

ORIGINAL RESEARCH

Using Social Network Analysis to Examine the Effect of Care Management Structure on Chronic Disease Management Communication Within Primary Care

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BACKGROUND: Care management and care managers are becoming increasingly prevalent in primary care medical practice as a means of improving population health and reducing unnecessary care. Care managers are often involved in chronic disease management and associated transitional care. In this study, we examined the communication regarding chronic disease care within 24 primary care practices in Michigan and Colorado. We sought to answer the following questions: Do care managers play a key role in chronic disease management in the practice? Does the prominence of the care manager's connectivity within the practice's communication network vary by the type of care management structure implemented?

METHODS: Individual written surveys were given to all practice members in the participating practices. Survey questions assessed demographics as well as practice culture, quality improvement, care management activities, and communication regarding chronic disease care. Using social network analysis and other statistical methods, we analyzed the communication dynamics related to chronic disease care for each practice.

RESULTS: The structure of chronic disease communication varies greatly from practice to practice. Care managers who were embedded in the practice or colocated were more likely to be in the core of the communication network than were off-site care managers. These care managers also had higher in-degree centrality, indicating that they acted as a hub for communication with team members in many other roles.

DISCUSSION: Social network analysis provided a useful means of examining chronic disease communication in practice, and highlighted the central role of care managers in this communication when their role structure supported such communication. Structuring care managers as embedded team members within the practice has important implications for their role in chronic disease communication within primary care.

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INTRODUCTION

Americans are increasingly plagued by chronic disease,¹ and evidence suggests that not all patients are receiving self-care support for managing their disease.^{2,3} As a response to the growing burden of chronic disease and the needs of an aging population, care management has become increasingly prevalent as a service provided to patients in primary care settings, often as a component of the patient-centered medical home.^{4,5} Care management is a patient-centered approach designed to “assist patients and their support systems in managing medical conditions more effectively,”⁶ and includes patient education, goal setting, and self-management support. Care management, when studied as a research-supported endeavor (i.e., researchers fund, train and support the care managers, provide tight control over their activities, and regularly assess their efforts as a means of maintaining fidelity), has the potential to improve patient clinical values and costs; however, studies evaluating more “real-world” clinical delivery conditions have demonstrated that care management can have varying effectiveness, likely due to differing circumstances, program characteristics, and implementation success.^{7–17}

The delivery of care management is usually encompassed within the role of a “care manager.” The tasks that care managers perform can vary widely, but generally focus on coordinating care in support of patients’ long-term care needs. As a member of the practice team, they also educate patients about the health care system, how to navigate the system, and how patients can care for their chronic conditions. Some care managers have been trained to facilitate behavior change by helping motivate patients and working collaboratively with patients and their primary care providers to set reasonable self-improvement goals and action plans, and providing support and assistance for patients making changes to improve their own health.^{18,19} Some studies have indicated that the extent to which the care manager is integrated or embedded within the

practice is directly proportional to the effectiveness of the care management implementation.^{5,20,21} Therefore, the way that care management is structured, including the location of the care manager and his/her relationship to the primary care practice, is a program design decision worth examining.

Social network analysis is an analytic method that can be used to examine agglomerations of advice-seeking and referral interactions. Based on graph theory, social network analysis has its roots in statistics, sociology, and anthropology, and has been widely applied in various subfields relating to health—including HIV transmission and peer influence on health outcomes.²² Social network data typically involves individuals (nodes) and their relationships (ties or links) to one another. Examples of the use of social network analysis in health include advice-seeking behaviors within hospitals,²³ the use of health information technology and multi-professional communication in patient handoffs,²⁴ and the association of complex communication patterns with medical errors.²⁵ An emerging field of interest is the application of social network analysis for understanding and changing relationship-based organizational knowledge and processes within health care systems.^{26,27}

A review of the literature in PubMed Central using the search terms “social network analysis” and “primary care” revealed very few papers, suggesting that social network analysis may represent an innovative method for examining communication networks within primary care. Nonetheless, some studies have assessed the nature and effectiveness of interactional patterns among practice team members,^{28,29} whereas others have examined networks from the patient perspective to understand patients’ views of the importance of the health care team within the network related to their health issue.^{30,31} Outcomes research examining the effect of primary care social networks on patient outcomes is sparse, but seems to suggest that a larger number of distributed networks with greater collaboration is associated with improved outcomes, such as cost- and health-related gains.^{32,33} However, greater collaboration takes more time and thus may lead to unnecessary duplication.

Participation in a descriptive study to identify key factors for successful implementation of chronic disease management in primary care provided the opportunity to utilize social network analysis, with a special emphasis on the care manager role. The purpose of this paper is to answer the following questions: Do care managers play a key role in chronic disease management in the practice, as noted by other practice members? Does the prominence of the care manager’s connectivity within the practice’s communication network vary by the type of care management structure implemented?

METHODS

The data from this study constitute part of an effort to identify factors for successful care management implementation in primary care. The institutional review boards of the University

of Colorado Denver (Colorado Multiple Institutional Review Board [COMIRB]), Michigan State University, and Bronson Health Services approved this research.

Setting and Participants

The practices participating in this study were part of a larger study to assess the effectiveness of care management in primary care. A total of 24 primary care practices from within three administrative groups (i.e., independent practice associations or health system) in Michigan and Colorado participated in the overall study. The administrative leadership for the groups self-selected to participate, and within the groups, the practices also accepted participation. All practice members were included as participants in the research.

Instrument

At the practice level, a written survey instrument completed by the practice manager and at least one clinician assessed each practice’s demographics and background information, and this included a survey called the Practice Monitor, which is a self-assessment of each practice’s quality improvement efforts.³⁴ In addition, questions assessed the role, employer, and work location of the care manager.

At the individual practice member level, a written survey instrument was developed and administered to each practice member, including all roles within the practice. This individual survey assessed practice member demographics, role and years working in the practice, their assessment of chronic disease management satisfaction and tasks performed, including use and evaluation of the care manager. Surveys also assessed practice culture,³⁵ burnout³⁶ and chronic disease management communication.

The last section of the individual survey contained questions for the social network analysis. The survey asked: *As a busy practice member, you cross paths with and talk to a variety of people on any given day. Please write in the names of the three most important people from whom you talk with, seek advice, or refer to regarding the management of patients with all types of chronic disease. Consider your role within the practice even if you do not provide clinical care.* Each participant then named (by name—with notations about confidentiality) three different people, a process referred to as “nomination.” Questions to the respondent about each of the three individuals nominated included that person’s role, their physical work location, the frequency with which they interacted, usual topics of discussion (related to chronic disease care), and the importance of the conversation with this person to the participant’s role in the practice relative to patients with chronic conditions. The actual survey questions are appended.

Finally, each care manager was asked to complete a separate survey that described their own demographics, educational background, length of time as a care manager and working at that practice, personality,³⁷ job “calling (degree to which the care manager views her role as a job, career, or a calling),”³⁸

leadership (15-question self-assessment of leadership dimensions such as oral and written communication, judgment, and decisiveness),³⁹ and role confidence (authors developed set of 14 questions to rate degree of confidence with core care management duties on a scale of 1 to 5).

Data Collection

An investigator or research assistant visited each practice and distributed the surveys to practice members individually, usually at a group meeting, and collected them immediately. If the practice member was absent, the practice administrator was provided with the survey in a sealed envelope, and the participant was asked to complete the survey and send it back in a secure (sealed with signature) envelope for the research team member to collect later. No names were included on any surveys, but were instead coded for confidentiality by requesting participants' names ahead of survey administration and keeping a secure match list. Participants received a \$10 gift card to a local store for completion. Participants were able to decline by writing "decline" across the top of the individual survey and returning it in the sealed envelope. Research staff worked with the practice administrator to collect all sealed envelopes from all practice members so that the total completed surveys and declines equaled the total number of practice members.

The same process was used for the care manager survey when the care manager was located at the practice (embedded or co-located). Off-site care managers were given the survey at a separate administrative meeting held at the practice association administrative offices. The same procedures for confidentiality and refusal were followed.

Data Analysis

The primary independent variable of interest was care management structure: off-site, co-located, or embedded. Additional variables of interest were self-reported social network characteristics, clinician ratings of care manager performance, and care manager and practice member demographics. Network diagrams, and network and node properties were generated using VisuaLyzer.⁴⁰ We chose metrics that would be relatively independent of practice size: core-periphery measure, normalized in-degree percentage, and the ratio of the normalized in-degree percentage to the practice median.

"In-degree centrality"⁴¹ is a measure of how many times someone is nominated or named by respondents. The non-normalized in-degree centrality scores for each network member would range from zero to the number of people surveyed. We used a normalized version of in-degree centrality so that networks of slightly different sizes could be compared on a standardized range of values. For the core-periphery measure, being named many times by connected people might put a person in the denser core of the network versus the periphery or the less connected outer parts of the network.⁴² "Core-periphery" is a measure of whether an individual is in the

denser and connected core versus the more sparse or less connected periphery, wherein nodes in the core are generally connected to other nodes in the core as well as to some nodes in the periphery, while peripheral nodes are not well connected to one another.⁴³ Core-periphery is different from in-degree centrality in that an individual can have a relatively high number of ties from others, and thus high in-degree centrality, but still not be in the network core if they are part of a subgroup and not well connected to the core. This metric is of interest because it highlights how a high core-periphery may result when a core develops around certain individuals if they are in charge of many tasks, if most patient care is coordinated by a few individuals, or if the practice has very few providers, thus requiring most people to interact with them.

Frequency distributions and summary statistics (means, standard deviations, medians, rates) were generated on outcome variables, sociodemographic and clinical variables, and other relevant variables of interest. For continuous outcomes, distributions were evaluated to determine whether normality assumptions held or if transformations or other approaches were needed. Scales evaluating care managers were generated using chi-square and McNemar tests, Spearman/Pearson correlations, and analysis of variance (ANOVA). Analyses were performed using SAS 9.4M2 software (SAS Institute Inc., Cary, NC) for bivariate analyses.

RESULTS

The average response rate for capturing the social network data was acceptable, at 82% (82%, 89%, and 79% by provider organization); all but three practices had rates of at least 71%. Centrality scores were typically stable, with missing data of up to around 30%,^{44,45} while core-periphery scores were typically acceptably accurate, with missing data up to around 20%.⁴⁶ The care managers who were in the off-site grouping did not complete a survey for each practice they served. This affected the network scores for people the care managers would have nominated, but did not affect the ability of these care managers to be nominated by those in the practice (and thus did not affect in-degree centrality of the care managers). Similarly, being in the core of a core-periphery structure was much more dependent on being nominated more frequently than on nominating others, especially since we limited the number of people each interviewee could nominate (three per interviewee). Missing data at this level would probably reduce the in-degree centrality score value rather than the rank order, and still leave a person in the core due to the nature of directed data (i.e., tends to generate core-periphery structures), although it is possible that a person or two could be added to the core in place of others if all data were indeed captured from those not surveyed, and if the un-surveyed people had similar/biased—rather than relatively random—citations of others, which we expect was unlikely.

Table 1 Characteristics of Survey Participants and Their Organizations

Provider organization (letters indicate three different organizations)	A	B	C
State	Colorado	Michigan	Michigan
Number of practices and disciplines (FM = family medicine; IM = internal medicine)	8 Total: 6 FM, 2 IM	5 Total: 5 FM, 1 IM	11 Total: 8 FM, 3 IM
Ownership of practices	Independently owned, affiliated with PO	Independently owned, affiliated with PO	Owned by PO
No. of physicians involved in direct patient care, mean (SD)	3.5 (1.1)	3.4 (3.0)	3.1 (1.5)
Care management structure	Co-located and off-site	Embedded and co-located	Embedded
Respondents by clinic member type, <i>n</i> (% of total surveyed)			
Physicians	37 (95%)	23 (100%)	35 (80%)
Care managers	9 (90%)	7 (78%)	10 (90%)
Staff (non-clinician)	123 (93%)	92 (81%)	118 (80%)
Gender: female			
Physicians	20 of 37 (54%)	15 of 23 (65%)	23 of 35 (66%)
Care managers	9 of 9 (100%)	7 of 7 (100%)	10 of 10 (100%)
Staff (non-clinician)	113 of 122 (93%)	89 of 92 (97%)	115 of 118 (97%)
Years at practice, mean (SD)			
Physicians	16.6 (33.2)	10.7 (9.9)	8.8 (8.0)
Care managers*	3.5 (1.8)	2.4 (1.7)	0.7 (0.7)
Staff (non-clinician)	5.9 (7.0)	5.9 (6.4)	4.3 (5.3)
Years in role, mean (SD)			
Physicians	14.6 (10.0)	13.8 (11.9)	12.1 (4.5)
Care managers*	8.9 (8.2)	2.9 (1.8)	3.8 (5.1)
Staff (non-clinician)	9.4 (9.7)	10.6 (10.8)	8.7 (8.1)
Roles represented*			
Nurse	4 (3%)	7 (8%)	8 (7%)
Medical assistant	41 (34%)	40 (43%)	59 (50%)
Reception/Office Care manager	39 (32%)	25 (27%)	31 (26%)
Other patient care	7 (6%)	7 (8%)	5 (4%)
Administration	4 (3%)	0 (0%)	1 (0.9%)
Other	14 (11%)	6 (7%)	11 (9%)
Age of care managers, mean (SD)*	13 (11%)	7 (8%)	3 (3%)
Care manager held a previous position in the practice*	48.3 (7.7)	53.4 (6.7)	45.0 (5.1)
No. of years CM program in practice, mean (SD)	0 (0%)	4 (57%)	0 (0%)
CM case load/year, <i>n</i> (%)	2.0 (1.5)	3.0 (1.2)	1.7 (0.8)
<100	3 (50%)	3 (60%)	0 (0%)
100–249	2 (33%)	1 (20%)	4 (57%)
250+	1 (17%)	1 (20%)	3 (43%)
CM currently employed by the practice (yes)*	0/9 (0%)	5/7 (71%)	17/17 (100%)

*Statistically significant difference between organizations at $p < 0.05$, via chi-square, generalized linear modeling, and one-way ANOVA
PO Provider organization, CM Care manager

Although the data were not analyzed by organization (they were analyzed by types of care managers), Table 1 presents the characteristics of survey respondents by organization (labeled A, B, and C), because this is the larger context for how these communication activities actually take place. These three organizations varied little to moderately on most background and demographic features. Organizations were similar in size, with a median number of practice members of 20, 12, and 16. Staff in practices associated with organizations A and B had been working in the practice longer (and were older) than those in C, and their practices were not owned by the practice organization, unlike organization C. Gender makeup and staff distribution were similar across the organizations, as were the sample sizes. Organization A had more highly educated care managers and care managers with degrees in nursing and social work, while almost all care managers in organizations B and C had degrees in nursing. The most important variation—and the focus of this study—was in terms of care management models, with each of the three having a different combination of structures for care management.

Three types of care manager structures were evident: off-site, co-located, and embedded. These structures included features of both location and employer, as follows: 1) the off-site care manager, who did not maintain an office or workspace at the practice and was not an employee of the practice; 2) the co-located care manager, who was on-site at the practice part-time and shared with other practices, but was employed by the practice association or practice group; and 3) the embedded care-manager, who was a full- or part-time employee of the practice and who maintained a workspace in the practice. The results of the remainder of the analysis are shown by care management structure in Tables 2, 3 and 4.

Table 2 demonstrates the care manager demographics and personality characteristics by care management structure. There appear to be few real differences in the backgrounds of care managers based on the care management structure they utilized. Off-site care managers were more likely to have worked with the practices longer and to have a more varied educational background. There were no differences in the three scales related to care management work role confidence, job calling, personality, or leadership style.

Table 3 examines care manager structure by social network statistics. We found that embedded care managers were significantly more likely than off-site care managers to be located in the core of the chronic disease care communication network. A practice member's location within versus outside the core describes whether that practice member falls within a densely connected core or in a sparsely connected periphery of the network. Presence in the core indicates an increased likelihood of being an important or trusted source of information. Embedded care managers also had higher in-degree centrality than did the other care management structures. In-degree centrality is a value describing the extent to which information flows to one individual, and is measured as the number of times the individual was named by others. Embedded and some co-located care

Table 2 Care Manager Characteristics by Care Management Structure

Care managers by location*	Off-site N=9	Co-located N=7	Embedded N=17	p-value [†]
Gender: female, n (%)	9 (100%)	7 (100%)	17 (100%)	NA [‡]
Age, mean (SD)	49.2 (4.7)	48.4 (7.8)	47.2 (8.0)	0.78
Years at the practice, mean (SD)	4.0 (2.2)	2.4 (1.3)	1.3 (1.4)	0.005
Years as a care manager, mean (SD)	6.9 (7.4)	9.6 (8.7)	3.2 (3.9)	0.08
Care manager held a previous position in the practice, n (%)	0 (0%)	0 (0%)	4 (24%)	0.15
Care manager degree, n (%)				
Health care administration	2 (22%)	0 (0%)	0 (0%)	0.001
Nursing	3 (34%)	2 (29%)	15 (88%)	
Social work	2 (22%)	5 (71%)	1 (6%)	
Unknown	2 (22%)	0 (0%)	1 (6%)	
Care manager education, n (%)				
Associate's degree	2 (22%)	0 (0%)	4 (24%)	0.005
Bachelor's degree	5 (56%)	1 (14%)	13 (76%)	
Master's degree	2 (22%)	6 (86%)	0 (0%)	
Care managers' self-reports, mean (SD)				
Professional calling scale	64.7 (10.7)	67.5 (3.8)	55.1 (16.7)	0.08
Leadership style scale	75.0 (9.7)	80.0 (4.1)	79.6 (7.3)	0.30
Role confidence scale	78.4 (7.0)	83.9 (8.0)	80.9 (10.9)	0.53
Care managers' personality assessment, mean (SD)				
Honesty-humility	4.1 (0.4)	4.2 (0.4)	4.1 (0.4)	0.89
Emotionality	3.1 (0.3)	2.8 (0.5)	3.3 (0.4)	0.07
Extraversion	3.8 (0.4)	3.8 (0.4)	3.6 (0.5)	0.42
Agreeableness	3.2 (0.6)	3.8 (0.3)	3.6 (0.5)	0.08
Conscientiousness	4.2 (0.3)	3.8 (0.4)	4.1 (0.4)	0.16
Openness to experience	3.4 (0.8)	3.6 (0.7)	3.1 (0.7)	0.32

*Care managers were asked to complete care manager surveys for each of the practices for which they worked. [†]All p-values were generated by chi-square tests, generalized linear modeling, and one-way ANOVA. [‡]All care managers were female, so no statistical comparison was performed

managers had rich network connections with practice members of all types, both clinical and administrative.

Overall, the probability of being in the core was more strongly associated with structure than number of care managers in the practices (there could be one or two care managers in a practice). This does not lead to a large numeric increase in the chance of a care manager being named—because, for example, two care managers out of 20 people is not much different from one care manager out of 20, when all those people are options (10% chance instead of 5% chance). Of all practices in organization A (with no embedded care managers), zero were in the core; for the other two organizations with embedded or embedded and co-located, the percentage of care managers in the core was 100% and 73%. There was no significant difference among care management structures with regard to in-degree centrality

when comparing all practice members (instead of just care managers), which suggests that there was no difference among the three care management structures in level of communication. However, we created a ratio of the in-degree centrality of care managers to the in-degree centrality of others in each practice. This ratio might more accurately reflect the relative importance of care managers in their practices. These ratios indicated that the in-degree centrality of both embedded and co-located care managers was twice that of other practice members. Off-site care managers had far less in-degree centrality than other practice members. Indeed, the median off-site care manager was not even nominated as a go-to person for chronic care communication by anyone in their practice.

For purposes of illustration, we provide three diagrams depicting the three care management structure types across the three organizations. Figure 1 illustrates the off-site and co-located care managers for one practice in organization A. Figure 2 depicts the co-located and embedded care managers for a practice in organization B. Figure 3 illustrates only an embedded care manager for a third practice in organization C. These diagrams should be interpreted as follows: As noted in the figure legends, each shape represents a role. The care manager role is a triangle. The lines represent nominations from one practice member to another, which are noted by the direction of the arrow. Straight lines represent frequent communication, whereas dotted lines represent less frequent communication. There are two types of communication: clinical and non-clinical (and both). These are represented by the colors of the lines. Lastly, the circle around most of the practice members indicates that the work location for these members is within the practice. Members outside this circle do not have a work location in the practice. Those with a smaller dotted circle represent co-located practice members.

Examination of the three diagrams again reveals that the embedded care managers were nominated much more frequently than the co-located or off-site care managers. Such a result can be achieved by both descriptive quantitative analysis and social network analysis. However, graphically, we see that the embedded care manager is also located in the center of the diagram in Figures 2 and 3, thus representing the care manager as residing within the core of the communication network. This is not necessarily depicted in non-network analysis.

We examined additional measures for understanding communication or communication potential based on others' perceptions of each person, and found that care managers who were embedded or co-located had significantly better ratings from clinicians for trust and for five dimensions of their performance, compared to off-site care managers (Table 4). The fact that these non-network ratings were the same for the co-located and embedded care management types—while embedded care managers had higher core-periphery scores and higher in-degree centrality—suggests that the communication network measures do something different for chronic care communication than do these non-network perceptions of others' skills/attributes.

Table 3 Social Network Characteristics of Care Managers* by Structure

Node characteristics	All CM <i>n</i> = 56			Off-site <i>n</i> = 12			Co-located <i>n</i> = 11			Embedded <i>n</i> = 33			<i>p</i> -value
	Median	<i>p</i> 25	<i>p</i> 75	Median	<i>p</i> 25	<i>p</i> 75	Median	<i>p</i> 25	<i>p</i> 75	Median	<i>p</i> 25	<i>p</i> 75	
Care manager in core: % Yes (<i>n</i>)	29% (16)			0% <i>n</i> = (0)			18% (<i>n</i> = 2)			42% (14)			0.01
In degree centrality: median (IQR)	9.2 4.6 24.2			0.0 0.0 5.2			10.0 7.7 23.3			19.0 6.7 46.2			0.002
Care manager (<i>n</i> = 56)	6.2 0.0 14			5.6 0.0 16.7			5.0 0.0 12.9			6.2 0.0 14.1			>0.30
All members (<i>n</i> = 511)	1.0 0.6 3.2			0.0 0.0 1.0			2.0 1.0 2.0			2.0 1.0 6.0			0.005
Care manager ratio (CM in-degree to median of all members in same practice)													

*Some of the care managers are shared between practices and may have a different assigned location, depending on the practice and the types of social network evaluation within each practice. Additionally, more care managers and other practice members were nominated than filled out surveys. Within the organization C practices (which all have embedded care managers), staff or the care manager nominated care managers who were outside the practice but in the same care management/hospital system organization (*n* = 9 embedded care managers). Because of this, we show separate network characteristics for 56 care managers, versus 33 from which we obtained survey data. *P*-values generated by chi-square and Wilcoxon–Mann–Whitney tests. *p*25 = 25th percentile, *p*75 = 75th percentile

But could there be other reasons for the difference in the network importance of care managers, besides the employer and location? We examined other characteristics of the practices such as their self-rated quality improvement progress, burnout, and three different work culture scales (overall culture, teamness, and chaos). None of these factors affected the differences in the network measures across the three organizations representing the different types of care management structures.

DISCUSSION

To answer our first question—*Do care managers play a key role in chronic disease management and communication within the practice, as noted by other practice members?*—the answer is yes, at least in many cases. This seemed especially true for embedded care managers, but also to a lesser extent for co-located care managers. To answer our second question—*Does the role of care manager in the chronic disease care network vary by care manager employer and care management structure?*—the answer is also yes. There were two elements that defined the care manager structure: whether the care manager spent any of her working time at the practice, and how much, as well as who the care manager’s employer was. Clearly, care managers who spend more time at

a practice are considered more important members in the communication around these issues. These professionals, when embedded, might tend to do more that resembles care management than the case management that occurs when people are co-located or off-site. When they are part of the team, these people may be the go-between for primary care providers, staff, and patients. When they are not part of the team, they are managing patients.

What are other factors that may have influenced our results? We examined the effect of practice demographics, practice quality improvement efforts, practice culture, and burnout. None of these factors exerted a significant effect on the network statistics regarding care management structure. A key factor that may have influenced our results, but was intertwined with care manager location, is the number of years at the practice. One could intuit that more years at a practice would be associated with greater importance (and centrality) of the care manager role; however, our hypothesis was that care manager location would be most important. For example, practice organization C had the care managers with the least amount of time at the practice, but who were also embedded—with the result that they were frequently nominated. Another difficulty is that the embedded model highly favors bachelor’s level-trained nurses. The more independent models (off-site and co-location) are more likely to have master’s level and social work

Table 4 Clinician Rating* of Care Managers by Structure

Clinician rating category	Off-site <i>N</i> = 6		Co-located <i>N</i> = 7		Embedded <i>N</i> = 17		<i>p</i> -value
	Mean	SD	Mean	SD	Mean	SD	
Trust	2.0	0.8	2.7	0.5	2.5	0.9	0.41
Knowledge of chronic disease care	1.9	0.5	2.4	0.3	2.6	0.3	0.001
Competence in managing patients	2.1	0.9	2.8	0.2	2.8	0.3	0.02
Organizational skills	2.0	0.6	2.6	0.3	2.7	0.3	0.002
Patient motivational skills	2.0	0.5	2.4	0.2	2.7	0.3	0.004
Engagement of providers and staff	1.8	0.7	2.5	0.3	2.8	0.3	<0.001

*Higher score is better (scale 1 to 3); *p*-values generated by one-way ANOVA

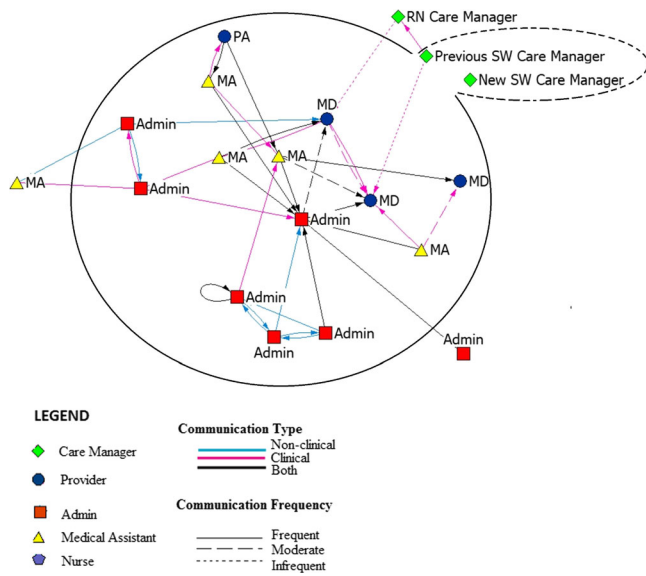


Figure 1 Example of practice in organization A with off-site and co-located care managers.

professionals. This may be mediating clinician perceptions—for example, nurses are more like clinicians than social workers, and may have better clinical/practice knowledge to begin with. However, this was not truly borne out in our data, as some of the off-site care managers were also nurses (Table 2), and they demonstrated the fewest network connections and

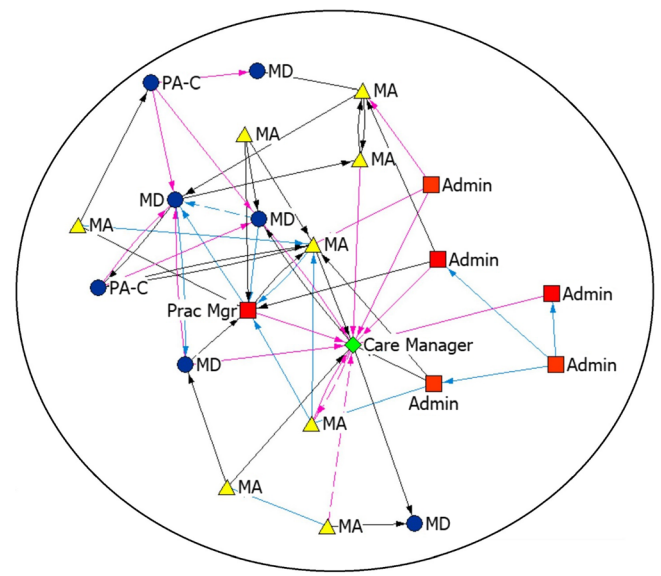


Figure 3 Example of practice in organization C with an embedded care manager.

were the least central. Therefore, our data lead us to believe that it was not training background, but availability at the practices, that influenced network statistics.

As a supplement to past research, these results suggest some mechanisms by which embedded care managers have improved implementation results and outcomes. Daaleman et al. reported on their implementation of care management within primary care practices, and noted the importance of interactions among team members in building a sustainable program. They reported that outreach and personal communication by the care manager were “key elements in effectively implementing the position into the FMC [University of North Carolina at Chapel Hill Family Medicine Center] workflow.”²⁰ Taliani et al. investigated the implementation of practice-based care management aimed at improving diabetes care within a patient-centered medical home framework. Using a positive deviance method to identify high- and low-performing practices, the authors found that high-performing care managers “performed patient-centered duties; fully leveraged the potential of the EMR for communication, patient tracking, and information sharing; and had open and frequent communication with physicians and office staff.”⁵ Other studies also support the importance of the care manager having an on-site presence and communicating frequently with the practice clinicians and staff.^{17,47}

As with most research, this study has limitations. This work represents a sample of 24 practices that were willing to participate in a study of care management. Analysis did not take into account the length of time that care management had existed in

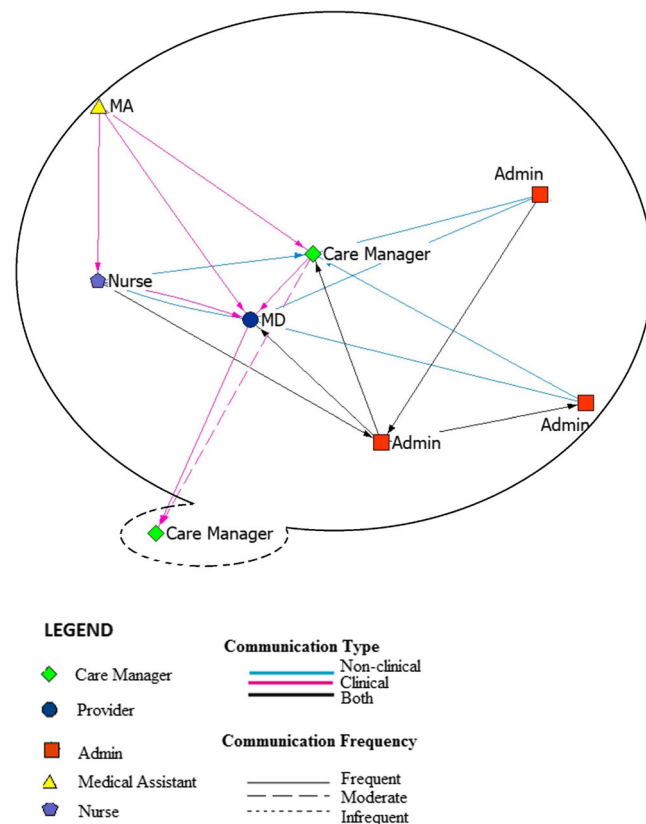


Figure 2 Example of practice in organization B with co-located and embedded care managers.

each practice. It is well known that lead-in time is needed for new care management to be established and to become a regular part of the practice. However, it was the organization with the newest care managers that also had the embedded care managers. If longer time in practice produces better within-practice communication, then the effect of care manager communication is less than what it is reported here.

There are also variables that are unaccounted for, such as the personalities and disposition of the practice members who completed the surveys, and their willingness to participate on a team; thus there may be more factors involved in establishing the network connections in a practice, and not simply the care manager's location and employer. However, the other measures we studied (i.e., practice quality improvement efforts, culture, and burnout) did not vary by care manager structure and did not appear to influence the results.

The variable rate of response to the social network portion of the survey may be a concern; however, response rates over 70% are considered reasonable for centrality measures.^{44,45} With the exception of three practices, we achieved response rates of at least 70%, and often much higher. Lastly, in this study, we chose an ego network, which means that the number of nominations of others was limited. This may have restricted the choices of individuals selected and could have caused us to overlook other important communication patterns. Along these lines, some practice members might have felt that they needed to nominate three people even if there were not three people important to their communication, leading to overrepresentation of the roles of others in and out of the practice.

In summary, this work presents a novel approach to examining practice communication regarding a topic of clinical care—chronic care management. Social network analysis provided a means of examining communication networks in primary care and was effective in illustrating the important role of care management structures in developing team-based care for chronic disease management. These results have implications for the design of future care management programs in primary care.

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Compliance with Ethical Standards:

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