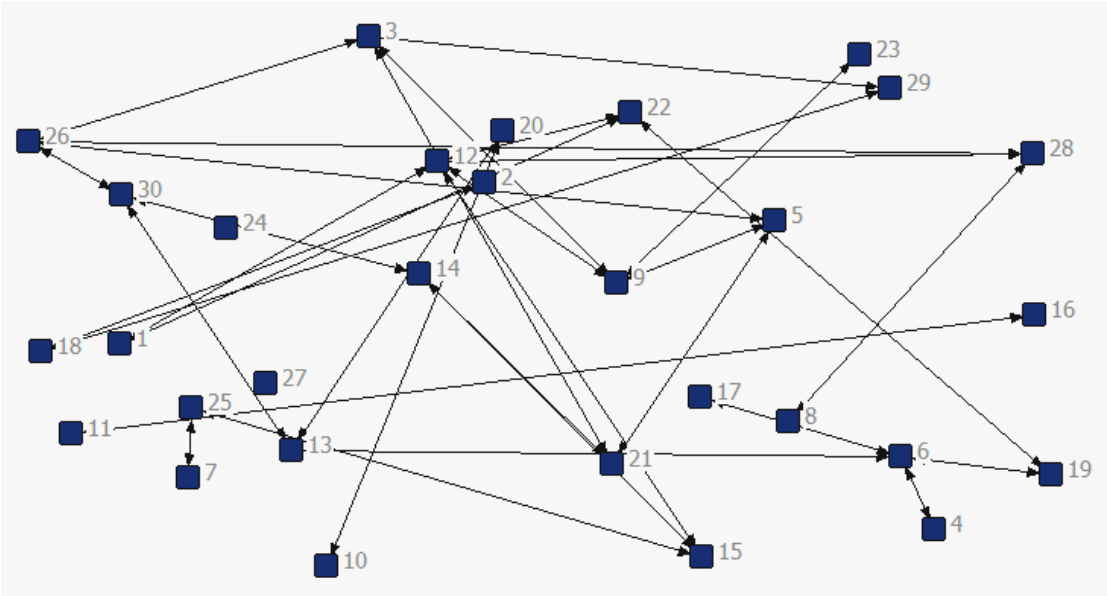
An Interorganizational Social Network Analysis of the Michigan Diabetes Outreach Networks

Measuring Relationships in Community Networks



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Executive Summary

Public health has always relied on partnerships to conduct organized community efforts for the purpose of improving community health. Traditional methods for measuring partnerships collect information about the characteristics of different partners to draw comparisons and conclusions about a social linkage. However, in social network analysis, the primary data collected are the relationships themselves.

Michigan's Diabetes Outreach Networks (DONs) are six regional, community-based organizations with the mission to promote innovative partnerships to strengthen diabetes prevention, detection and treatment throughout Michigan. Since the DONs emphasize collaboration as part of their activities and outcomes, there was a need to better assess the partnering efforts of the DONs. The purpose of the DON network pilot study is to: 1) provide a baseline measure of social network variables to measure changes in collaboration over time; 2) identify factors that affect the strength of existing partnerships; and 3) suggest methods for strengthening network partnerships in the future.

DON directors were asked to identify partner organizations with whom they worked in Fiscal Year 2006-2007 to define the regional network. Everyone within the network was asked to complete a 10-question online survey. Each DON region was analyzed as a separate network using specialized social network analysis software (UCINET and NetDraw). Additional analyses were performed to assess factors that contribute to relationship strength.

Findings

Measures from social network analysis confirm the DONs are central figures in the regional work of diabetes prevention and control. Well-established DONs show a higher density of partners and greater number of connections between partner organizations. DONs are highly influential in their networks and removal of well-established DONs from the network would hamper the exchange of information and resources within the network.

Within each network, frequency of contact plays a key role in predicting collaborative strength. DONs who reported less contact with their partners on average compared to other DONs had lower network scores. At the regional level, measures of network continuity explain regional differences in collaborative strength. DONs that had been in existence longer or had a director who served longer had higher network scores. However, these factors cannot always be controlled and are therefore difficult to change. The best opportunity for addressing differences in regional collaboration is to improve network density, the number and/or quality of relationships with partners. Making changes to the pattern of relationships (how partners interact) can change the structure of the network and, in turn, change network scores.

Next Steps

DONs should emphasize frequent contact with their partners and provide opportunities for partners to better communicate with each other, with the purpose of strengthening existing collaborative relationships. However, as the number of ties increases, the maintenance of relationships may become too time consuming and costly for network partners. DONs will be challenged to find a balance of the number and type of network relationships needed.

As DONs prioritize work goals, they should give special attention to the resources that are top-ranked by their network partners and work to preserve professional education opportunities, online resources and outreach to the public/consumers. A needs assessment would help to determine whether there is a need for additional resources that would be more useful to network partners.

While a baseline network analysis is useful in demonstrating the extent of collaboration among organizations, its greater value lies in tracking progress of building community capacity over time. It is recommended that the network survey for the DONs be repeated for Fiscal Year 2011-2012.

Introduction

Public health has always relied on partnerships to conduct organized community efforts for the purpose of improving community health. Over the past few years, chronic disease prevention programs have begun to recognize the need to evaluate these community partnerships and describe their impact on public health activities and accomplishments. Social network analysis is a research approach uniquely suited to describing, exploring and understanding relationships in an objective manner.[1]

What is Social Network Analysis?

Traditional methods for measuring partnerships collect information about the characteristics of different partners to draw comparisons and conclusions about a social linkage. The Centers for Disease Control and Prevention (CDC), Heart Disease and Stroke Prevention section published the "Evaluating Partnerships Guide" that suggested conducting partner evaluations at several levels: 1) reporting the number, diversity and participation of partners; 2) conducting a process evaluation of partner activities; and 3) conducting a performance evaluation of partner outcomes.[2] However, none of these approaches actually measures relationships.

In social network analysis, the primary data collected are on the relationship between actors (actors are either individuals or organizations) with actor characteristics collected as secondary data.[3] Social network analysis uses both graphical and statistical methods to present relational data. The following overview is adapted from Hanneman and Riddle.[4]

An actor is represented in a network diagram by a node, or point in space. A tie, the relational connection or linkage between two actors, is represented by a line connecting the two nodes. Ties can be directional, if actor A claims a relationship with actor B, an arrow is drawn between the nodes pointing to actor B. If actor B also claims a relationship with A, then the arrow would be bi-directional (Figure 1). Ties can also have values. Binary data (such as yes/no questions) are represented by the presence or absence of a tie. Valued data (such as "on a scale of 1 to 7") gives information on the strength of an existing tie.

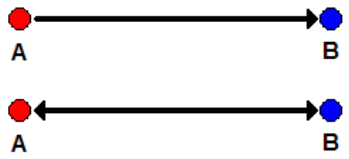


Figure 1. Examples of directional and bi-directional ties.

Social network analysis involves the examination and comparison of ties at many levels: between two nodes (also called a dyad), among and between clusters of nodes (also called cliques), and among all nodes included in the network (Figure 2). The structure of a network can influence the outcomes and characteristics of individual actors because the position of a node in the network can provide both opportunities and constraints. Changes in the pattern of relationships among actors can change the structure of the network and in turn change its outcomes.

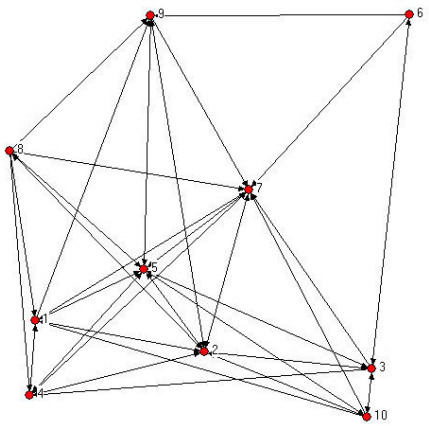


Figure 2. An example of a network diagram (from Hanneman and Riddle).[4]

Social network data also uses matrix algebra to present information since the data may be too complex to see some patterns in a graph. Network diagrams can be represented in this mathematical format and calculations performed to summarize the information on the graph. Figure 3 is the mathematical representation of Figure 2. Traditional statistical measures for social networks are constructed in this manner.

	1	2	3	4	5	6	7	8	9	10
1	0	1	0	0	1	0	1	0	1	0
2	1	0	1	1	1	0	1	1	1	0
3	0	1	0	1	1	1	1	0	0	1
4	1	1	0	0	1	0	1	0	0	0
5	1	1	1	1	0	0	1	1	1	1
6	0	0	1	0	0	0	1	0	1	0
7	0	1	0	1	1	0	0	0	0	0
8	1	1	0	1	1	0	1	0	1	0
9	0	1	0	0	1	0	1	0	0	0
10	1	1	1	0	1	0	1	0	0	0

Figure 3. An example of a network matrix (from Hanneman and Riddle).[4]

Study Overview

The Michigan Department of Community Health (MDCH) established Michigan's Diabetes Outreach Networks (DONs) statewide in 1995 (Figure 4), which were modeled after the first Diabetes Outreach Network founded in Michigan's Upper Peninsula in 1985. The DONs are six regional, community-based organizations with the mission to promote innovative partnerships to strengthen diabetes prevention, detection and treatment throughout Michigan. The DONs accomplish this through initiatives that include: improving access to care, services and supplies; providing consultation for health care systems change; conducting outreach to culturally diverse high-risk populations; and offering educational programs, resources and materials to health care professionals. The foundation of the DONs effectiveness is their collaboration and

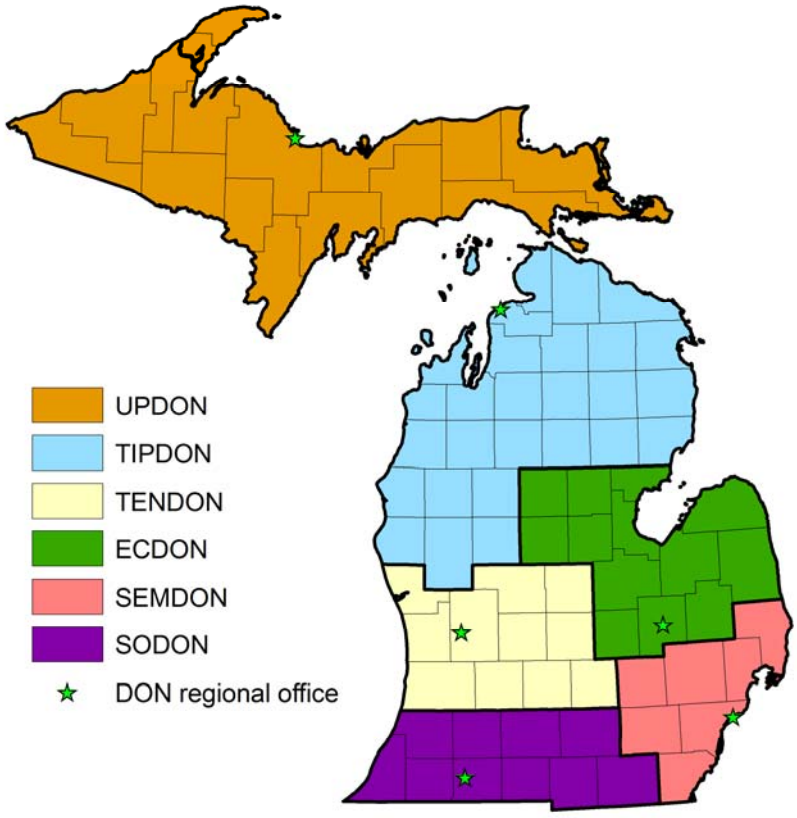


Figure 4. Michigan's Diabetes Outreach Network (DON) regions and office locations (see Appendix A for acronym definitions).

relationship-building across health systems, community organizations, access to care coalitions and other key community partners in their region. Collaborative partnerships in the DON regions have been intentionally cultivated because it is understood that a single organization cannot provide all resources needed for diabetes care and prevention. Rather, multiple partners need to be interconnected and pool assets in a region to more adequately address diabetes care issues. Other research has shown that partnerships among diverse organizations can lead to improved diabetes self-care behavior and health outcomes in the face of limited resources.[5]

Past methods of measuring DON partnerships included quantifying the number of organizations listed in resource directories, surveying resource directory users to determine if needs were met, and quantifying website usage (www.diabetesinmichigan.org). While these methods conformed to the first-level evaluation of the CDC's "Evaluating Partnerships Guide," they do not describe the strength of the relationships built between DONs and their partners. Since the DONs emphasize collaboration as part of their activities and outcomes, there was a need to better assess the partnering efforts of the DONs.

A social network analysis pilot study of the DONs was undertaken to provide a measure of partnerships in each of the six regions. The DON study was highly influenced by the social network study of state tobacco control programs.[6] In the tobacco network study, organizations were interviewed to measure the relationships between public and private agencies that had a common goal of reducing tobacco use. The study of relationships between agencies is referred to as interorganizational social network analysis and differs from other types of network analysis because the focus is on relationships between organizations rather than between individuals.

The interorganizational social network approach has been utilized in public health only recently as the discipline has moved toward looking at a system-level approach when evaluating public health programs.[1] The Agency for Healthcare Research and Quality (AHRQ) has begun to incorporate social network analysis as part of its evaluation studies.[7] American Public Health Association (APHA) conference sessions in recent years have presented several social network models that describe and provide feedback to specific public health networks.[8,9,10,11,12] The system-level network evaluations published in public health journals focus on using findings to illustrate the usefulness of social network analysis as a tool.[6,13,14,15,16]

Objectives

The purpose of the DON pilot study is to: 1) provide a baseline measure of social network variables to measure changes in collaboration over time; 2) identify factors that affect the strength of existing partnerships; and 3) suggest methods for strengthening network partnerships in the future.

Methodology

Data Collection

The directors of the six DON regions were asked to identify partner organizations with whom they worked in Fiscal Year 2006-2007. A partner organization was defined as one "having contributed significantly to diabetes prevention and control in your region or having a unique role in work that might not otherwise be done." Large agencies, such as a hospital or health care system, could potentially have multiple departments identified within the agency as separate partner organizations if each department contributed a unique role to the network. For each

partner organization, a key informant was identified as the representative most familiar with the diabetes work in their organization. Similar studies used a snowball sampling method where the partner organizations are also asked to identify the key partners they work with.[6] However, a decision was made to limit sampling to the boundaries defined by the DON director for a manageable network size for the pilot study.

Informed consent was obtained by all identified partners because the mapping of network ties does not allow for anonymous responses. Partners who signed the informed consent were sent a login name and password to the online network survey tool.[17] The survey tool was 10 questions in length and included measures for the following variables (see Appendix B):

- Frequency of contact
- Strength of relationship tie / level of collaboration
- Referrals made to partners
- Perceived expertise of partners
- Effect of economics on relationships
- Usefulness of DON resources

Network data were available for some non-respondent organizations by using "unconfirmed" contact and relationship ratings from respondent organizations. Unconfirmed data, or data from a dyad where only one partner answered the questionnaire, can provide useful information about impressions of interactions but fall short as an indicator of collaboration.[14] Organizations that declined to participate, or "opted out" on the consent form, were removed from the network and not included in analysis.

Each of the six DON regions was treated as its own separate network with partner organizations only rating other organizations nominated by their regional DON director. Each DON region was then analyzed as separate networks using specialized software, UCINET and NetDraw.[18] Organizations also rated factors that could impact the structure or strength of the regional networks. Finally, factors that affect the strength of existing partnerships used a two-level analysis of variables within each DON (level-1) and across all DONs (level-2).

Table 1. Overview of analysis plan.

Level of Analysis	Measure	Variable Used
Network Analysis – social network statistics	Density	Frequency of contact
	Reciprocity	Level of collaboration
	Indegree Centrality	Level of collaboration
	Betweenness Centrality	Frequency of contact
	Indegree Centrality	Referrals made
	Indegree Centrality	Perceived expertise
Network Ratings – additional network factors	Rating by partners	Perceived economic effect
		Usefulness of DON resources
Hierarchical Linear Modeling (HLM) – factors affecting partnership strength	Level-1 (within DON)	Mean frequency of contact
		Influence of economics on partnerships
		Distance between DONs and partners
		Usefulness of DON resources
	Level-2 (across DONs)	Number of years DON director served
		Number of years DON director in office
		Disruption of DON activities
		Network density

Defining Network Measures

Baseline measures of the DONs were analyzed using common social network statistical measures: density, reciprocity, betweenness, and indegree centrality. What constitutes a "high" or "low" score is relative to both the network and the measure.

Density – This is the proportion of observed relationships among all possible ties, or the interconnectness of a network. A higher density score reflects more ties, which is generally interpreted as a more coordinated network with more opportunities for sharing of information and resources among network partners. Scores for this measure are proportions that range between 0 and 1, which are expressed as percentages in this report.

Reciprocity – While density simply measures whether or not a relational tie exists, reciprocity measures the direction and strength of that tie. For example, A nominates B as a partner with whom they have a strong relationship, and B may also nominate A as a partner with a strong relationship, indicating reciprocity. Conversely, B may not have the same view of the relationship and gives a lower rating or does not acknowledge a relationship with A. If they rate each other similarly, then they will have a high reciprocity score. Scores for this measure are proportions that range between 0 and 1, which are expressed as percentages in this report.

Indegree Centrality – Actors who have more ties have more opportunities because they are have more access to network resources.[4] Indegree centrality is the number of ties an actor has "in-coming" from other actors. These incoming ties indicate network partners are seeking a connection with the actor and therefore represent an actor's importance in a particular area. A

high score indicates higher prestige, or that the actor is "where the action is" in the network. Scores for this measure are standardized as a percentage of maximum possible incoming ties between 0 and 100 percent.

Betweenness Centrality – Betweenness is a common measure for diffusion of information in a network and denotes an actor's value in communication. An actor with a high score lies between other actors and provides the shortest path between those other actors. If an actor with a high betweenness centrality was removed from the network, it would hinder communication between the remaining actors. Scores for this measure are standardized as a percentage of maximum possible betweenness between 0 and 100 percent.

Coding Network Measures

To simplify network analysis, valued data for frequency of contact and level of collaboration were transformed into binary data. While it seems counterintuitive to lose the richness of the collected data, valued network graphs are more difficult to read. Asymmetric ties, where one actor in a dyad indicates a tie is present but the other actor does not, were included in UCINET computational matrices.

Frequency of Contact – This variable was used to calculate density and betweenness centrality. The response categories were *never, annual, bi-annual, quarterly, monthly, weekly,* or *daily.* For analysis purposes, this variable was recoded into a binary variable where *monthly, weekly,* or *daily* contact was considered "Frequent contact" and *never, annual, bi-annual,* or *quarterly* contact was considered "Infrequent contact."[16]

Level of Collaboration – This variable was used to calculate reciprocity and indegree centrality for relationships. The response categories used a previously validated relationship integration scale by Harris et al, 2008:[16]

1) *Not Linked* – We did not work together at all and have separate program goals.
2) *Communication* – We shared information only when it is advantageous to either or both programs.
3) *Cooperation* – We shared information and worked together when an opportunity arose.
4) *Coordination* – We worked side-by-side as separate organizations to achieve common program goals; efforts were coordinated to prevent overlap.
5) *Collaboration* – We worked side-by-side and actively pursued opportunities to work together, but did not establish a formal agreement.
6) *Partnership* – We worked together as a formal team with specified responsibilities to achieve common goals (had a Memorandum of Understanding (MOU) or other formal agreement).
7) *Fully Linked* – We mutually planned and shared staff and/or resources to accomplish common goals.

Actors that reported they never had contact with an organization were assumed to have a *not linked* relationship with that organization. While the scale used by Harris was dichotomized as "Not Linked" and "Linked" with a cutoff between *cooperation* and *coordination*, we found our methods to create network boundaries meant that all of our network relationships were *linked* using this definition. Therefore, we dichotomized our network relationships as "Not Collaborative" and "Collaborative" with the cutoff between *coordination* and *collaboration*.

Referrals Made – This variable also calculates an indegree centrality. However, instead of measuring the importance of an actor in network relationships, it measures the importance of an actor in network referrals. Respondents were asked to select organizations to whom they made referrals. The selection created a binary variable: 1 for "made referral to" and 0 for "no referral made."

Perceived Expertise – The indegree centrality calculated for this variable measures the importance of an actor in providing expert knowledge to network activities. Respondents were asked to select organizations in their network that provided assistance (or expertise) for prevention activities. The selection created a binary variable: 1 for "provided assistance" and 0 for "no assistance."

Coding Additional Network Ratings

Ratings of additional network factors use rater-ratee scores (raters are the actors doing the voting and ratees are the actors receiving the votes). Scores range from zero to the total number of organizations in a network.

Perceived Economic Effect – At the time of the survey, the economic situation in Michigan resulted in budget cuts for many, which had the potential to affect collaboration between network partners. Respondents were asked to rate the effect of the economic situation on their relationships with other partner organizations. Ratings were averaged over the entire network (rater score) and then specifically for the DON office (ratee score).

Usefulness of DON Resources – The DONs provide many resources to people in their network. Respondents were asked to rate the usefulness of ten resources. In this case, the resources themselves are considered the ratee. Ratings for each resource were averaged across all organizations.

Defining Hierarchical Linear Modeling

Factors that affect the strength of existing partnerships were analyzed using two-level Hierarchical Linear Modeling (HLM). HLM is a specialized statistical technique that is designed to simultaneously analyze data from different hierarchical levels to explain an observed outcome. In social research and other fields, data often have a hierarchical structure.[19] That is, individuals may be arranged in groups that have qualities that are influential to the outcome, which in turn may be nested in other groups that have their own influential qualities. The DON data are arranged in a hierarchical structure, with interactions between organizations as one level nested in a DON region with unique characteristics as another level.

Various published studies explore networking activities and the effectiveness of collaboration in interorganizational relationships, but most focus on descriptive analysis (such as network size, centrality and density). Few of them used inferential statistics, such as HLM, to predict how characteristics of networks can affect the strength of relationships built.

Coding the Hierarchical Linear Model

Specialized software called "HLM" was used for this analysis.[20] The full maximum likelihood estimation method was used to take advantage of the model comparison testing feature.

Modeling begins with an "empty" model, or one with no level-1 or level-2 variables, to determine how much variance is explained by the DON regions alone. Level-1 and level-2 variables are added to the model in a "step-up" approach based on what might logically explain variation and on the significance of variables already in the model. Unlike the baseline network measures, "unconfirmed" non-respondent organizations are not included in this analysis.

The dependent variable of the model, the outcome we are interested in, is the mean strength of collaborative relationship between DONs and their network partners (a dyadic score). This is defined as the average score of the collaboration rating given by the DON office of the network partner and the rating given by the partner of the DON office.

Level-1 predictors of the model describe the different attributes of the ties that could affect the relationship between DONs and their partners:

- *Mean frequency of contact* – The average score of the contact frequency rating given by the DON office of the network partner and the rating given by the partner of the DON office. This score used the 1 to 7 scale rather than the dichotomized scale used in the network analysis.
- *Influence of fiscal condition in Michigan* – The average score of the "effect of the economic conditions in the state" rating given by the DON office of the network partner and the rating given by the partner of the DON office.
- *Geodesic distance between DONs and partners* – Office locations were plotted in latitude/longitude coordinates and "as the crow flies" distance was calculated in miles between the DON office and each network partner office (using ArcGIS).

- *Usefulness of DON resources* – Ten resources were rated by network partners (DON offices could not rate their own resources). The average rater score across the ten resources was calculated for each network partner.

Level-2 units of the model describe attributes of the DON offices themselves that could affect the relationship between DONs and their partners:

- *Number of years DON director served* – Since interorganizational relationships are typically relationships among people in organizations, it was thought that the number of years the DON director had been serving would affect the stability of network relationships. This would also impact the DON's ability to identify network partners and appropriately rate them.
- *Number of years DON office in service* – The length of time the DON office has been operational could affect network variables. This variable was given a binary code where 1 represented UPDON which had been operational for 22 years, and 0 represented the remaining DONs which had been in operation for 12 years.
- *Disruption of DON activities* – At the time of the survey, the economic situation in Michigan resulted in budget cuts that caused a disruption of activities for some DONs. The number of months in the survey year that the DON office was in operation was coded for this variable.
- *Network density* – The proportion of observed relationships among all possible relationships. This measure comes from the UCINET output.

Results

Response Rate

In theory, network analysis needs near 100% response for the most accurate results. However, in application it is rare to reach such a high response rate from a survey-based methodology. UPDON had the highest response rate with 81% of identified partners answering the survey.

Table 2. Response rates for DON regions.

	Network Size	# of Respondents	Response Rate
UPDON	58	47	81%
TIPDON	60	43	72%
TENDON	32	15	47%
ECDON	18	7	39%
SEMDON	25	10	40%
SODON	15	8	53%

Network Measures

Relationship density was measured using contact frequency. None of the DONs have an overly high density score (Table 3). UPDON has the highest density with 10% out of a possible 100%. These scores indicate the networks are not very interconnected. This may demonstrate that DONs are successfully connecting community partners that would otherwise have no relationship.

Table 3. Network density for DON regions.

UPDON	TIPDON	TENDON	ECDON	SEMDON	SODON
10.3%	6.1%	5.8%	5.6%	5.2%	6.2%

Reciprocity was measured using a count of dyads that had the same collaboration rating between the partner and the DON out of all possible pairs of ties. In UPDON, 37% of the partners agreed with the relationship level the UPDON director gave (Table 3). TIPDON and TENDON had 27% and 23% of partners agree with the characterization of their relationship. These reciprocity estimates indicate that some partners were likely to overstate some relationships and understate others. The remaining DONs lacked enough response to create bi-directional relationships and could not produce a reliable reciprocity estimate.

Table 4. Symmetric reciprocity of relationship between the DON and network partners.

UPDON	TIPDON	TENDON	ECDON	SEMDON	SODON
37.3%	26.8%	23.1%	--*	--*	--*

* The network was not robust enough to produce a reliable statistic.

Freeman indegree centrality was used to determine the prestige of DONs within their network relationships. Relationship level (collaborative/not collaborative) was used as the model input. UPDON, TIPDON, TENDON and SODON were the most prominent actors in their networks, or the actor with the highest level of "collaborative" ties from their partners. In the other cases, the DON shared a prominent role with other highly influential partners.

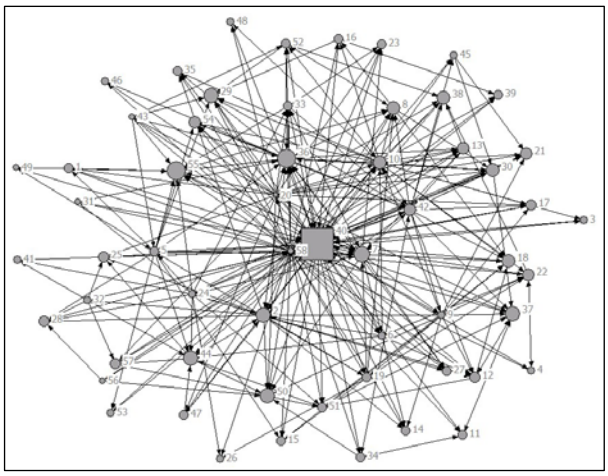
- UPDON was clearly the most prominent actor in its network with 42% of partners declaring a collaborative relationship with them. Other prominent actors included the UPDON Advisory Council (23%), Medical Care Association Coalition (21%), and Family Care Doctors (18%).
- TIPDON was clearly the most prominent actor in its network with 22% of partners declaring a collaborative relationship with them. Other prominent actors included

District Health Department #10 (12%), Let's Get Moving Northern Michigan (10%), Northwestern Community Health Agency (10%), North Central Council of the Michigan Hospital Association (10%), and the Alpena Regional Medical Center (10%).

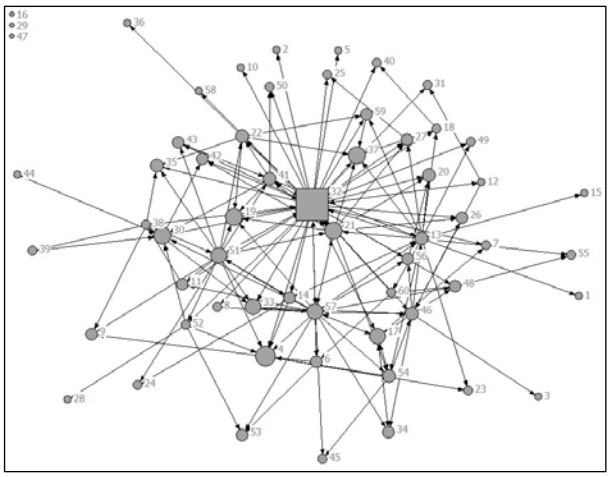
- TENDON was clearly the most prominent actor in its network with 29% of partners declaring a collaborative relationship with them. Other prominent actors included Allegan General Hospital (16%) and the Kent County Health Department (12%).
- ECDON was equally as prominent as the Greater Flint Health Coalition with 12% of partners declaring a collaborative relationship with them. No other prominent actors were noted.
- SEMDON was equally as prominent as the REACH Detroit Partnership – Community Health and Social Services with 13% of partners declaring a collaborative relationship with them. Other prominent actors included the Detroit Public Health Department (8%) and the Joy Southfield Health and Education Center (8%).
- SODON was the only prominent actor noted with 21% of partners declaring a collaborative relationship with them.

NetDraw was used to create network diagrams for overall network importance using indegree centrality (Figure 5). The nodes are represented by circles for the network partners and a square for the DON. Directional ties are seen between nodes that are "collaborative." It is worth noting that actors may be communicating at some level, but the relationship may not be categorized as "collaborative." Nodes that are "not collaborative" with any other partner are listed in the upper left corner of the diagram. The size of the node indicates the indegree score for the actor.

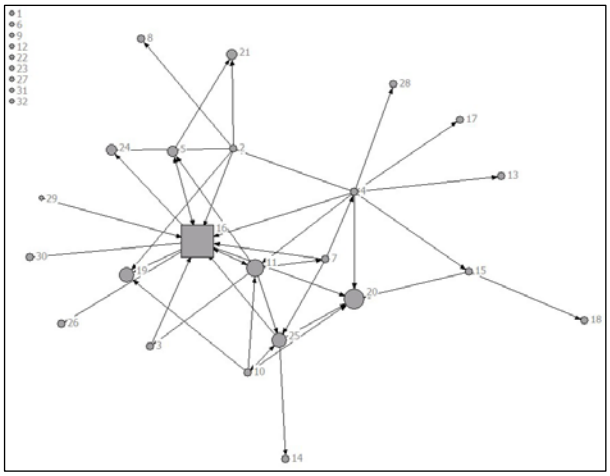
Figure 5. Indegree Centrality Network Diagrams.



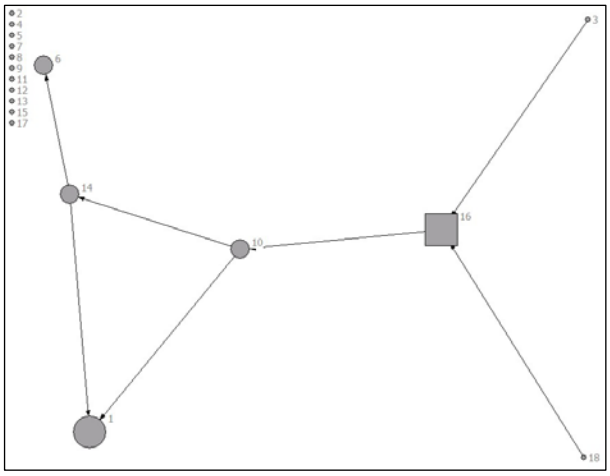
UPDON



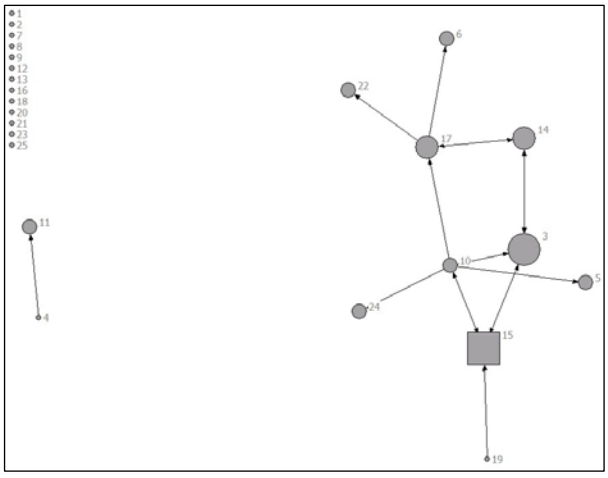
TIPDON



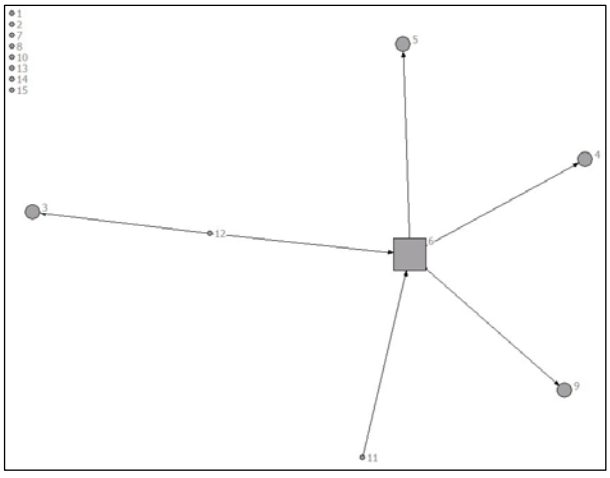
TENDON



ECDON



SEMDON



SODON

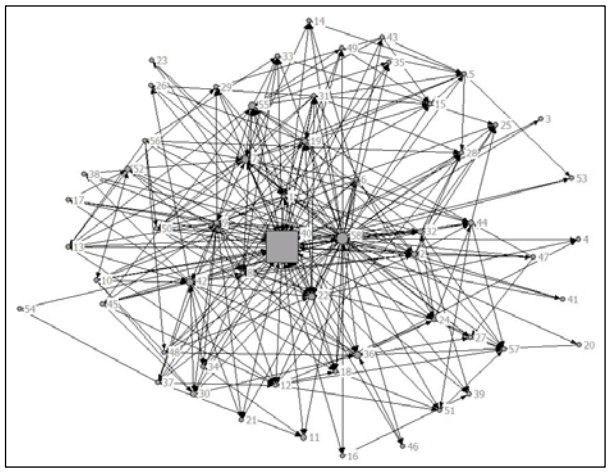
Freeman betweenness centrality was used to determine the flow of information in the networks. Contact frequency (linked/not linked) was used as the model input. UPDON and TIPDON have the highest network betweenness and therefore the best flow of information (Table 5). Lower betweenness scores may indicate communication in these networks could happen without the DON acting as an intermediary. However, in all six networks, the DONs had the highest measure of betweenness, indicating they are currently the most important connection for the flow of information between partners.

Table 5. Network Centralization Scores (Betweenness) for DON office.

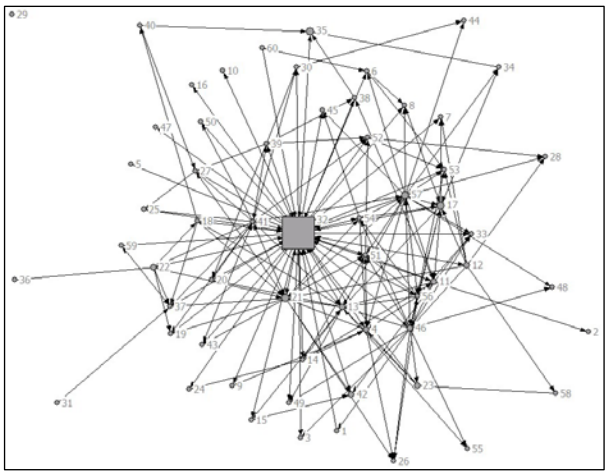
UPDON	TIPDON	TENDON	ECDON	SEMDON	SODON
38.5%	36.5%	17.6%	7.1%	5.1%	15.1%

NetDraw was used to create network diagrams for betweenness centrality (Figure 6). The nodes are represented by circles for the network partners and a square for the DON. Directional ties are seen between nodes that are "linked." Nodes that are "not linked" to any other partner are listed in the upper left corner of the diagram. The size of the node indicates the betweenness score for the actor and DONs are 2-10 times more influential in communication than the next highest ranked partner in their network.

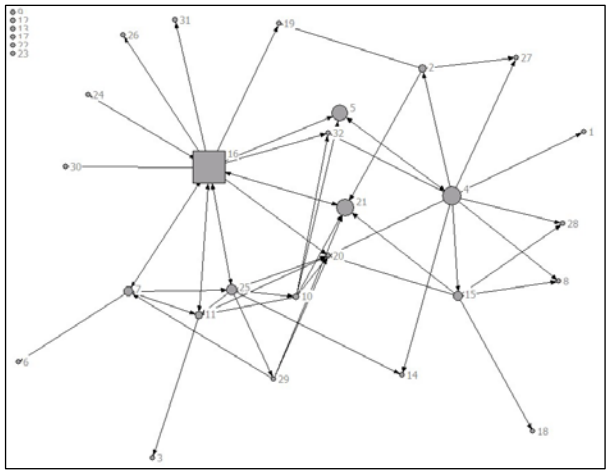
Figure 6. Betweenness Centrality Network Diagrams.



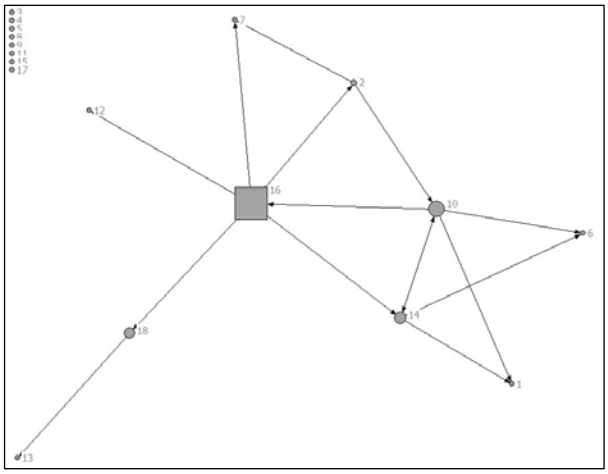
UPDON



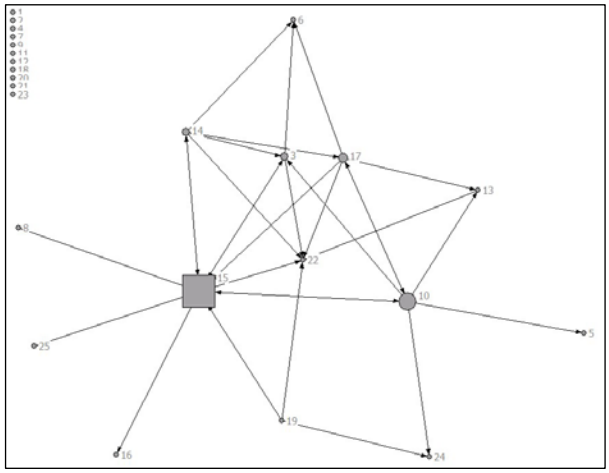
TIPDON



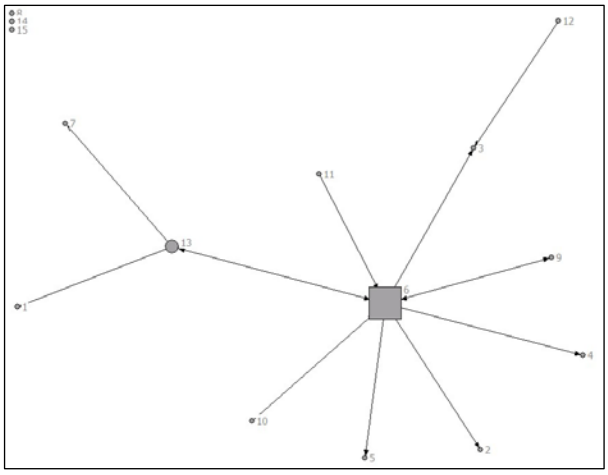
TENDON



ECDON



SEMDON



SODON

Freeman indegree centrality was used to determine the importance of an actor in network referrals. Actors with high scores were likely perceived as having access to necessary resources to assist clients. UPDON, TIPDON and SODON received the highest percentage of referrals from partners in their networks.

- UPDON had 58% of partners making referrals to them. The Medical Care Access Coalition had the next highest score with 35% of partners making referrals to them.
- TIPDON had 37% of partners making referrals to them. Let's Get Moving Northern Michigan had the next highest score with 34% of partners making referrals to them.
- In TENDON's region, the American Diabetes Association had the highest score with 32% of partners making referrals to them. TENDON had the next highest score with 26% of partners making referrals to them.
- In ECDON's region, Hamilton Community Health Services had the highest score with 29% of partners making referrals to them. ECDON tied for the next highest score with Hurley Diabetes Center with 18% of partners making referrals to them.
- In SEMDON's region, the American Diabetes Association had the highest score with 29% of partners making referrals to them. SEMDON tied for the next highest score with the Detroit Public Health Department and AIM-HI with 21% of partners making referrals to them.
- SODON had 29% of partners making referrals to them. Bronson Hospital, Borgess Hospital and the Battle Creek Health System tied for the next highest score with 21% of partners making referrals to them.

Freeman indegree centrality was used to determine the importance of an actor in providing assistance or expertise with network activities. Actors with high scores were likely perceived as holding expert knowledge needed for execution of activities. All of the DONs had the highest percentage of partners connecting to them for assistance in activities, although SEMDON was tied for the high score.

- UPDON had 65% of partners connecting to them for activity assistance. The UPDON Advisory Council had the next highest score with 33% of partners connecting to them for activity assistance.
- TIPDON had 56% of partners connecting to them for activity assistance. Let's Get Moving Northern Michigan had the next highest score with 15% of partners connecting to them for activity assistance.
- TENDON had 35% of partners connecting to them for activity assistance. The American Diabetes Association had the next highest score with 23% of partners connecting to them for activity assistance.
- ECDON had 35% of partners connecting to them for activity assistance. Hamilton Community Health Services had the next highest score with 18% of partners connecting to them for activity assistance.
- SEMDON was tied for the highest rank with the American Diabetes Association with 21% of partners connecting to them for activity assistance. The American Heart Association had the next highest score with 17% of partners connecting to them for activity assistance.

- SODON had 36% of partners connecting to them for activity assistance. Borgess Hospital had the next highest score with 21% of partners connecting to them for activity assistance.

Additional Network Ratings

Network partners were asked how they felt the economic situation in the State of Michigan affected their relationship with other network partners. Respondents rated the level of impact for each partner on a scale of 1 (Not Much) to 7 (A Lot). SODON experienced a 3-month disruption in services and received a score from their partners that fell in the "Somewhat High" impact range of the scale (Table 6). When SODON's partners rated the perceived effect on all of their network relationships, the score was in the "Somewhat Low" impact range but higher than what was seen in other networks. It is possible this score reflects the temporary closure of SODON may have been the beginning of an impact on communication and relationships throughout the network. ECDON experienced a 2-month disruption in services and also received a score from their partners that fell in the "Somewhat High" impact range; however, the overall network response was not similar to SODON.

Table 6. Perceived impact of economic situation on relationships with the DON and with the overall regional network, on a scale of 1 (Not Much) to 7 (A Lot).

	Averaged Regional Rating					
	UPDON	TIPDON	TENDON	ECDON	SEMDON	SODON
With the DON	3.27	2.67	3.23	5.00	2.50	5.29
Overall Network	2.50	2.51	2.95	2.65	2.41	3.26

Network partners were asked to rate the usefulness of resources provided by the DONs. DONs could not rate their own resources. Respondents rated the usefulness of each resource on a scale of 1 (Not Useful) to 7 (Very Useful). Respondents were instructed to leave blank any resource they did not use. Across all DONs, most resources received an average rating score that ranged from "Neutral" to "Somewhat Useful" (Table 7), indicating that many resources that DONs provide are used by the network partners. Certain resources are likely more strongly used by some types of partner organizations than others. While there were some regional variation, resources top ranked by network partners included professional education opportunities, website/online resources, and outreach to the public/consumers.

Table 7. Averaged rating for DON resources across all regions, on a scale of 1 (Not Useful) to 7 (Very Useful).

Resource	Rating Received
Professional education opportunities	5.35
MDON website	5.20
Online educational handouts	5.13
Education of public/consumers	5.13
Online resource directories	4.96
Self-management programs (PATH, DSMT)	4.87
Support groups	4.84
1-on-1 consultation	4.43
Physical activity initiatives	4.40
Access to care coalitions	3.98

Hierarchical Linear Model

The results of "empty" model, the model with no variables, shows the DON regions alone explain 14% of the variability in relationship strength (see Appendix C for final models). This suggests collaborative relationships are not independent and there are differences by DON region, which isn't surprising since there are known regional differences in availability of resources and organizations available to partner with. When contact frequency was added to the model, it was a significant variable and also produced a significant improvement over the "empty" model ($p < 0.001$). The addition of other level-1 variables with contact frequency was not significant. When level-2 variables were added to the model, the number of years DON director served, the number of years DON office was in service, and the network density were all significant – just not all at the same time. This is because these level-2 variables are highly correlated (multicollinear) and are therefore functionally equivalent in the model. In other words, any one of the significant level-2 variables could be used interchangeably in the model.

A non-significant model is also of some interest. When the influence of fiscal conditions in Michigan was added to the model as the only level-1 variable, the variable was nearly significant ($p < 0.054$) and the improvement over the "empty" model was also nearly significant ($p < 0.066$). The economic situation impacted DON activities at some level for roughly 3 months of the survey year. The question is whether this model would have been significant had the fiscal impact been longer.

Discussion

Findings

Interorganizational social network analysis confirms the DONs are central figures in the regional work of diabetes prevention and control. Well-established DONs show a higher density of partners and greater number of connections between partner organizations. DONs are highly influential in their networks and removal of well-established DONs from the network would hamper the exchange of information and resources within the network. It was expected that regional differences could be explained by the characteristics used in the Hierarchical Linear Model.

Within each network, frequency of contact plays a key role in predicting collaborative strength. DONs who reported less contact with their partners on average (rater scores) compared to other DONs had lower network scores. The distance between the DON offices and their partner offices did not have any effect on collaboration. This is a positive result since it indicates all partners are given equal consideration and that DONs are not focusing on the "low-hanging fruit" or partners closest to them. The resources provided by DONs, while used by partners, also did not affect collaboration.

At the regional level, measures of network continuity explain regional differences in collaborative strength. DONs that had been in existence longer or had a director who served longer had higher network scores. However, these factors cannot always be controlled and are therefore difficult to change. The best opportunity for addressing differences in regional collaboration is to improve network density. Making changes to the pattern of relationships

(how partners interact) can change the structure of the network and, in turn, change network scores.

Baseline measures were collected during the initial period of cuts to the Healthy Michigan Funds. Survey measures and other observational data were used to try to determine what impact, if any, cuts to DON funding had on the networks as a whole. While it is difficult to definitively say how the cuts impact networks given the limited data, it appears that the longer the DON office is closed, the more likely the entire network communication is affected. The near significance of fiscal issues in the HLM model also lends weight to this argument. This has implications in terms of future funding. It would seem to be preferable to have the DON office operating under a minimal set of tasks rather than closing the office and severing relationships with partners.

Next Steps

All DONs should emphasize frequent contact with their partners to strengthen existing collaborative relationships. Additionally, DONs should improve opportunities for their partners to better communicate with each other, such as advisory councils, to improve network density. However, it should be noted that the optimal density for a community network is unknown.[15] As the number of ties increases, the maintenance of relationships may become too time consuming and costly for network partners.[21] DONs will be challenged to find a balance of the number and type of network relationships needed, although most DONs can aim to match the density that was seen in UPDON. On the other side of the coin, UPDON should use care in potentially

expanding its network density. It has been found that lower-density networks may be more efficient for organizing evidence-based prevention programs in communities.[15]

As DONs prioritize work goals, they should give special attention to the resources that are top-ranked by their network partners and work to preserve professional education opportunities, online resources and outreach to the public/consumers. Since the highest ranked resources only received a "Somewhat Useful" rating across all partners, it might be useful if DONs conducted a needs assessment in their region. Such an assessment would help to determine whether there is a need for additional resources that would be more useful to network partners.

Although a baseline network analysis is useful in demonstrating the extent of collaboration among organizations, its greater value lies in tracking progress of building community capacity over time.[14] It is recommended that the network survey for the DONs be repeated for Fiscal Year 2011-2012. MDCH and DON offices will document circumstances that occur in the interim that may need to be considered in the next network analysis.

Limitations

Many of the results drawn from the analysis, and the conclusions made from them, are limited by the response rate of the network. The main question to ask is whether we would reach the same conclusions if a different cross-section of the same number of partners answered. In most networks, the non-respondent partners were rated on average by the DONs as having lower contact frequency than the respondent partners. This is particularly important given the results of the HLM model, which conclude that the strength of relationships is dependent on contact

frequency. In a sense, non-response could be viewed as an indicator of lower collaborative relationships in the network. UPDON and TIPDON are likely to see similar network results in a different cross-section of respondents given their high network response rates. Also, the contact frequency of their non-respondents is more similar to their respondents than is seen in other networks.

Recall bias could have played a role in answering the questionnaire. All questions asked the respondent to think about the previous fiscal year when answering. There were anecdotal reports that some respondents had difficulty differentiating current year activities from the previous year. Additionally, turnover of staff at both the DON and the partner organizations were higher in some regions than others. Some respondents may have lacked the historical knowledge to appropriately answer the questions.

A more serious limitation lies in the ability of networks to use the data from the pilot baseline network survey. The timing of the survey and report means the data from the network study is two years old. The networks likely have already changed and the findings may not be as relevant as they would have been if the networks had been given more immediate feedback.[14]

Appendix A – Michigan Diabetes Outreach Networks Acronym List

UPDON – Upper Peninsula Diabetes Outreach Network

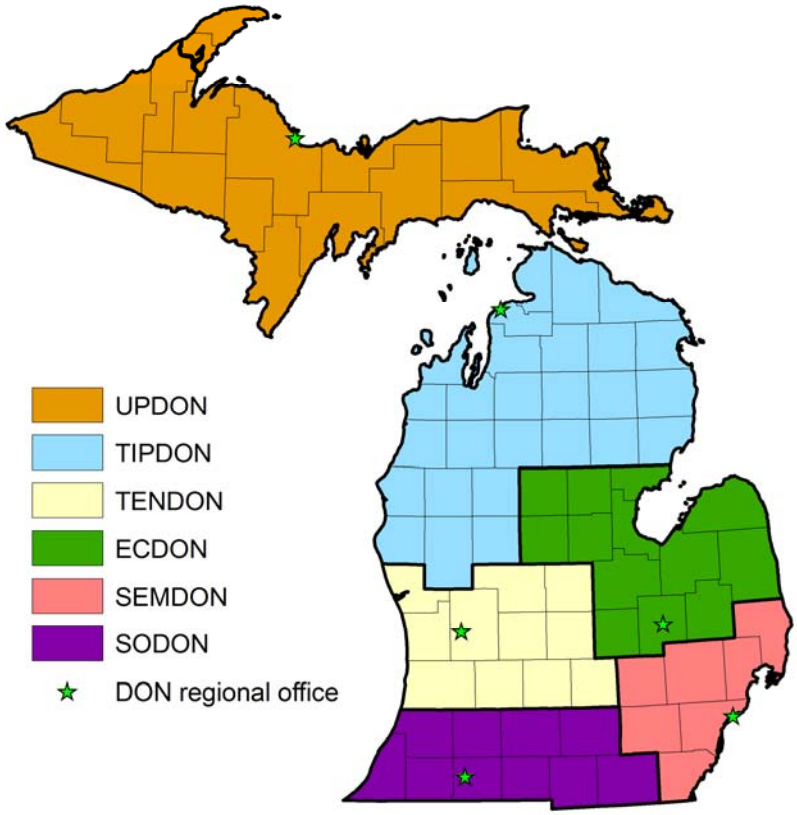
TIPDON – Northern Michigan Diabetes Outreach Network

TENDON – Ten Counties in Central & Western Michigan Diabetes Outreach Network

ECDON – East Central Diabetes Outreach Network

SEMDON – SouthEast Michigan Diabetes Outreach Network

SODON – Southern Michigan Diabetes Outreach Network



Appendix B – Network Survey Questionnaire Tool

Social Network Analysis of the Michigan Diabetes Outreach Networks Questionnaire Tool

Introduction

Thank you for participating in this social networking survey for organizations helping people with diabetes or those at risk. Some questions will ask about "prevention activities", which may include but are not limited to:

* Primary prevention -- focusing on obesity, physical activity, nutrition, smoking cessation, and access to affordable health care; and
* Secondary or tertiary prevention -- focusing on screening people for diabetes and prediabetes, self-management education, access to diabetes medications and testing supplies, and access to appropriate health care to prevent and treat diabetes complications.

Many questions will ask you to give a rating. Some questions will have a specific rating scale listed under the question where it defines what each numeric value means. When these scales are given, please use them to guide your answers. You may select a rating by either clicking on the scale bar for the desired number or by "grabbing" the diamond-shaped marker and dragging it with your mouse. The numeric value will display next to the rating bar after you select an answer.

Some additional information is available in the "More Help" section at the upper right corner of each question.

If you need to stop the survey and continue at another time, click the 'logout' text in the upper right corner of the screen and answer 'yes' to saving changes.

Contact

1. Between October 2006 and September 2007, on average, how often did you have contact with the following organizations? Contact can be meetings, phone calls, or emails.

	Never	Annual	Biannual	Quarterly	Monthly	Weekly	Daily
List organizations	❍	❍	❍	❍	❍	❍	❍
	❍	❍	❍	❍	❍	❍	❍

No Contact

2. For the organizations that you said you did not have contact with between October 2006 and September 2007, please comment on those you would like to start a relationship with, or have perhaps started a relationship since September 2007.

List subset organizations	❑
Where Q1 = "Never"	❑

Relationship

3. How would you describe your relationship with the following organizations between October 2006 and September 2007?

Not linked	We did not work together at all and have separate program goals.
Communication	We shared information only when it is advantageous to either or both programs.
Cooperation	We shared information and worked together when an opportunity arose.
Coordination	We worked side-by-side as separate organizations to achieve common program goals; efforts were coordinated to prevent overlap.
Collaboration	We worked side-by-side and actively pursued opportunities to work together, but did not establish a formal agreement.
Partnership	We worked together as a formal team with specified responsibilities to achieve common goals (had a Memorandum of Understanding (MOU) or other formal agreement).
Fully linked	We mutually planned and shared staff and/or resources to accomplish common goals.

	Not Linked	Communication	Cooperation	Coordination	Collaboration	Partnership	Fully Linked
List subset organizations	❍	❍	❍	❍	❍	❍	❍
Where Q1 ≠ "Never"	❍	❍	❍	❍	❍	❍	❍

Refer To

4. Between October 2006 and September 2007, which organizations did you refer people TO?

List subset organizations	❑
Where Q1 ≠ "Never"	❑

Refer From

5. Between October 2006 and September 2007, which organizations did you get referrals FROM?

List subset organizations	❑
Where Q1 ≠ "Never"	❑

Appendix B – Network Survey Questionnaire Tool

Experts

6. Between October 2006 and September 2007, which of the following organizations provided assistance and/or expertise to your prevention activities?

List subset organizations	❑
Where Q1 ≠ "Never"	❑

Fiscal

7. Between October 2006 and September 2007, how did the economic situation in the State of Michigan affect your organization's relationship with other regional organizations?

	Not Much A Lot
List subset organizations	❍------❍------❍------❍------❍------❍------❍
Where Q1 ≠ "Never"	❍------❍------❍------❍------❍------❍------❍

Resources

8. Listed below are some of the resources provided by the Diabetes Outreach Networks. Please rate each resource on it's usefulness to your organization. You may leave blank any resource that you have not used.

	Not Useful Very Useful
Access to Care Coalitions	❍------❍------❍------❍------❍------❍------❍
Diabetes Support Groups	❍------❍------❍------❍------❍------❍------❍
Education of the Public/Consumers	❍------❍------❍------❍------❍------❍------❍
One-on-one Professional Consultation	❍------❍------❍------❍------❍------❍------❍
Online Diabetes Resource Directories	❍------❍------❍------❍------❍------❍------❍
Online Educational Handouts	❍------❍------❍------❍------❍------❍------❍
Physical Activity Initiatives	❍------❍------❍------❍------❍------❍------❍
Professional Education Opportunities	❍------❍------❍------❍------❍------❍------❍
Self-Management Programs (DSMT, PATH)	❍------❍------❍------❍------❍------❍------❍
www.diabetesinmichigan.org website	❍------❍------❍------❍------❍------❍------❍

Misc

9. How many years have you worked with your local Diabetes Outreach Network? _____

10. Is there anything else you would like to tell us?

Save

Your survey will be completed once you click 'save and logout'; however, you can come back later and edit your answers if you wish.

Thank you for your time!

Appendix C – Final Hierarchical Linear Model Equations and Results

Empty Model: No variables entered

Level-1

$Y = \beta 0 + r$

Level-2

$\beta 0 = \gamma 00 + \mu 0$

Fixed Effect	Coefficient	Std Error	T-ratio	df	p value
Intercept	4.484860	0.201492	22.258	5	0.000

$\sigma^2 = 0.99527$
$\tau = 0.16303$
ρ (ICC) = 0.140749

Deviance = 331.465057
Est. Parameters = 3

Contact Model: Mean frequency of contact entered

Level-1

$Y = \beta 0 + \beta 1*(CONTACT) + r$

Level-2

$\beta 0 = \gamma 00 + \mu 0$

$\beta 1 = \gamma 10$

Fixed Effect	Coefficient	Std Error	T-ratio	df	p value
Intercept	1.020466	0.414488	2.462	5	0.056
CONTACT	0.764714	0.085985	8.894	113	0.000

$\sigma^2 = 0.60532$
$\tau = 0.05175$
ρ (ICC) = 0.078759

Deviance = 271.931119
Est. Parameters = 4
Model comparison $\chi^2 = 59.53394$ (df = 1, $p < 0.001$)

Contact + Density Model: Mean frequency of contact and network density entered

Level-1

$Y = \beta 0 + \beta 1*(CONTACT) + r$

Level-2

$\beta 0 = \gamma 00 + \gamma 01*(DENSITY) + \mu 0$

$\beta 1 = \gamma 10$

Appendix C – Final Hierarchical Linear Model Equations and Results

Fixed Effect	Coefficient	Std Error	T-ratio	df	p value
Intercept	0.209801	0.425895	0.493	4	0.648
DENSITY	0.138158	0.034836	3.966	4	0.026
CONTACT	0.734345	0.084540	8.686	112	0.000

$\sigma^2 = 0.58538$ Deviance = 262.937299
$\tau = 0.00002$ Est. Parameters = 5
ρ (ICC) = 0.000034 Model comparison $\chi^2 = 8.99382$ (df = 1, p = 0.003)

Contact + Years Model: Mean frequency of contact and years of DON director entered

Level-1

$Y = \beta0 + \beta1*(CONTACT) + r$

Level-2

$\beta0 = \gamma00 + \gamma01*(YEARS) + \mu0$

$\beta1 = \gamma10$

Fixed Effect	Coefficient	Std Error	T-ratio	df	p value
Intercept	0.857495	0.394441	2.174	4	0.092
YEARS	0.054616	0.014187	3.850	4	0.029
CONTACT	0.731752	0.085138	8.595	112	0.000

$\sigma^2 = 0.58946$ Deviance = 263.735758
$\tau = 0.00003$ Est. Parameters = 5
ρ (ICC) = 0.000051 Model comparison $\chi^2 = 8.19536$ (df = 1, p = 0.004)

Contact + History Model: Mean frequency of contact and years of DON office service entered

Level-1

$Y = \beta0 + \beta1*(CONTACT) + r$

Level-2

$\beta0 = \gamma00 + \gamma01*(HISTORY) + \mu0$

$\beta1 = \gamma10$

Appendix C – Final Hierarchical Linear Model Equations and Results

Fixed Effect	Coefficient	Std Error	T-ratio	df	p value
Intercept	0.998438	0.394078	2.534	4	0.062
HISTORY	0.612376	0.152765	4.009	4	0.025
CONTACT	0.739983	0.084057	8.803	112	0.000

$\sigma^2 = 0.58387$
$\tau = 0.00002$
ρ (ICC) = 0.000034

Deviance = 262.638713
Est. Parameters = 5
Model comparison $\chi^2 = 9.29241$ (df = 1, p = 0.003)

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