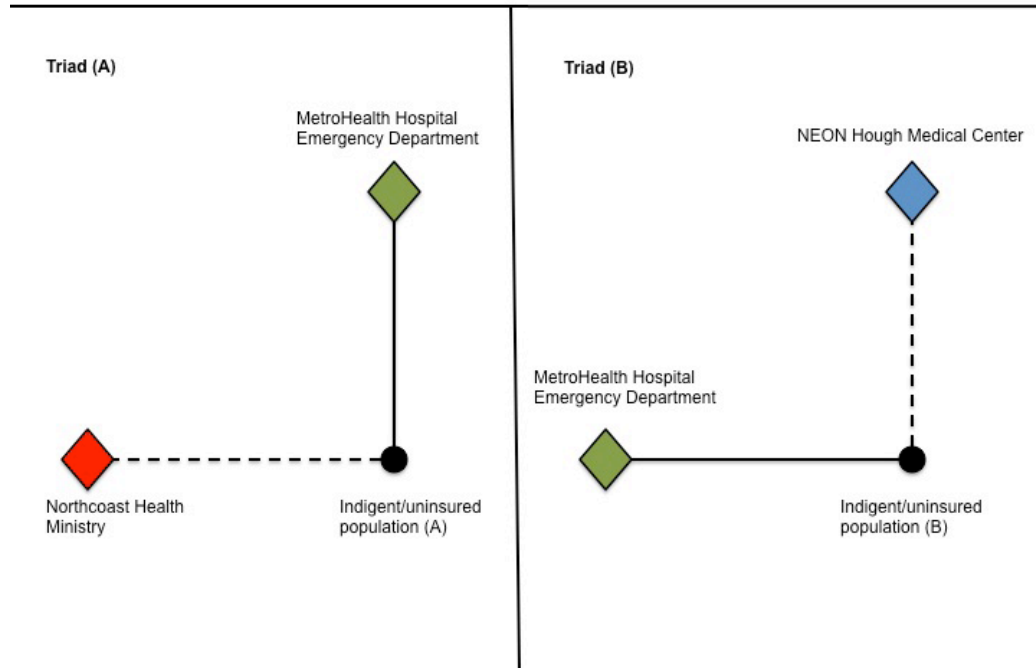
nificantly underused these non-hospital health care providers.

CONSTRUCTING THE SOCIAL-AFFILIATION NETWORK OF PROVIDERS AND UNINSURED PATIENTS

Network theory offers a compelling method for illustrating charity care consumption in this paper’s three-city interest area in 2008. In constructing this particular network structure, I considered the three cities—Lakewood, Cleveland, and East Cleveland—in terms of the uninsured patients, the major hospitals, and the smaller primary care clinics found within them. Not only do Cleveland, Lakewood, and East Cleveland contain high concentrations of the county’s uninsured and indigent patients, but the cities also cover much of Cuyahoga County’s physical territory.¹¹

Figure 1 depicts the building blocks of the social-affiliation network of this system.

Building the Sample Social-Affiliation Network: Indigent/Uninsured Populations and Their Ties to Care Providing Organizations in Cuyahoga County



In both Triad A and Triad B, a single circular node depicts

a *social node*, defined as a particular community of uninsured patients. The social node in Triad A represents a portion of the uninsured demographic residing in Cleveland's West Side districts, west of the Public Square, the main plaza of Cleveland's central business district. The social node in Triad B illustrates a portion of the uninsured population living in Cleveland's East Side districts, east of the Public Square. Each triad also contains two diamond-shaped focal nodes. As defined by Scott Feld, focal nodes represent points around which people interact, or more specifically, any "social, psychological, legal, or physical entity around which joint activities are organized."¹² In our three-city interest area, each focal node represents a health care providing organization to which the social node is connected. Given MetroHealth's high charity ED care caseload, the MetroHealth focal node attracts a significantly high number of uninsured patients from both social nodes—East and West. MetroHealth is widely known as the public safety-net hospital throughout the Greater Cleveland area, and as such, both social nodes are connected to the MetroHealth focal node with strong ties, indicated by a solid line.¹³ Despite spatial proximity, the smaller primary care clinic is both less known and less used by the social node in each triad. Thus, a weak tie, illustrated by a dashed line, connects each social node to its respective primary care provider organization.¹⁴

Figure 2 illustrates the social-affiliation network structure of these communities and health care providers in 2008 (at $t = 1$), which is constructed by joining the two triads. Here, both social nodes are connected to the MetroHealth focal node. By the Strong Triadic Closure Property:

We say that a node A violates the Strong Triadic Closure Property if it has strong ties to two other nodes B and C, and there is no edge at all (either a strong or weak tie) between B and C. We say that node A satisfies the Strong Triadic Closure Property if it does not violate it.¹⁵

Thus, as a result of the shared knowledge of and attraction to the MetroHealth ED throughout the Greater Cleveland area, a strong tie is illustrated to close the gap between the two social nodes.

Figure 2

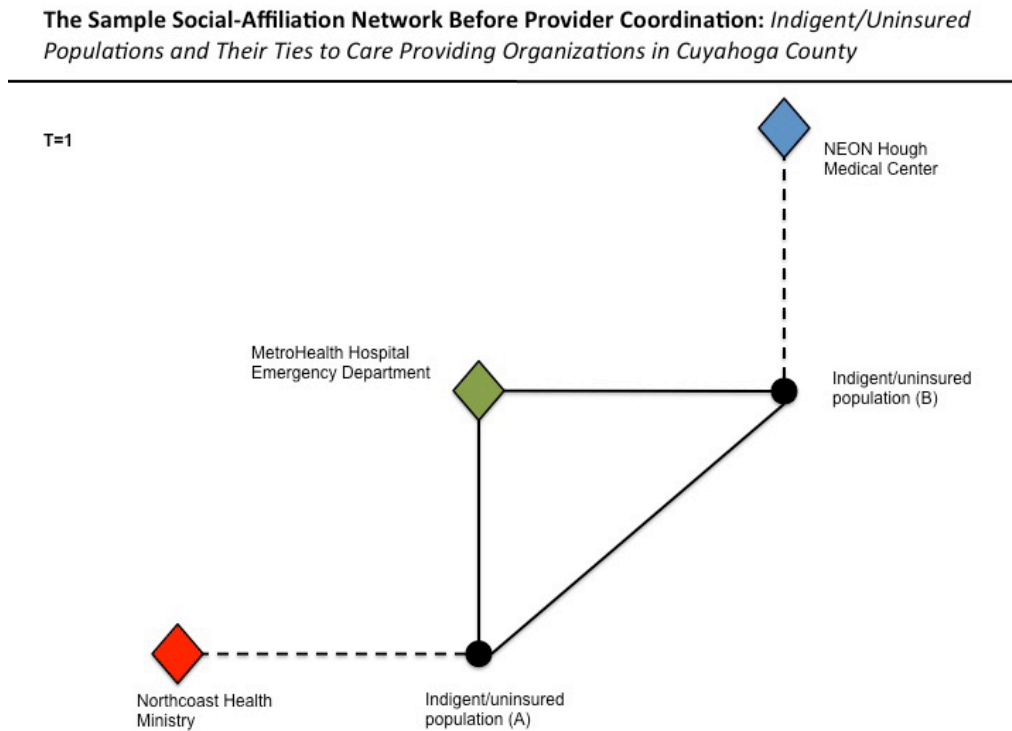


Figure 2 offers a telling illustration of the charity care system's egregious structural problem in 2008. Although prospective patients live in close spatial proximity to several health care provider options, the patients are not equally connected to each nearby care-providing organization. Unseen on a standard map of the area, this network depicts "structural holes" that exist between disparate clusters of nodes within the network.¹⁶ As MetroHealth is strongly connected to the two social communities, it forms a complete clique.¹⁷ Northcoast Health Ministry and NEON Hough Medical Center are not in complete cliques; in fact, each of these smaller primary care organizations is only weakly tied to one other social node in the network.

The presence of these structural holes highlights the negative aspect of the social-affiliation network's structure at $t = 1$: viable

health care centers, which happen to be spatially proximal to prospective patients, are underused relative to the services rendered at the MetroHealth ED. The holes also represent a potential source of optimism, however. As Ronald Burt asserts, structural holes offer a “competitive advantage for . . . individual[s] whose relationships span the holes,” as well as “opportunities [for these individuals] to broker the flow of information between [nodes].”¹⁸

A SIMPLE GAME-THEORETIC CONSIDERATION OF SOCIALLY SUB-OPTIMAL CHARITY CARE CONSUMPTION IN 2008

Assuming the above structure accurately models the social-affiliation network of health care providers in the three-city interest area, we can formally illustrate how uninsured patients in the region consumed charity care in 2008. In order to depict this behavior in a clear and concise manner, I will establish further assumptions on which to build a simple game-theoretic model. With these set assumptions, a system of first-order differential equations can be established to illustrate patient actions within the game, as well as Nash equilibrium levels of charity care consumption attained through patient action at each stage of the game.

First, let charity care be considered a common-pool resource—a good that is both non-excludable and beneficial to those who qualify for it, but is limited in its quantity.¹⁹ The government often subsidizes charity care, yet there are limits to the quantity of charity care that can be subsidized. Consequently, the stock of charity care at any given hospital in the network is fixed at a certain upper bound. Despite this constraint, the provision of charity care to those who qualify, such as the uninsured population living at less than 200 percent of the FPL in our three-city interest area, is non-excludable by any particular health care provider.

Next, let the qualifying uninsured patients in our three-city interest area act as rational agents in their consumption of charity care. That is, when deciding to choose a health care provider, such as MetroHealth in Cleveland or Northcoast Health Ministry in

Lakewood, these patients have complete and transitive preferences. They understand with certainty what they prefer, and for any A, B, and C, if A is preferred to B, and B is preferred to C, then A is preferred to C. The patients also prefer to have more of something they like and their preferences experience diminishing marginal returns.²⁰

Finally, assume that each uninsured patient seeking charity care in our three-city interest area has the same information about available charity care options. Also assume that whenever medical care is deemed necessary, the patient strategically seeks to exploit the common-pool resource as best as possible with the belief that every other patient will be acting in the same manner.

With these assumptions defined, we can begin to explain how individuals possibly acted within this setting in pursuit of charity care in 2008. More specifically, I implement a mathematical optimization model similar to those envisioned by Gordon (1954) and by Brander and Taylor (1997) in their considerations of collective action and the consumption of common-pool resources.²¹

Geography plays a central role in this social affiliation network. The network contains two social nodes, or communities of people. One is situated on the West Side of Cleveland; the other is located on the East Side. As depicted in both triads shown in Figure 1, each social cluster can choose between two health care providers for its care: either MetroHealth, the largest hospital provider of charity care in the area, or a small local primary care clinic.

This decision can be illustrated at the level of the individual within each triad. For the purpose of illustrating this phenomenon in a simple manner, assume a situation in which there are 30 individuals in need of charity care in either triad. Formally, each prospective patient has two options. He or she can go to MetroHealth and realize a positive utility at the hospital, $H(\theta)$, modeled by the function:

$$\text{MetroHealth} \Rightarrow H(\theta) = 20 - \frac{\theta}{2}$$

where θ represents the number of other prospective patients

who concurrently seek care from MetroHealth. Alternatively, the patient can visit a small local primary care clinic and realize a currently constant positive utility at the clinic, $C(\theta)$, modeled by the function:

$$\text{Small clinic} \Rightarrow C(\theta) = 10$$

Given the volume of public information about MetroHealth's role as a public safety-net hospital, and considering the strong ties connecting the hospital to the network's social nodes, MetroHealth attracts a higher frequency of prospective patients in the uncoordinated health care network at $t = 1$, as confirmed by the empirical data on MetroHealth's charity ED care caseload burden in 2008. As a result, although patients can initially experience a higher individual positive utility at low levels of θ , prospective patients realize increasing disutility proportionate to θ , due to congestion, limited resources, and increased wait times at the ED, all of which intensify as θ increases. Though under-promoted in the network at $t = 1$, the small primary care clinic offers an initially smaller individual amount of positive utility to the prospective patient, without the disutility component that comes with congestion and over-competition for care.

Following the above assumptions about the individuals and their strategic behavior in this game situation, a Nash equilibrium is reached when each of the thirty prospective patients strategically seeks out charity care at either location in a manner that is perceived to be a best response to other patients doing the same. In such equilibrium, there is no perceived incentive for any patient to switch from one health care provider to the other.²² Thus:

$$\begin{aligned} \text{Nash equilibrium} \Rightarrow H(\theta) = C(\theta) = 20 - \frac{\theta}{2} = 10 \\ \theta^* = 20 \end{aligned}$$

At this equilibrium state, twenty of the thirty prospective patients seek care at MetroHealth, while just ten seek care at the smaller primary care clinic. As there is no incentive to switch between providers, each patient realizes a standard individual utility of $U_i = 10$, where:

$$H(20) = 20 - \frac{20}{2} = 10$$

$$C(10) = 10$$

The total utility is signified by:

$$\sum_{i=1}^{30} U_i = 30 * 10 = 300$$

Does this equilibrium illustrate a socially optimal consumption of charity care in our three-city interest area in 2008? The structure of the social-affiliation network suggests that it does not. Lack of coordination among charity care providers creates a network in which small primary care clinics are less known and underutilized compared with hospitals like MetroHealth. The effects of this lack of coordination are formally illustrated when we derive the socially optimal level of charity care consumption from our model. By optimizing total socially optimal utility with respect to θ :

$$\text{Total } U_{S.O.}(\theta) = \theta \left(20 - \frac{\theta}{2} \right) + 10(30 - \theta)$$

$$\Rightarrow \frac{d[TU_{S.O.}(\theta)]}{d\theta} [TU_{S.O.}(\theta)] = 20 - \theta - 10$$

$$\text{and} \\ \theta_{S.O.}^* = 10$$

With respect to $\theta_{S.O.}^*$,

$$\text{Total } U_{S.O.}(\theta_{S.O.}^*) = 10 * 15 + 20 * 10 = 350 > [300|\theta^*]$$

Indeed, as of 2008, the social-affiliation network of health care providers in the three-city interest area promoted a socially sub-optimal level of charity care consumption. That being said, within the network structure at $t = 1$, as depicted in this model, the prospective patients do not have an incentive to act in a way that would reach the socially optimal level of charity care consumption. Moreover, the formal calculation of total socially optimal utility suggests that in order to reach $TU_{S.O.}$, prospective patients would

need to randomly choose to seek charity care at particular primary care providers, be actively directed to them, or be significantly empowered and incentivized to seek them out.

CHAP: COORDINATION AMONG CHARITY CARE PROVIDERS, “EXPANDED” GEOGRAPHY, AND SOCIALLY OPTIMAL CHARITY CARE CONSUMPTION

In 2009, the Greater Cleveland health care community, led by health policy officials within the local Cuyahoga County government, formed a coordinated coalition in order to increase the use of smaller primary care providers and promote preventive medicine in the county. This organization, the Cuyahoga Health Access Partnership (CHAP) is a public-private collaboration of fifteen organizations in the Greater Cleveland health care area. CHAP offers a coordinated system of health care access for Cuyahoga County’s low-income, uninsured adults (ages 18-64), and was founded on the principle that its members have a shared responsibility to address the uninsured crisis in Cuyahoga County and to provide a coherent system of access for the uninsured adults in question. Despite its primary care focus, CHAP addresses the entire spectrum of care. One of the principal goals of the organization is to significantly reduce visits to area hospitals’ emergency departments, which have proven to be, on average, both unnecessarily frequent and costly.²³

Crucially, CHAP officially coordinates charity care provision among the various hospitals and small primary care clinics in the network. Through a shared and standardized patient eligibility and enrollment system, CHAP helps to optimally distribute the charity care caseload among the county’s various providers. To accomplish this goal, CHAP performs community outreach to its target population and disseminates information about the availability and value of care provided by the small primary care clinics.

Although CHAP is a new organization, and there is no empirical data on its effectiveness, CHAP has profound theoretical implications for the model depicted in the previous section.

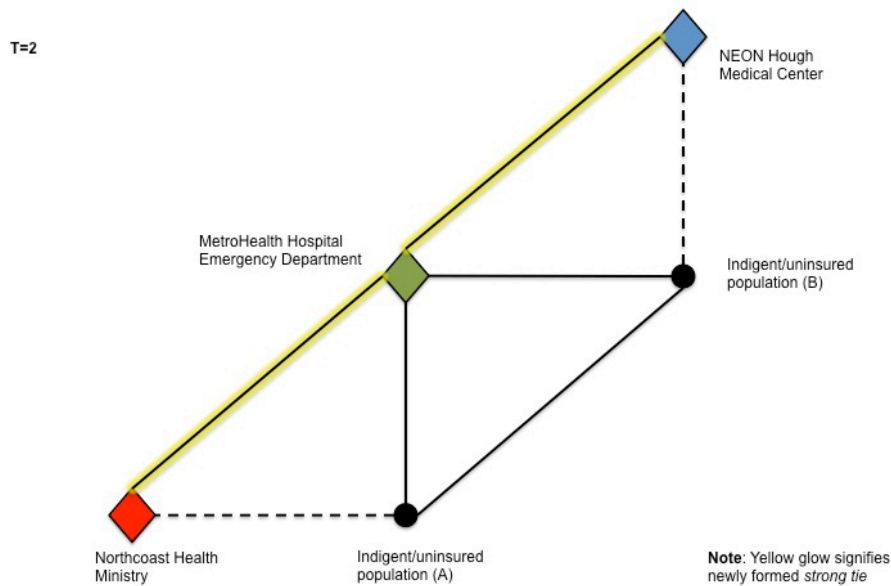
Whereas prospective patients previously had no incentive to act in a manner that yielded a socially optimal level of charity care consumption, under CHAP, patients can be directly referred to care providers. This new coordination in the social-affiliation network suggests that updated calculations of the total utility in the system could begin to approach $TU_{S.O.}$.

CHAP AND CHANGES IN THE NETWORK STRUCTURE

CHAP's formation indicates an expansion of the informational geography of providers in the social-affiliation network. Figure 3 shows the network at $t = 2$, immediately following CHAP's official establishment. At this time, systematic coordination is formed between the health care providers in the network. This is depicted by the emergence of a strong tie path that connects Northcoast Health Ministry, MetroHealth, and NEON Hough Medical Center. At $t = 2$, there are no other changes to the network structure.

Figure 2

The Sample Social-Affiliation Network at Time of Provider Coordination: *Indigent/Uninsured Populations and Their Ties to Care Providing Organizations in Cuyahoga County*

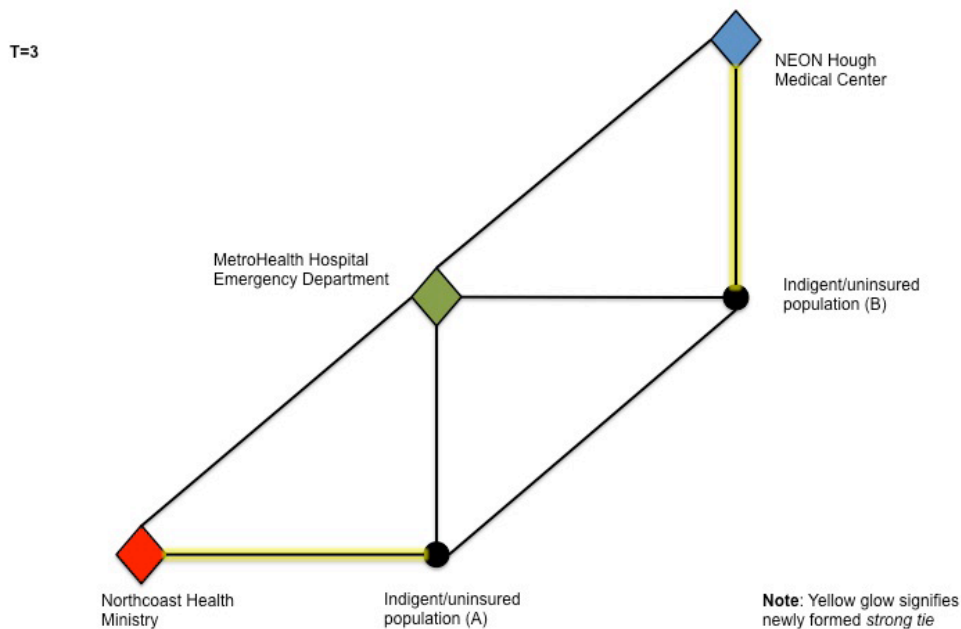


After some time, however, these newly formed strong ties

should spur further change in the network structure. As Figure 4 illustrates, at $t = 2$, the Strong Triadic Closure Property pressures a conversion of the weak ties that initially connected each social node to its respective primary care clinic at $t = 2$.

Figure 4

The Sample Social-Affiliation Network After Provider Coordination: Indigent/Uninsured Populations and Their Ties to Care Providing Organizations in Cuyahoga County



Strong ties replace both weak ties and the social-affiliation network is complete. Just as the simple game-theoretic model constructed in the previous section illustrates how the social-affiliation network structure at $t = 1$ leads to a socially sub-optimal consumption of charity care, the post-CHAP network illustrates how optimal consumption may be feasible in the three-city interest area. Notice that Figure 4 depicts a network that now contains one complete clique. The structural holes depicted in the pre-CHAP network have been closed. At $t = 3$, the newly coordinated health care system can be thought of as one focal node rich in resources and information. In this sense, the coordinated health care node is structurally central. It lies on the shortest path between the two social

nodes and it represents a single point” that can control the communication flow within the network.²⁴ The new flow of information may entice patients to utilize the formerly underused primary care clinics within the system; similarly, it can repel them from the previously overused and congested hospital emergency departments.

DISCUSSION AND CONCLUSION

The simple game-theoretic explanation of patient consumption of charity care in the three-city interest area offers some explanation for the changing social-affiliation network illustrated above. On the surface, the model concisely illustrates how the coordination of various types of health care providers in the region may lead to more optimal levels of charity consumption, thereby ameliorating a lingering social ill. But what is the underlying force that allows this change to transpire? A local spatial element is certainly central.

Intuitively, an expanded geography of available health care providers should promote a more efficient and socially optimal provision of care. Researchers have found evidence of a “supplier induced demand” for health care, wherein there is a direct positive spatial relationship between an area’s access to health care and its social utilization of it.²⁵ This may be true when comparing urban Greater Cleveland with rural Appalachian Ohio, an area with far lower health care capital. However, this spatial relationship appears to fail to explain the intra-community inefficiencies in the consumption of care. If this relationship holds true in all cases, prospective patients would logically disperse their charity care consumption more universally among the Cuyahoga County health care providers, rather than rely heavily on hospital-based emergency departments.

Theoretical models and subsequent simulations have been conducted to predict the spatial interaction patterns of health care access in lower income areas. A core assumption in such models, however, has been that primary care providers—the general first point of entry into the health care system—are primarily accessed in times of medical necessity.²⁶ Yet, as shown in this paper, the behav-

ior of the uninsured population of Cuyahoga County contradicts this ostensibly sound assumption. Despite the presence of accessible primary care clinics, a significant segment of uninsured patients seeks care at hospital-based emergency departments. The situation in Cuyahoga County exhibits the presence of this geographical paradox. Although the same physical network of health care facilities is present in 2011 as in 2008, they were uncoordinated in 2008 and consumers were unaware of how to optimally use them.

Given the sub-optimal use of primary care resources discussed in this paper, perhaps it is not surprising that Litaker, Koroukian, and Love (2005) found that “Individuals living in counties in which primary care physicians comprised a larger proportion of practicing physicians were also somewhat less likely to report having no usual source of care.”²⁷ It is plausible to conclude that there was a geographical paradox in the consumption of preventive, primary, and charity care in Cuyahoga County in 2008. As supported by both the empirical results and theoretical considerations, mere spatial proximity to sources of primary care is not the sole determinant for where an individual seeks care. Nor is spatial proximity the solution to the problem of socially sub-optimal consumption of charity care in a given area, although it should be considered. Outreach policies must be actively pursued toward the county’s uninsured and indigent social communities. Only then will information flow effectively through the social-affiliation network and empower individuals to make optimal health care consumption choices. Proximity alone cannot connect uninsured patients to favorable care-providing sites; information must be the driver of systematic connection.

But who has the power and resources to augment the information flow within the health care network? As asserted in the introduction, this is a local problem. Due to the halt in U.S. national health care policy debate, local government appears to be the most viable mechanism for enacting expeditious policy change. Indeed, county and municipal governments are responsible for upholding the rights and welfare of their citizens through the administration of public resources. Local governments have an inherent interest

in fostering coordination between health care leaders that operate within their limits, for such action stands to benefit both the health of their citizens (through increased care quality) and the soundness of their health care corporations (through decreased costs). Though the powers of county and municipal governments are inferior to those of the states, most local governments, including those of Cuyahoga County and the City of Cleveland, can directly influence this issue through control of the city's emergency medical services, local income taxes on health care professionals, and zoning ordinances that can affect the expansion of the region's health care organizations.²⁸

Though CHAP has only recently been fully implemented, the operation represents a promising example of system-wide health care coordination begotten by a single county government agency. While the success of CHAP is uncertain, time will no doubt yield important information about the effectiveness of locally initiated resource coordination projects far before substantive health care policy reform is enacted and evaluated at the federal level.

The trends illustrated in this paper intimate deep-running issues concerning access to care and the sub-optimal consumption of charity care across the nation. Most highly populated regions throughout the United States have not begun to explore locally initiated care-access collaborative projects. As Medicaid expansion is implemented under the Affordable Care Act, the entire nation will need to consider creative solutions for lower costs and improved care access.

This paper employs network structure to highlight one possible explanation for the seemingly unlikely sub-optimal charity care consumption within a particular health care arena. However, the models laid out in this paper are limited by their underlying assumptions and overall generality. In-depth structural analyses of health care systems are needed to determine actual structural holes within health systems, which in turn may be used to ascertain how to better coordinate existing resources, interact with patients, and optimally provide care. Moreover, patient experience response surveys should be developed to accurately pinpoint patient behaviors

as they interact with other patients in competition for charity care resources. This paper lays the theoretical groundwork for further data-driven research.

To view all charts and tables, visit:
<http://www.helvidius.org/2012/goldstein>

Endnotes

1 Lisa Potetz and Juliette Cubanski, A Primer on Medicare Financing, (Henry Kaiser Family Foundation: 2009), Exhibit 2.

2 Each case-specific FPL is measured by the Department of Health and Human Services' (HHS) poverty guidelines, a federal measure is issued each year in the Federal Register. Detailed explanation and current numbers available at: <http://aspe.hhs.gov/poverty/11poverty.shtml>; Ohio Department of Health, Ohio Family Health Survey 2008, (2008).

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4 Information on current Cleveland Clinic acclaim: http://my.clevelandclinic.org/p2/us_news_rankings.aspx.

5 For example, pursuant to specific protocols, the state government's Health Care Assurance Program can subsidize hospital systems in Ohio for portions of their charity care services. An extensive explanation of this program is offered at: Ohio Hospital Association, HCAP, Uncompensated and Charity Care Fact Sheet, (2009).

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