



Community partnerships in healthy eating and lifestyle promotion: A network analysis

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ARTICLE INFO

Article history:

Received 29 November 2016

Received in revised form 7 February 2017

Accepted 13 March 2017

Available online 24 March 2017

Keywords:

Community networks

Diet

Life style

ABSTRACT

Promoting healthy eating and lifestyles among populations with limited resources is a complex undertaking that often requires strong partnerships between various agencies. In local communities, these agencies are typically located in different areas, serve diverse subgroups, and operate distinct programs, limiting their communication and interactions with each other. This study assessed the network of agencies in local communities that promote healthy eating and lifestyles among populations with limited resources. Network surveys were administered in 2016 among 89 agencies located in 4 rural counties in Michigan that served limited-resource audiences. The agencies were categorized into 8 types: K-12 schools, early childhood centers, emergency food providers, health-related agencies, social resource centers, low-income/subsidized housing complexes, continuing education organizations, and others. Network analysis was conducted to examine 4 network structures—communication, funding, cooperation, and collaboration networks between agencies within each county. Agencies had a moderate level of cooperation, but were only loosely connected in the other 3 networks, indicated by low network density. Agencies in a network were decentralized rather than centralized around a few influential agencies, indicated by low centralization. There was evidence regarding homophily in a network, indicated by some significant correlations within agencies of the same type. Agencies connected in any one network were considerably more likely to be connected in all the other networks as well. In conclusion, promoting healthy eating and lifestyles among populations with limited resources warrants strong partnership between agencies in communities. Network analysis serves as a useful tool to evaluate community partnerships and facilitate coalition building.

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1. Introduction

Promoting healthy eating and lifestyles among populations with limited resources is a complex undertaking that often requires strong partnerships between various agencies within a community, such as health care service providers, social resource centers, emergency food suppliers, schools, and housing complexes (Merzel and D'Afflitti, 2003). In rural communities, these agencies are typically located in different geographic areas, serve diverse subgroups, and operate distinct programs that do not necessarily have the primary focus of healthy eating, which may limit their communication and interaction (Roussos and Fawcett, 2000). Assessing the network of these community-rooted agencies can be crucial for documenting existing connections, quantifying coalition-building efforts, identifying strengths and weaknesses of partnerships, and informing future endeavors to promote inter-agency collaboration and integration (Grills et al., 2014). By building the capacity of the network and strengthening partnerships between agencies, it may reduce the duplication of services while increasing access of

resources, such as human capital, to provide more effective services to low-income populations. (National Cancer Institute, 2007).

Network analysis is a research methodology for investigating inter-entity structures through the use of network and graph theories (Martínez-López et al., 2009). During the past decade, many tools and applications have been developed to facilitate the adoption of network analysis on mapping, measuring, and modeling interrelationships between various social entities (e.g., people, groups, and organizations) (Ioana-Alexandra, 2013). Network analysis characterizes interlinked structures in terms of nodes (e.g., agencies in local communities) and the connecting ties or edges (relationships or interactions) (Martínez-López et al., 2009). In public health research, network analysis has been widely performed to examine disease transmission, information diffusion, role of social support and social capital, impact of personal and social networks on health and risk behavior, and inter-organizational structure of health care systems (Luke and Harris, 2007). For example, network analysis has been adopted to assess the collaboration among partners working in state tobacco control programs and active living promotion programs (Buchthal et al., 2013; Harris et al., 2008).

Our survey focused on 2 major USDA-funded programs in Michigan: Supplemental Nutrition Assistance Program Education (SNAP-E)—a

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nutrition education program available to SNAP recipients and other limited-resource individuals and families, and the Expanded Food and Nutrition Education Program (EFNEP)—an education program for limited-resource audiences that provides knowledge and skills needed to eat a nutritious diet and to live a healthy lifestyle. SNAP-Ed and EFNEP target audience from local communities where they live. One main strategy to ensure participation is to collaborate with other community organizations that community members frequently visit. Given this program delivery model, the effectiveness and long-term growth of SNAP-Ed and EFNEP in Michigan highly depends upon a healthy and constructive relationship with other local agencies. This study aimed to: (1) document and map community partnership structure; (2) quantify the level of inter-agency connection; (3) measure the degree of centralization in the network; and (4) evaluate the relationships between different types of agencies in a network and between different networks. Application of network analysis has the potential of bringing unique insights on network structure that may not be readily revealed by conventional survey and analytic procedures.

We hypothesized that: (1) agencies in local communities are loosely connected with low network density; (2) agencies in a network are decentralized rather than centralized around one or a few influential agencies; (3) agencies of the same type are more likely to be connected compared to agencies of different types in a network; and (4) agencies that are linked in one network (e.g., communications network) are more likely to be linked in other networks as well (e.g., funding network).

2. Methods

2.1. Participating agencies

Participating agencies were located in 6 Michigan counties, including Allegan, Ingham, Isabella, Muskegon, Tuscola, and Van Buren. Due to the low response rates in Ingham (44%) and Muskegon (51%), data collected in these two counties was excluded from network analysis. Table 1 summarizes the number and types of agencies in each of the remaining 4 counties that were included in the network analysis. All 4 counties are located in rural areas where Non-Hispanic whites are the majority (82.7% to 94.3%). Most residents (86.3% to 91.1%) have high-school or higher education, and the poverty rates range from 11.2% to 26.1%. A total of 20, 31, 26, and 20 agencies located in Allegan, Isabella, Tuscola, and Van Buren were selected to participate into the network survey, in which 18 (90%), 26 (84%), 26 (100%), and 19 (95%) completed the survey, respectively. Fig. 1 highlights the locations of these 4 counties in the Michigan county map.

Eligible participating agencies were chosen using a two-stage selection process. First, a comprehensive list was compiled of all agencies in the relevant county that served nutrition- and/or health-related needs of SNAP-Ed eligible populations, defined as those at or below 185% of the federal poverty level (FPL). Listed agencies were classified into 8 main categories: K-12 schools, early childhood centers, emergency food providers, health-related agencies, social resource centers, low-income/subsidized housing complexes, continuing education organizations, and other miscellaneous agencies that serve low-income populations. Second, a case-by-case examination of listed agencies against the SNAP-Ed eligibility guidelines was conducted to finalize the list. The SNAP-Ed eligibility guidelines specify eligible agencies based on the following criteria: K-12 schools providing at least 50% or more free and/or reduced-price meals; early childhood centers such as Head Starts or day care centers that reside in a census tract where at least 50% of the population is at or below 185% of the FPL or where >50% of the children receive subsidized childcare or the Child and Adult Care Food Program (CACFP); emergency food providers such as food banks and/or food pantries; Section 8 or subsidized housing as part of the U.S. Department of Housing and Urban Development; and social resource centers participating in the CACFP, participating as a

Table 1
Participating agencies in network survey.

County	Characteristics	No. of agencies	Agency type	No. of agencies			
Allegan	Population: 111,408 Non-Hispanic whites: 89.7% High-school graduates: 89.9% Persons under poverty line: 11.2%	18	K-12 school	7			
			Early childhood center	3			
			Emergency food provider	1			
			Health-related agency	1			
			Social resource center	3			
			Housing complex	0			
			Continuing education organization	1			
			Other miscellaneous agency	2			
			Isabella	Population: 70,311 Non-Hispanic whites: 87.5% High-school graduates: 91.1% Persons under poverty line: 26.1%	26	K-12 school	5
						Early childhood center	6
Emergency food provider	3						
Health-related agency	6						
Social resource center	5						
Housing complex	0						
Continuing education organization	1						
Other miscellaneous agency	0						
Tuscola	Population: 55,729 Non-Hispanic whites: 94.3% High-school graduates: 88.7% Persons under poverty line: 15.5%	26				K-12 school	2
						Early childhood center	3
			Emergency food provider	3			
			Health-related agency	11			
			Social resource center	3			
			Housing complex	2			
			Continuing education organization	1			
			Other miscellaneous agency	1			
			Van Buren	Population: 76,258 Non-Hispanic whites: 82.7% High-school graduates: 86.3% Persons under poverty line: 15.7%	19	K-12 school	5
						Early childhood center	3
Emergency food provider	4						
Health-related agency	1						
Social resource center	3						
Housing complex	0						
Continuing education organization	0						
Other miscellaneous agency	3						

state summer feeding agency, or providing services for other low income programs (U.S. Department of Agriculture, 2016).

Once the agency list was finalized for each county, a contact person such as a school principal, an agency supervisor/manager, or a nutrition/wellness coordinator was identified based on their job characteristics/position and familiarity with both the agency they worked in and their agency's interaction with other agencies in the county. The contact person in each agency was initially contacted via a phone call, in which trained staff explained the purpose of the network survey. Following the phone call, the network survey was sent to the contact person via email. The survey was designed and administered in Qualtrics®, a web-based survey creation and collection platform. Reminder emails were sent to survey non-responders at regular two-week intervals. Staff followed up with agency contacts to troubleshoot technical problems and offer the option of taking a paper-based version of the survey if requested. If a contact person chose to complete the paper-based survey (mostly due to lack of an organization email or personal preference), researchers manually entered data into the Qualtrics® database. Out of a total of 89 completed surveys in Allegan, Isabella, Tuscola, and Van Buren, 8 were administered in paper format. The survey was launched during in May 2016 and completed in September 2016.



Fig. 1. Michigan county map with network survey participating counties.

2.2. Network survey

Adapted from Buchthal et al. (2013), the network survey consists of 3 core questions that assess the frequency of communication, financial exchange, and level of integration among agencies in each of the 4 Michigan counties.

The question regarding the frequency of communication between agencies was, “In the past 12 months, how often did your agency have contact (such as meetings, phone calls, or emails) with each of the following agencies about nutrition education programs(s) such as SNAP-Ed, EFNEP, etc.?” Respondents were asked to choose one answer from “never”, “yearly”, “half-yearly”, “quarterly”, “monthly”, “weekly”, and “daily”. A dichotomous communications network was constructed based on the above question, in which agencies reporting contact “monthly” or more frequently were coded as connected (receiving a value of 1) in the communications network. The communications network is directed to account for the cases of non-reciprocity (i.e., 2 agencies had discrepancies in reporting their mutual communication status).

The question regarding financial exchange across agencies was, “In the past 12 months, did your agency send or receive money to or from any of the following sites?” Respondents were asked to choose one answer from “never”, “sent”, “received”, or “both”. A dichotomous funding network was constructed based on the above question, in which agencies reporting sending, receiving, or both sending and receiving money, goods, or services were coded as connected (receiving a value of 1) in the funding network. The funding network is directed to account for the cases of non-reciprocity (i.e., two agencies had discrepancies in reporting their mutual financial exchange status).

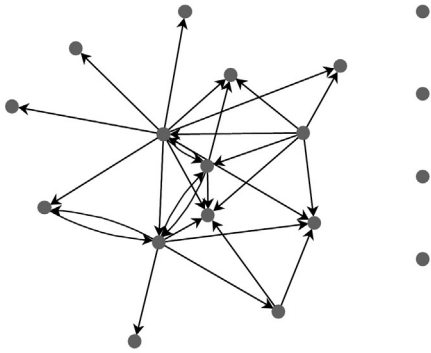
The question regarding the level of integration among agencies is, “Please choose the response that best describes the current relationship between your agency and each of the following agencies. (1) Don’t know/not applicable; (2) Not linked or integrated at all—we do not work together at all and have separate program goals; (3) Communication—we share information only when it is advantageous to either or both programs; (4) Cooperation—we share information

and work together when any opportunity arises; (5) Coordination—we work side-by-side as separate organizations to achieve common program goals (i.e., efforts are organized to prevent overlap, but tasks are performed as separate organizations); (6) Collaboration—we work side-by-side and actively pursue opportunities to work together as an informal team (i.e., attempt to find ways to work together but do not establish a formal agreement or contract; ‘in the spirit of collaboration’); (7) Partnership—we work together as a formal team with specified responsibilities to achieve common program goals (i.e., have formally identified common goals and areas of responsibility for each organization, usually outlined in a Memorandum of Understanding or other agreement); and (8) Fully linked or integrated—we mutually plan, share staff and/or funding resources and evaluate activities to accomplish our common goals.” Two dichotomous networks—cooperation network and collaboration network were constructed based on the reported level of integration. Agencies reporting cooperation and beyond (i.e., coordination, collaboration, partnership, and fully linked or integrated) were coded as connected (receiving a value of 1) in the cooperation network. Agencies reporting collaboration and beyond (i.e., partnership, and fully linked or integrated) were coded as connected (receiving a value of 1) in the collaboration network. Both the cooperation and collaboration networks are directed to account for the cases of non-reciprocity (i.e., 2 agencies had discrepancies in reporting their mutual cooperation or collaboration status).

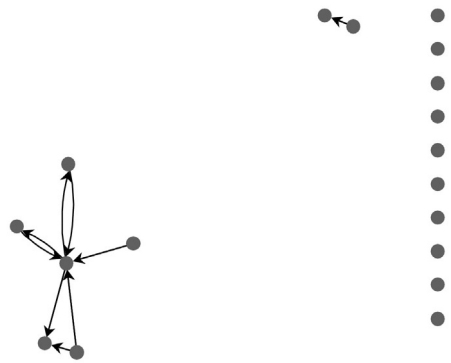
2.3. Network analysis

Network analysis was conducted to examine the previously-defined 4 networks—communications, funding, cooperation, and collaboration networks in Allegan, Isabella, Tuscola, and Van Buren. The “nwcommands” package in Stata 14.2 SE version (StataCorp, College Station, TX) was used to construct network maps using multidimensional scaling, and calculate network characteristics including density, reciprocity, centralization, homophily, and between-network correlation (Grund, 2015).

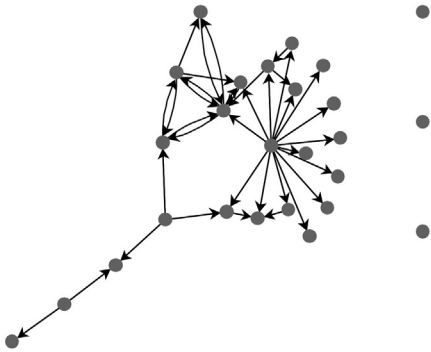
a) Communications network in Allegan



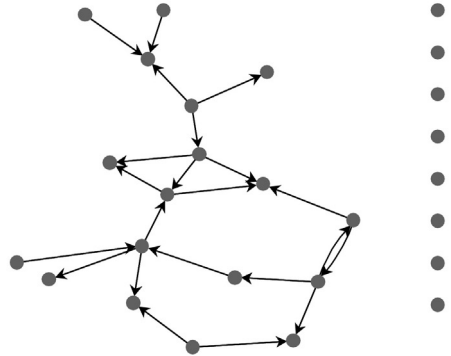
a) Funding network in Allegan



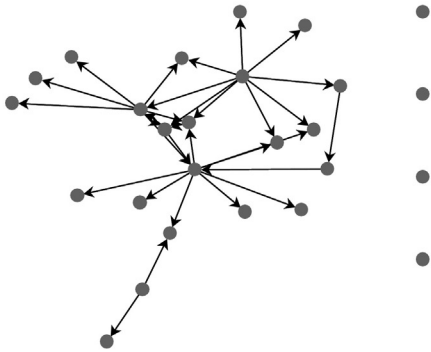
b) Communications network in Isabella



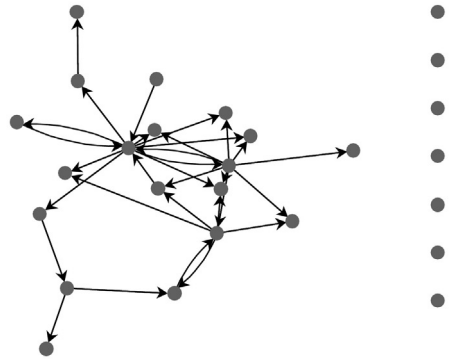
b) Funding network in Isabella



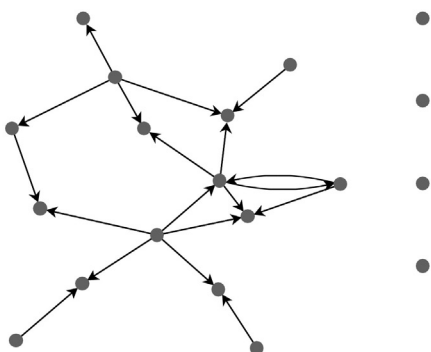
c) Communications network in Tuscola



c) Funding network in Tuscola



d) Communications network in Van Buren



d) Funding network in Van Buren

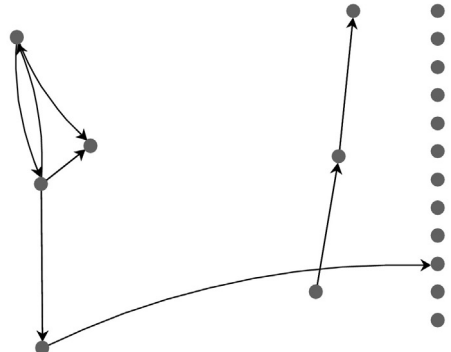
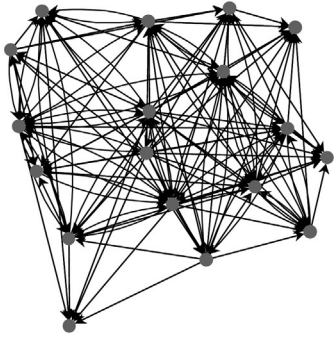


Fig. 2. Communications network.

Fig. 3. Funding network.

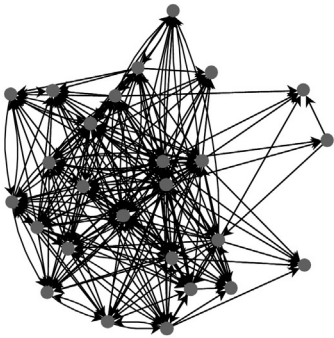
a) Cooperation network in Allegan



b) Cooperation network in Isabella



c) Cooperation network in Tuscola

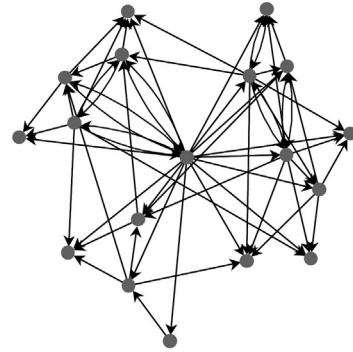


d) Cooperation network in Van Buren

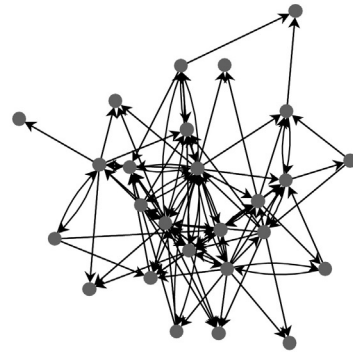


Fig. 4. Cooperation network.

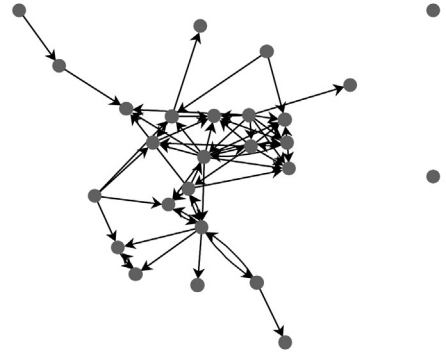
a) Collaboration network in Allegan



b) Collaboration network in Isabella



c) Collaboration network in Tuscola



d) Collaboration network in Van Buren

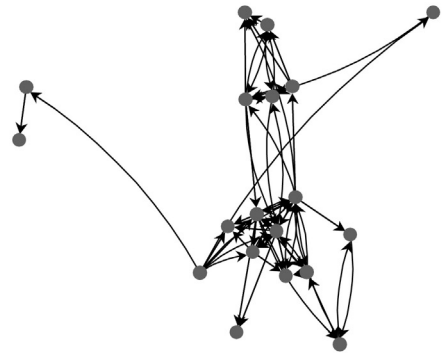


Fig. 5. Collaboration network.

2.3.1. Network density

Network density measures the degree to which the agencies in a network are connected (Scott, 2013). Its value ranges from zero

Table 2
Network characteristics.

Network characteristics	Network type	County	Value
Network density	Communications network	Allegan	0.095
		Isabella	0.057
		Tuscola	0.048
		Van Buren	0.056
	Funding network	Allegan	0.029
		Isabella	0.034
		Tuscola	0.048
		Van Buren	0.023
	Cooperation network	Allegan	0.454
		Isabella	0.360
		Tuscola	0.378
	Collaboration network	Van Buren	0.354
Allegan		0.203	
Isabella		0.209	
Tuscola		0.088	
Network reciprocity	Communications network	Van Buren	0.178
		Allegan	0.115
		Isabella	0.156
		Tuscola	0.033
	Funding network	Van Buren	0.056
		Allegan	0.286
		Isabella	0.048
		Tuscola	0.107
	Cooperation network	Van Buren	0.143
		Allegan	0.287
		Isabella	0.326
		Tuscola	0.268
Collaboration network	Van Buren	0.330	
	Allegan	0.127	
	Isabella	0.220	
	Tuscola	0.118	
Individual agency centrality (range)	Communications network	Van Buren	0.245
		Allegan	0–0.167
		Isabella	0–0.282
		Tuscola	0–0.218
	Funding network	Van Buren	0–0.164
		Allegan	0–0.033
		Isabella	0–0.103
		Tuscola	0–0.153
	Cooperation network	Van Buren	0–0.023
		Allegan	0–0.026
		Isabella	0–0.051
		Tuscola	0–0.045
Collaboration network	Van Buren	0–0.002	
	Allegan	0–0.226	
	Isabella	0–0.118	
	Tuscola	0–0.182	
Network centralization	Communications network	Van Buren	0–0.012
		Allegan	0.016
		Isabella	0.027
		Tuscola	0.022
	Funding network	Van Buren	0.031
		Allegan	0.002
		Isabella	0.022
		Tuscola	0.015
	Cooperation network	Van Buren	0.005
		Allegan	0.009
		Isabella	0.010
		Tuscola	0.008
Collaboration network	Van Buren	0.002	
	Allegan	0.020	
	Isabella	0.020	
	Tuscola	0.027	
Network homophily (correlation coefficient)	Communications network	Van Buren	0.006
		Allegan	0.020 (<i>p</i> -value = 0.419)
		Isabella	0.215 (<i>p</i> -value < 0.001)
		Tuscola	0.031 (<i>p</i> -value = 0.346)
	Funding network	Van Buren	0.153 (<i>p</i> -value = 0.022)
		Allegan	0.118 (<i>p</i> -value = 0.062)
		Isabella	0.079 (<i>p</i> -value = 0.023)
		Tuscola	–0.077 (<i>p</i> -value = 0.112)
	Cooperation network	Van Buren	–0.008 (<i>p</i> -value = 0.556)
		Allegan	0.162 (<i>p</i> -value = 0.008)
		Isabella	0.149 (<i>p</i> -value < 0.001)
		Tuscola	0.134 (<i>p</i> -value = 0.023)
Van Buren	0.240 (<i>p</i> -value < 0.001)		

Table 2 (continued)

Network characteristics	Network type	County	Value
	Collaboration network	Allegan	0.140 (<i>p</i> -value = 0.014)
		Isabella	0.228 (<i>p</i> -value < 0.001)
		Tuscola	0.127 (<i>p</i> -value = 0.017)
		Van Buren	0.321 (<i>p</i> -value < 0.001)

(completely unconnected) to one (completely connected). The density of a dichotomous network is the proportion of all possible connections that are actually present.

2.3.2. Network reciprocity

Network reciprocity is a measure of the likelihood of agencies in a directed network to be mutually linked (Scott, 2013). Any dyad in a directed network can be mutually connected, asymmetrically connected, or not connected at all. Reciprocity is defined as the proportion of mutually connected dyads over all connected dyads (i.e., either mutually or asymmetrically connected dyads).

2.3.3. Network centralization

Following Buchthal et al. (2013) and Harris et al. (2008), 2 indices were adopted to measure network centralization—betweenness centrality of individual agencies, and betweenness centralization of the entire network. Betweenness centrality is an indicator of an agency's influence in a network (Scott, 2013). It is equal to the number of shortest paths from all agencies to all others that pass through that agency. An agency with high betweenness centrality has a large influence on the transfer of items through the network. Betweenness centralization measures the degree to which connections in a network are controlled by a small number of agencies—agencies with high centrality.

2.3.4. Network homophily

Network homophily refers to the principle that a connection between similar agencies occurs at a higher probability than between dissimilar agencies (Scott, 2013). Correlation coefficient measures the degree of network homophily, with values ranging from negative one (when connections only exist between agencies of different type) to one (when connections only exist between agencies of the same type). Correlation coefficient was calculated based on the 8 predetermined agency types (i.e., K-12 schools, early childhood centers, emergency food providers, health-related agencies, social resource centers, housing complexes, continuing education organizations, and other miscellaneous agencies). *P*-value of correlation coefficient was obtained based on 1000 quadratic assignment procedure permutations of the network (Grund, 2015).

2.3.5. Between-network correlation

Between-network correlation measures the degree to which 2 networks are correlated (Scott, 2013). It intends to answer the question: Are agencies connected in one network more (0 < correlation coefficient ≤ 1) or less (–1 ≤ correlation coefficient < 0) likely to be connected in the other network? Correlation coefficients were calculated for all pairs of the 4 networks—communications, funding, cooperation, and collaboration networks in Allegan, Isabella, Tuscola, and Van Buren. *P*-value of correlation coefficient was obtained based on 1000 quadratic assignment procedure permutations of relevant networks (Grund, 2015).

3. Human subjects protection

This study was approved by the University of Illinois at Urbana-Champaign Institutional Review Board (IRB No.16165). Consent was obtained from individual respondent via Qualtrics® prior to survey participation.

4. Results

Figs. 2–5 illustrates the 4 networks—communications, funding, cooperation, and collaboration networks in Allegan, Isabella, Tuscola, and Van Buren, respectively. Each node denotes an agency, and each line with arrowhead(s) denotes the presence and direction of connection in the network. For instance, if a line runs between agency A and agency B with a single arrowhead pointing to agency B, it denotes that agency A reports to be connected with agency B but not vice versa (i.e., non-reciprocity). If a line runs between agency C and agency D with double arrowheads pointing to both agency C and agency D, it denotes that agency C reports to be connected with agency D and vice versa (i.e., reciprocity). Agencies that are not connected with any other agency in the network, if any, are placed at the right corner of each figure.

Table 2 reports network characteristics including density, reciprocity, centralization, and homophily for each of the 4 networks (i.e., communications, funding, cooperation, and collaboration networks). Densities of communications, cooperation, and collaboration networks are low—across Allegan, Isabella, Tuscola, and Van Buren, densities of communications, funding, and collaboration networks range 0.05–0.10, 0.02–0.05, and 0.09–0.21, respectively, indicating that agencies in these 3 networks are only loosely connected. Density of cooperation collaboration network is moderate—across the 4 counties, density of cooperation network ranges 0.35–0.45, indicating that agencies have a moderate level of cooperation. Reciprocities of communications, funding, cooperation, and collaboration networks are low—across the 4 counties, reciprocities of communications, funding, cooperation, and collaboration networks range 0.03–0.16, 0.05–0.29, 0.27–0.33, and 0.12–0.25, respectively, indicating that a majority of dyads (i.e., pairs of agencies) are asymmetrically connected in these networks. Betweenness centralizations of communications, funding, cooperation, and collaboration networks are low—across the 4 counties, betweenness centralizations of communications, funding, cooperation, and collaboration networks range 0.016–0.027, 0.002–0.022, 0.002–0.010, and 0.006–0.027, respectively, indicating that agencies in these networks are decentralized rather than centralized around a few influential agencies. Despite overall low degree of network centralization, betweenness centralities of individual agencies in the communications, funding, cooperation, and collaboration networks to some extent vary—across the 4 counties, betweenness centralities of individual agencies in the communications, funding, cooperation, and collaboration networks range 0–0.28, 0–0.15, 0–0.05, and 0–0.23, respectively. The correlation coefficients measuring network homophily are statistically significant

(p -values < 0.05) for the communications network in Isabella and Van Buren, the funding network in Isabella, and the cooperation and collaboration networks in all 4 counties, indicating that agencies of the same type have a higher probability to form a connection than agencies of different types.

Table 3 reports between-network correlations in Allegan, Isabella, Tuscola, and Van Buren. All correlation coefficients measuring between-network correlations are positive and statistically significant (p -values < 0.05), indicating that agencies connected in one network are more likely to be connected in other networks as well. Across the 4 counties, the correlation coefficient between the communication and funding network ranges 0.17–0.32, between the communication and cooperation network ranges 0.18–0.29, between the communication and collaboration network ranges 0.21–0.48, between the funding and cooperation network ranges 0.15–0.21, and between the funding and cooperation network ranges 0.19–0.27.

5. Discussion

Populations with limited resources are often vulnerable in multiple dimensions, and various risk factors tend to cluster geographically (Noble et al., 2015). No single agency has the resources and capability needed to address this complex mix of risk factors such as poor dietary habits, sedentary behavior and physical inactivity, risk behaviors (e.g., smoking, alcohol misuse, and drug addiction), financial strain, anxiety and stress, functional limitations, and comorbidities (Kolbe-Alexander et al., 2013; Noble et al., 2015). A strong community partnership in which different agencies share information and resources and work collaboratively in a coordinated manner can be essential to optimally address the needs of residents with limited resources (Tandon et al., 2007). In the academic literature, network analysis has been applied to examine the structure of multi-organizational partnerships; however, this tool is less well known outside the small group of researchers who study networks, and it is rarely adopted as an approach to assist communities (Provan et al., 2005). To advance community based programs such as SNAP-Ed and EFNEP and to better serve community-dwelling limited-resource individuals and families, the network survey was administered among agencies in local Michigan communities with the aim of promoting and supporting healthy eating and lifestyles. Findings from network analysis provide important insights regarding community partnerships at status quo and shed light on future directions. First, communications and collaborations between local agencies are still at preliminary levels, largely driven by the needs of individual cases as they occur rather than through systematic organizational

Table 3
Between-network correlations.

County			
Allegan	Communications network		
	Funding network	0.208 (p -value = 0.018)	
	Cooperation network	0.287 (p -value < 0.001)	0.152 (p -value = 0.001)
	Collaboration network	0.475 (p -value < 0.001)	0.201 (p -value = 0.006)
Isabella	Communications network		
	Funding network	0.174 (p -value < 0.001)	
	Cooperation network	0.177 (p -value = 0.008)	0.162 (p -value = 0.001)
	Collaboration network	0.364 (p -value < 0.001)	0.266 (p -value < 0.001)
Tuscola	Communications network		
	Funding network	0.187 (p -value = 0.002)	
	Cooperation network	0.257 (p -value < 0.001)	0.212 (p -value < 0.001)
	Collaboration network	0.237 (p -value < 0.001)	0.186 (p -value = 0.001)
Van Buren	Communications network		
	Funding network	0.320 (p -value < 0.001)	
	Cooperation network	0.242 (p -value < 0.001)	0.180 (p -value < 0.001)
	Collaboration network	0.205 (p -value = 0.012)	0.215 (p -value = 0.004)

development and outreach strategy. Second, there is a lack of leadership among these local agencies that would serve as the organizers or “brokers” and lead the efforts in community partnership building through collecting and disseminating information and resources, bridging multiple agencies, identifying and/or creating collaboration opportunities, and setting common goals. Third, possibly due to the similar nature of work, agencies of the same type (e.g., all K-12 schools or all food pantries) tend to form stronger ties, whereas those of different types are loosely connected. This segregation by agency type may call for a more robust leadership and coalition-building role of county governments, as they often regulate, supervise, and partner with diverse types of agencies in local communities (National Center for Chronic Disease Prevention and Health Promotion, 2015). Finally, as indicated by the strong correlations between different networks, cultivating community partnership may not need to be comprehensive but first focus on forming a single type of network (e.g., communications network). As long as that tie is well established, other types of ties (e.g., funding network) may occur naturally.

A few limitations of this study should be noted. Despite substantial efforts made by research staff to boost response rate, 2 of the 6 counties (Ingham and Muskegon) were excluded from network analysis due to low response rate. Main reasons for nonparticipation include being unreachable by email and phone, and lack of interest or time. Data quality could be of concern given the low degree of reciprocity. This could partially result from survey respondents' lack of familiarity to inter-agency relationships. Although research staff attempted to recruit respondents who had the best knowledge regarding daily operations of their respective agencies, some respondents' knowledge regarding community partnerships could be limited and inconsistent due to institutional change (e.g., seasonality, opening, or closure), job change, and alternation in roles and responsibilities. On the other hand, the low degree of reciprocity also reflects the lack of consistent and long-term partnerships in the network of community-rooted agencies. Answers to survey questions are self-reported, and thus subject to measurement error, recall bias, and institutional knowledge limitations (Donaldson and Grant-Vallone, 2002). All 4 Michigan counties are located in rural areas with predominantly non-Hispanic white population, which could limit the generalizability of study findings to urban communities and communities with higher proportion of racial/ethnic minorities.

This study serves as a pilot effort to understand and document the network of community-rooted agencies. In future we plan to deepen our research in two aspects. First, we will design, implement, and evaluate an intervention that aims to improve and strengthen community partnership. Second, we will examine the impacts of community partnership on agency- and individual-level outcomes such as number of people served, cost containment, service quality, customer satisfaction, and program adherence.

6. Conclusions

This study examined the networks of agencies in local communities that promote healthy eating and lifestyles among limited-resource populations. Agencies have a moderate level of cooperation, but are only loosely connected in the other 3 networks, indicated by low network density. Reporting accuracy is of concern, indicated by low reciprocity. Agencies in a network are decentralized rather than centralized around

a few influential agencies, indicated by low centralization. There is suggestive evidence regarding homophily in a network, indicated by some significant correlations within agencies of the same type. Agencies connected in one network are considerably more likely to be connected in all the other networks as well. Promoting healthy eating and lifestyles among populations with limited resources warrants strong partnership between agencies in communities. Network analysis serves as a useful tool to evaluate community partnerships and facilitate coalition building. Finding of this study provide a baseline for local communities, but the goal moving forward is to identify effective strategies that will further enhance community partnerships to better serve limited-resource populations.

Conflict of Interests statement

This study was funded by the USDA North Central Nutrition Education Center of Excellence (Grant No. NIFA 2014-48757-22608). The authors have no conflict of interests to declare.

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