

# **1Multispecialty Physician Networks in Ontario**

## **2ABSTRACT**

### **Background**

Large multispecialty physician group practices, with a central role for primary care, have been shown to achieve high quality, low cost care for chronic disease patients. We assessed the extent to which informal multispecialty physician networks in Ontario could be identified by exploiting natural linkages among patients, physicians, and hospitals based on existing patient flow using health administrative data.

### **Methods**

We linked Ontario residents to their usual provider of primary care (UPC). We linked specialists to the hospital where they performed the most inpatient services. We linked primary care (PC) physicians to the hospital where most of their UPC patient panel was admitted for non-maternal medical care. Residents were linked to the same hospital as their UPC physician. Smaller clusters were aggregated to create networks based on a minimum population size, distance and loyalty. Networks were not constrained geographically. The network assignment period was 2008 to 2010.

### **Results**

We identified 78 multispecialty physician networks, comprising 12,581 PC physicians, 14,516 specialists and 175 acute care hospitals serving 12,917,178 people. Median network size was 134,000 residents, 125 PC physicians and 141 specialists. Most residents (99%) were linked to a UPC and to a network. Most specialists (94%) and PC physicians (98%) were linked to a hospital. Median network physician loyalty was 68% for physician visits and 81% for PC visits. Median admission loyalty was 67%. Urban networks had lower loyalties and were less self-contained but had more healthcare resources.

### **Interpretation**

We demonstrated the feasibility of identifying informal multispecialty physician networks in Ontario based on patterns of healthcare seeking behaviour. Networks were reasonably self-contained so that patients received most of their care from providers within the network. Formal constitution of networks could foster accountability for efficient, integrated care through care management tools and quality improvement, the idea behind ‘accountable care organizations’.

## INTRODUCTION

There is widespread evidence that quality of care for chronic disease patients is suboptimal,<sup>1-3</sup> with large variations in the provision of evidence-based services.<sup>3-8</sup> Serious gaps in the quality of chronic disease management are attributed to poor coordination and fragmented care.<sup>1,2,9-11</sup> Effective chronic disease management requires coordinated, longitudinal care and the engagement of multi-disciplinary teams across different sectors.<sup>11-13</sup> Large multispecialty physician group practices have been shown to achieve high quality, low cost care. Through better ambulatory management of their patients, they reduce complications and avoid costly readmissions to the hospital and emergency department (ED).<sup>13-19</sup>

The development of multidisciplinary accountable care organizations in the USA has illustrated the central role of primary care.<sup>20</sup> Strong primary care (PC) systems are associated with higher quality of care for chronic disease, including increased preventive care, and fewer avoidable ED visits and hospital admissions.<sup>21-24</sup> Ontario leads other Canadian provinces in deploying a range of PC group models, such as Family Health Teams, using financial incentives to reward continuity and comprehensiveness of care, after-hours coverage, and electronic medical records.<sup>25-28</sup> However, PC reform has paid little attention to integrating specialists and hospitals into the management of patients with chronic disease.

The current healthcare structure and payment system is focused on acute care and is poorly aligned with chronic disease patient needs. To incentivize integrated, coordinated care among providers and promote collective accountability will require a major reorganization of traditional health delivery and payment systems.<sup>11-13</sup>

While formal multispecialty physician networks are uncommon in Canada, healthcare providers tend to form informal networks based on sharing patients and information. ‘Virtual’ networks, behaving as informal, organic “self-organizing systems”, consisting of primary care physicians, specialists and the

hospitals where their patients are admitted, have likely developed naturally through patient travel patterns, long-standing referral patterns, information sharing, and admission of patients to local hospitals.

Our objective was to identify naturally occurring multispecialty physician networks in Ontario by exploiting linkages among patients, physicians, and hospitals based on existing patient flow using health administrative data, and to characterize them in terms of population and physician characteristics.

This ‘natural’ model of physician organization would reflect the way PC physicians, specialists and hospitals actually practice together to care for a defined population, and would permit evaluation of quality and costs of care. The overarching goal would be to identify which networks provide high quality, low cost care and examine what factors contribute to their efficiency. Understanding what constitutes a high-performing system provides an opportunity to focus policy reforms on promoting and sustaining the best systems.<sup>29</sup>

## **METHODS**

We identified physician networks with the idea of defining “medical neighborhoods” for chronic disease care.<sup>30</sup> A medical neighborhood would consist of PC physicians (medical homes), and the specialists and hospitals from which their patients receive most of their care. The reason to include hospitals is to foster accountability for hospital readmissions among the multiple providers who might be responsible for reducing the rates of such events.<sup>31,32</sup> While improving the quality of chronic disease care is important, one of the markers for excellent care is avoiding costly readmissions. Our algorithm was similar to that used to derive networks in the USA,<sup>33,34</sup> but was adapted to reflect the Ontario health care system.

### **Data sources**

Multiple Ontario health administrative databases containing information on all publicly insured hospital and physician services were linked using unique, anonymized, encrypted identifiers for patients and physicians. These included the Discharge Abstract Database (DAD) for hospital admissions, procedures and transfers; National Ambulatory Care Reporting System (NACRS) for ED visits; Ontario Health Insurance Plan (OHIP) database of physician billings for type and location of service, diagnosis codes and procedures; Ontario Drug Benefits (ODB) Plan for outpatient drug prescriptions for those over age 65 years; Registered Persons Database (RPDB) for patient demographic information and deaths; Client Agency Program Enrolment (CAPE) registry to identify rostered patients and PC models; Ontario Physician Workforce Database (OPWD)<sup>35</sup> and the ICES Physician Database (IPDB) to identify physician activity status, self-designated and functional specialty, and FTEs. Neighborhood income was derived from Statistics Canada 2006 census estimates. The 2008 rurality index (RIO) accounts for population size and travel time.<sup>36</sup>

#### Eligible Residents and Physicians

The eligible population included residents of Ontario who were alive and aged < 100 years on April 1, 2008, including newborns and immigrants who registered with OHIP during FY08-10, excluding those with no healthcare system contact since FY00. Ontario physicians with a valid physician number were eligible if they were in active practice during FY08-10, defined as having at least one OHIP billing or an active CAPE patient roster. All acute care inpatient institutions, including general, cardiac, children's and psychiatric hospitals, were eligible.

#### Linkage of Residents to the Usual Provider of Primary Care (UPC)

PC physicians were those whose self-designated or functional specialty was general practice, family practice or community medicine. Pediatricians were considered PC providers if they billed >30 well baby or well child visits in FY08-10.<sup>37</sup> In the spirit of defining medical homes, we linked Ontario

residents to their UPC in the following hierarchical manner. Residents were linked to the physician to whom they were rostered at the midpoint of the period since this physician was contractually responsible for their primary care; rostered residents who died before the midpoint were linked to their last PC physician. Non-rostered residents were linked to the PC physician who provided most of their core PC services based on a set of billing codes used by the Ontario Ministry of Health to determine virtual patient rosters (Appendix A). The remaining unlinked residents were linked to the PC (preferentially) or other physician who provided the greatest number of ambulatory services, including visits, laboratory tests, diagnostic tests and prescriptions, counting each type of service once per patient per day. Residents with no ambulatory contact with a physician were not linked to a UPC.

#### Linkage of Physicians to Hospitals

We linked specialists to the acute care hospital where they provided the highest volume of inpatient services, including visits, procedures, imaging and diagnostic tests billed during the admission. We did not include same-day surgery or ED visits. Several specialists could provide services to the same inpatient.

PC physicians were linked to the hospital where most of their UPC patient panel was admitted. We reasoned that this hospital would be responsible for discharge planning for their patients. We used non-maternal medical admissions for hospital assignment since the focus for chronic disease patients is avoidable medical admissions; surgery is often regionalized and maternal admissions are not avoidable. Each admitted patient was counted once in order that those who were admitted more frequently would not bias the assignment; for those admitted to >1 hospital, we weighted each admission proportionally to the total number of admissions for that patient. Unlinked rostering physicians were linked to the hospital where most physicians in their PC group were assigned.

## Linkage of Residents to Hospitals

Ontario residents were linked to the hospital where their UPC physician was assigned as this would likely be the hospital responsible for their discharge planning. Unlinked residents who were admitted to a hospital or seen in the ED during FY08-10 were directly linked to this hospital.

## Aggregation of Provider Clusters to form Networks

A provider cluster comprised the population and physicians linked to a particular hospital. We combined provider clusters to derive multispecialty physician networks, aggregating small clusters that shared patients and were in close proximity so that the resulting network had a minimum population size and included at least one medium or large hospital. A network consisted of the combined population, physicians and hospitals linked to its component provider clusters. A satellite network was a collection of small, rural provider clusters that were geographically distant from the large hospital upon which they depended for complex services. The population served and the local services provided were very different from that in the nearest large provider cluster. Depending on the purpose, it could always be aggregated to the nearest network. A glossary of terms is provided for clarity (Appendix B).

We defined an index of localization that measured the extent of self-containment of provider clusters and networks. Admission loyalty was defined as the percent of a provider cluster population's total admissions that were to the assigned hospital. Physician loyalty was defined as the percent of a provider cluster population's ambulatory visits that were with physicians linked to the cluster. Similar loyalty measures were computed using network populations (Appendix B). High loyalty implies that network providers deliver most of the care for their assigned population.

To aggregate provider clusters, we reviewed the top 4 admission and physician loyalties of each cluster's population to itself and other clusters to determine where the population was primarily seeking care. We

computed travel times between centroids of hospital postal codes with a Geographic Information System (GIS) system that used posted speed limits on the road network. Using a combination of high admission and physician loyalty, indicating shared patients, close geographic proximity, and GIS mapping, we aggregated small provider clusters to form networks of minimum population size 50,000, where possible, respecting hospital governance structures. The minimum population size was based on having sufficient patients to accurately measure network performance for chronic diseases with prevalence <10%, and being sufficiently large to provide a range of healthcare services and implement system improvements.<sup>29</sup>

Table 1 shows an example of aggregating provider cluster A having 27,474 patients to a larger cluster. Provider cluster A's admission loyalty to itself is moderate (54%) since it is small and has few specialists (N=4) so that patients are admitted to larger, nearby hospitals for serious conditions. Provider B is further away than provider C but it is linked to A by a major highway, and its main hospital is a large tertiary center. Cluster A's residents travel more frequently to B than to C for care, as evidenced by a higher percentage of admissions and ambulatory visits to providers in B. We, therefore, aggregated provider cluster A with cluster B.

### Characteristics of Physician Networks

We report network population characteristics, computing median, 10<sup>th</sup> and 90<sup>th</sup> percentiles, weighting by network population. Characteristics include network size, loyalty, distance between residents and providers, sociodemographic information, prevalence of chronic diseases including diabetes, acute myocardial infarction, congestive heart failure, hypertension, chronic obstructive pulmonary disease, and asthma using chart-validated algorithms,<sup>4,38-42</sup> and PC model affiliation.<sup>43</sup>



Physician supply was calculated as full-time-equivalents (FTEs) per capita network population. FTEs were calculated using total payments from all sources, assigning an FTE of 1.00 to physicians who fell between the 40th and 60th percentiles, by specialty.<sup>44,45</sup> PC continuity was measured as the proportion of ambulatory visits that were with one's UPC.<sup>5</sup>

#### Sponsor role

Funding was provided by an Emerging Team Grant (ETG92248) in Applied Health Services and Policy Research from the Canadian Institutes of Health Research. The funding agency had no role in the study design, collection, analysis and interpretation of data, or writing the report.

#### Ethics approval

The study was approved by the research ethics board of Sunnybrook Health Sciences Centre.

## RESULTS

We began with 12,971,629 Ontario residents, including 359,963 immigrants and 435,381 newborns, 27,437 physicians and 175 acute care hospitals that were eligible to be linked to a network. 97.5% of PC physicians and 100% of PC pediatricians were designated as UPCs. 12,845,793 (99%) residents were linked to a UPC; of these, 70.8% were linked through rostering, 27.1% through use of core PC services, and 2.1% through other physician services. We were unable to link 125,836 (<1%) residents to a UPC since they received no ambulatory physician services over the 3-year period.

The majority (93.5%) of specialists were linked to a hospital through their hospital activity, and the majority (98.2%) of PC physicians through their UPC patient panel admissions. Pathologists had low linkage rates since they generally do not bill OHIP. Most (98.8%) residents were linked to a provider cluster, and therefore, to a network. The majority (92%) of specialists' inpatient activity was in one hospital. PC physicians' UPC panel admissions were often to several hospitals but on average, more than

half (58%) were in one hospital. PC physicians who could not be linked typically had small, healthy patient panels; since the networks were created to foster chronic disease care, these physicians remained unlinked.

We began with 175 provider clusters, each containing one acute care hospital, that were aggregated to 78 multispecialty physician networks. The networks comprised 12,581 PC physicians and 14,516 specialists serving 12,917,178 people. Some networks comprised only one hospital as they were large (N=38). Many comprised >1 hospital (N=33) and appear as “spiders” in Figure 1. There were 7 satellite networks. Although most hospitals in a network were located inside LHIN boundaries, this was not true of the PC physicians or the population served. Figure 2 plots the envelope of PC providers linked to each network based on their billing postal code. It demonstrates substantial geographic overlap, especially in urban areas, and shows that residents do not seek care within defined or distinct geographic boundaries.

There were large variations in numbers of residents and physicians linked across networks (Table 2). Large networks contained large hospitals and had greater breadth and numbers of specialists. In general, admission and physician loyalty were high. Median network loyalty was 68.4% for all physicians and 80.6% for PC physicians. Median non-maternal, medical admission loyalty was 67.4%. Loyalty was higher in rural than urban networks but varied considerably across networks. Distances between residents and providers were generally small. Prevalence of chronic conditions varied about 2-fold across networks (Table 3). There was modest variability in proportion of patients rostered to a PC group. PC physician supply varied about 1.5-fold, and specialist supply about 4-fold, across networks (Table 4). Acute care and ICU bed supply varied 3 to 5-fold.

## **INTERPRETATION**

We have identified and characterized informal, multispecialty physician networks in Ontario. These can be viewed as “self-organizing systems of care” that collectively serve their large panels of patients. Physicians in these informal networks are associated by virtue of sharing care for common patients and admitting patients to the same hospital. Every physician does not share patients or consult with every other physician in their network, but they collectively share important resources such as acute care beds, specialists, and inpatient medical technologies that affect the outcomes of their patients. These networks provide a snapshot of how care is currently being delivered rather than a prescription for how care should be delivered. Other groups have created physician networks, based on shared patients, but none included hospitals.<sup>46,47</sup> The US groups did not aggregate provider clusters to networks, and included only US Medicare residents aged  $\geq 65$  years.<sup>33,47</sup>

Strengths of the work are high face validity based on high loyalty and close proximity among patients and providers. Most networks had sufficient chronic disease patients to measure performance and outcomes. PC loyalty was high since primary care is provided locally. Physician loyalty was moderately high since patients can be referred to specialists outside their network; nevertheless, care is generally concentrated within local providers since PC physicians often refer to the specialists who work in the hospitals where their patients are admitted. Admission loyalty was lower for urban networks since patients and physicians can be admitted to many nearby hospitals. Networks were not constrained geographically but were based on where patients seek care since healthcare is not delivered according to geographic boundaries. Finally, this method permits the identification of a target population served by providers in the network for reporting of quality and performance.

The primary limitation is the fluid nature of healthcare seeking behaviour. We linked residents and physicians based on average utilization patterns over 3 years; however, patients may switch PC physicians, and both may move over this period. As long as there are no major hospital openings or

closures, or changes to workforce policy, the basic network organization should persist. In fact, we applied the same method over FY05-07 and obtained identical network structures with similar numbers of linked residents and physicians, and loyalties. Another limitation is that PC physician patient panels are hospitalized in >1 hospital, especially in large urban areas, so that the specificity of assignment to a single hospital was moderate; however, this is the nature of patient flow in large urban areas. We could not link home care, long-term care, Community Care Access Centres, and public health units to the networks since we did not have the data. It will be important to add these services as they play a support role in the community that may help to reduce hospital admissions and readmissions.

This work is aligned with a systems-minded approach to providing chronic disease care and promoting accountability.<sup>29,48</sup> The overarching aim is to better understand systems factors and strategies associated with highly efficient networks that provide high quality care at lower costs. We propose to explore virtual multispecialty physician networks as a functional and organizational unit for chronic disease care. Such networks would comprise large, multi-disciplinary groups that work together to manage chronic disease patients and would, therefore, be more conducive to evaluation, system interventions, and physician accountability frameworks than individual physicians or PC practices. These networks could provide the context and information to engage hospitals, physicians and policymakers in discussions of how to better align medical practice with evidence, and address resource use and integration across hospital and ambulatory sectors. Large multispecialty physician networks may be the most practical level for targeting reforms for integration of care since providers are already connected by virtue of caring for the same patients.

It will not be a small task to exploit these networks for the purpose of improving care. There is currently no accountability framework that encompasses the different entities. The current payment system is a patchwork of fee for service (FFS), capitation and incentives for primary care, with FFS and alternate

funding plans for specialists, which are not aligned with multidisciplinary practices. Ontario has recently shown a willingness to embrace new structural models through the creation of a set of pilot Health Links that, in some respects, resemble these networks, to improve care for high-cost chronic disease patients and reduce avoidable readmissions to hospitals.<sup>49</sup> The developments in Ontario may provide a nascent organizational structure for vertically integrated networks.

In summary, formal constitution of multispecialty physician groups around existing patterns of patient flow could foster accountability for efficient, integrated care, investment in electronic medical records, care coordination, performance measurement, care management tools and quality improvement, the main ideas behind ‘accountable care systems.’<sup>29</sup>

## Figure Legends

Figure 1 maps the locations of the multispecialty physician networks in Ontario. The large green cross shows the location of the largest hospital in the network. The small black dot shows the location of other hospitals in the network. A network consists of either one provider hub, or an aggregation of provider hubs which are linked by straight lines to the largest hospital, resulting in “spiders”. Satellite networks are linked by dotted lines to the centroid of their provider hubs.

Figure 2 maps the concentration of PC physicians within the networks. We drew lines between the billing postal codes of PC physicians and the postal code of the primary network hospital. We first removed outliers, defined as those for whom this distance was  $> 200$  km. The “stars” show the locations of the PC physicians linked to a network.

Table 1. Data used to aggregate provider cluster A to a larger provider cluster.

Provider Cluster	# of residents in Provider Cluster	# of physicians in Provider Cluster	# of PC physicians in Provider Cluster	Ambulatory Visits by Cluster A Residents			PC Visits by Cluster A Residents			Medical non-maternal Admissions to Cluster A Residents			Travel time from Provider Cluster A (min)
				# of visits	Loyalty* (%)	rank	# of visits	Loyalty* (%)	rank	# of admissions	Loyalty* (%)	rank	
Provider Cluster A	27,473	32	28	286,120	67.1	1	277,205	87.4	1	2,373	53.8	1	0
Provider Cluster B	181,060	612	246	89,190	20.9	2	21,792	6.9	2	1,199	27.2	2	70
Provider Cluster C	119,223	211	104	22,550	5.3	3	7,710	2.4	3	282	6.4	3	53
Provider	56,405	100	57	4,765	1.1	4	706	0.2	4	201	4.6	4	73

\* Loyalty does not add to 100% since only visits and admissions by Cluster A residents to Clusters B, C and D are included.

Table 2. Network Size, Loyalty and Distance Measures

	Percentile*		
	10 <sup>th</sup>	50 <sup>th</sup>	90 <sup>th</sup>
Network size			
Overall population, N	48,016	134,723	343,527
Newborns	1,311	4,261	11,561
New immigrants	301	1,844	14,380
Physicians, N	75	294	822
PC physicians	51	125	295
Specialist physicians	20	141	526
Loyalty to network physicians, %			
PC physician loyalty, overall	73.8	80.6	92.4
PC physician loyalty, RIO <10 (urban)	71.8	77.4	87.9
PC physician loyalty, RIO 10+ (rural)	81.3	88.8	92.4
Physician loyalty, overall	59.4	68.4	86.3
Physician loyalty, RIO <10 (urban)	56.4	64.7	77.9
Physician loyalty, RIO 10+ (rural)	65.5	78.1	86.3
Loyalty to network hospital(s)			
Admission loyalty, overall	36.0	58.7	81.3
Admission loyalty, RIO <10 (urban)	31.3	42.5	87.9
Admission loyalty, RIO 10+ (rural)	55.9	69.5	81.0
Non-maternal admission loyalty, overall	34.5	67.4	88.0
Non-maternal admission loyalty, RIO <10 (urban)	33.0	45.0	88.5
Non-maternal Admission loyalty, RIO 10+ (rural)	66.1	75.9	87.9
Distance between residents and UPC, 90 <sup>th</sup> percentile (km)	20.8	26.7	43.1
Distance between residents and provider cluster, 90 <sup>th</sup> percentile (km)	20.9	28.0	47.8
Distance between physicians and provider cluster, 90 <sup>th</sup> percentile (km)	8.7	18.5	71.7

- Characteristics are computed at the network level, and then weighted by network population before computing the percentiles.



Table 3. Network Patient Characteristics, as of April 1, 2008

	Percentile		
	10 <sup>th</sup>	50 <sup>th</sup>	90 <sup>th</sup>
Population demographics			
Age (mean)	34	37	41
Female, %	50.6	51.6	52.7
Mean household income, \$	55,886	67,818	80,948
RIO, %*			
0 to 9 (Urban)	4.3	90.3	98.2
10-39 (Sub-urban)	1.2	5.3	50.5
40+ (Rural)	0.3	0.7	24.3
UPC is a PC physician, %	94.4	98.4	99.5
Patient is rostered to a PC group model, %¶	63.1	70.1	79.9
Prevalence of chronic conditions, % †			
None	52.6	60.4	64.5
Diabetes mellitus	6.1	7.8	9.1
Acute myocardial infarction	0.9	1.5	2.2
Congestive heart failure	2.4	3.4	4.6
Chronic obstructive pulmonary disease	6.6	10.3	15.6
Asthma	11.3	13.4	16.4
Hypertension	21.8	25.4	31.6
Cancer	2.3	3.4	4.5
3 or more chronic conditions	3.5	4.9	7.2
Pre-term babies (among ≤5 years of age), %	5.2	6.1	7.2
Charlson comorbidity score 3+, % §	6.0	8.1	10.5

\* Ontario rurality index.

¶ Rostered as of midpoint, October 1, 2009.

† For diabetes, asthma and cancer, based on population of all ages; for AMI and hypertension, based on population 20+ years; for COPD and CHF based on population 40+ years.

§ Among those with hospitalization.

Table 4: Network Health care Resource Supply

	Percentile		
	10 <sup>th</sup>	50 <sup>th</sup>	90 <sup>th</sup>
Physician Supply (FTEs per 100,000 population)			
PC physician FTEs	70.2	80.4	103.0
Specialist physician FTEs	45.7	69.7	193.8
PC physicians			
UPC Panel size, mean	923	1,358	1,773
Continuity of care, %	88.8	92.6	94.9
Belong to a PC group model, % *	70.8	78.0	87.5
Hospital Resource Supply			
Acute care beds per 1000	0.8	1.2	2.4
ICU beds per 10,000	0.5	1.0	2.3

\* As of midpoint, October 1, 2009.

## Appendix A

The 18 adult and 21 child comprehensive primary care codes:

ADULT	CHILD
A001 – Minor Assessment	A001 – Minor Assessment
A003 – General Assessment	A261 – Minor Assessment - paediatric
A007 – Intermediate Assessment	A003 – General Assessment
A903 – Pre-operative Assessment	A007 – Intermediate Assessment*
E075 – Geriatric General Assessment Premium	A903 – Pre-operative Assessment
G212 – Allergy injection alone	G212 – Allergy injection alone
G271 – Anticoagulant supervision	G271 – Anticoagulant supervision
G372 – Injection with visit	G372 – Injection with visit
G373 – Injection sole reason	G373 – Injection sole reason
G365 – Pap Test	G365 – Pap Test
G538 – Immunization with visit	G538 – Immunization with visit
G539 – Immunization - sole reason	G539 – Immunization - sole reason
G590 – Influenza immunization - with visit	G590 – Influenza immunization - with visit
G591 – Influenza immunization - sole reason	G591 – Influenza immunization - sole reason
K005 – Primary Mental Health Care	K005 – Primary Mental Health Care
K013 – Counseling – Individual Care	K013 – Counseling – Individual Care
K017 – Annual Health Exam – Child after second birthday	K017 – Annual Health Exam – Child after second birthday*
P004 – Minor prenatal assessment	K267 – Annual Health Exam – Child after second birthday (billed by pediatrician)*
	K269 – Annual Adolescent Health Exam (billed by pediatrician)*
	P004 – Minor prenatal assessment

\*PC codes used to identify PC paediatricians.

## Appendix B - Glossary of terms

### Network Terms

- A provider cluster comprised the population and physicians, both PC and specialists, linked to a particular hospital. This was the first step in the process.
- A network was an aggregation of provider clusters based on high admission and physician loyalty, close geographic proximity and GIS mapping with a minimum population of 50,000 residents. A network consisted of the combined population, physicians and hospitals linked to its component provider clusters.
- A satellite network was a collection of small rural provider clusters that were geographically distinct from the large hospital upon which they depended for complex services. The population served and the local services provided were very different from that in the nearest large provider cluster.

### Loyalty

- Physician loyalty is defined as the percent of a provider cluster (or network) population's ambulatory visits that were with physicians linked to the cluster (or network)
- PC loyalty is defined as the percent of a provider cluster (or network) population's ambulatory PC visits that were with PC physicians linked to the cluster (or network).
- Admission loyalty is defined as the percent of a provider cluster (or network) population's total admissions that were to the linked hospital (or network hospitals)
- Similar loyalty measures were computed using network populations.

For the population in network A, network loyalty is computed as:

$$\text{Network Physician Loyalty} = \frac{\text{No. of ambulatory visits to physicians in network A}}{\text{No. of ambulatory visits}}$$

$$\text{Network PC Loyalty} = \frac{\text{No. of ambulatory visits to PC physicians in network A}}{\text{No. of ambulatory visits to PC physicians}}$$

$$\text{Admission Loyalty} = \frac{\text{No. of admissions to hospitals in network A}}{\text{No. of admissions}}$$