

Mapping the Possibilities: Using Network Analysis to Identify Opportunities for Building Nutrition Partnerships Within Diverse Low-Income Communities

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ABSTRACT

Objective: To identify communication and collaboration patterns among organizations involved in nutrition education within an ethnically diverse low-income community.

Design: A snowball sample methodology was used to identify 27 organizations involved in nutrition activities in the community. The researchers conducted an online survey and network analysis to identify communication and collaboration patterns among these organizations.

Setting: An urban neighborhood in Honolulu, HI.

Participants: Individuals responsible for nutrition activities at state, county, and nonprofit organizations.

Main Outcome Measures: Network structure, betweenness, and centralization.

Analysis: Communication was uncentralized and collaboration was limited. Collaboration was affected by differences in mission, location, and population served. Child care/youth development organizations and community health centers provided links across the community. Agencies serving different ethnic populations were poorly linked and located on the periphery of the network. Ethnic-specific churches expressed strong interest in nutrition partnership but were not identified as potential partners by other agencies in the network.

Conclusions and Implications: Limited communication between agencies serving different populations in the same community may result in missed opportunities for collaboration. Network analysis is an effective tool for identifying these gaps and helps build community capacity for improving nutrition outcomes.

Key Words: social networking, community networks, community development, community health education, Supplemental Nutrition Assistance Programs (*J Nutr Educ Behav.* 2015;47:300-307.)

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INTRODUCTION

Demographic trends suggest that the US is on the path to becoming one of the most ethnically diverse nations in the world. Between the 2000 and 2010 censuses, 5 states became majority-minority states, in which no single ethnic group was a majority.¹ States in which diversity is increasing rapidly are those where population growth is the strongest,² and it is in these low-income and diverse communities that obesity

and diabetes rates are rising most rapidly.³ Ethnic community agencies providing culturally and linguistically consonant services may be one of the best ways to reach these populations.⁴ However, ethnic community agencies often struggle with limited access to resources outside their own communities.⁵ Building collaborative networks for addressing shared nutrition concerns across diverse communities could strengthen these agencies' capacity to support behavior change.^{6,7}

Because community organizations link families to resources not contained within their own social networks,⁸ bridges between diverse organizations may diffuse health resources and messaging across the community's social boundaries.

Within a multiethnic community, however, connections between agencies working with different populations may be weak. There are currently no data on how organizations addressing nutrition among different populations in ethnically diverse neighborhoods communicate or collaborate on nutrition issues.

Social network analysis is an emerging tool that can be used to assess the structure and characteristics of links between organizations.⁹ Network analysis can uncover links between groups, map communication pathways, and identify opportunities for improving collaboration. Network studies have been used to identify communication patterns between agencies working in statewide

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tobacco prevention¹⁰ and physical activity promotion¹¹ efforts, to track patterns in partnership between organizations involved in regional and international health collaborations,¹² and to assess changes in regional partnership patterns among Supplemental Nutrition Assistance Program–Education (SNAP-Ed) agencies.¹³ Network analysis may prove a useful diagnostic tool for building nutrition partnerships within complex communities.

This study was conducted in a low-income, urban community in the state of Hawai'i, one that contains established Native Hawaiian, Filipino, and Samoan families intermixed with recent immigrant populations from many Pacific Island and Asian nations.¹⁴ Within this neighborhood of 5 square miles, ethnic populations tend to be served by their own faith-based and ethnic community agencies, whereas social service, health, and governmental agencies provide services across populations. This study employed social network analysis to identify existing patterns of collaboration on nutrition issues such as food insecurity, healthy food access, nutrition education, and other primary prevention programs that address obesity, diabetes, and diet-related chronic disease risk within the community. The results should provide information on patterns of interagency connection within ethnically diverse neighborhoods and suggest paths for strengthening collaboration.

METHODS

Study Design

This study contained 2 phases: community interviews to identify key organizations for nutrition partnerships, and a network analysis to map existing communication and collaboration patterns among these organizations. This study was submitted to the University of Hawai'i's Institutional Review Board; institutional review board review determined that the study was not human subjects research, as per US Department of Health and Human Services guidelines.

A key methodological issue in network research design is whether to use a fixed list or expanding list sample.⁹ In a fixed list sample the researcher defines the boundaries and components of the network.¹² A fixed

list sample is often used in coalition assessment because it prompts participants to recall agencies with which they rarely link, providing data on both strong and weak links in the network. Because the network is predefined by the researcher, however, this sampling method increases the possibility of sampling bias. An expanding list sample uses a snowball methodology. This technique identifies each agency's most active connections, and because it is participant rather than researcher driven, it may reduce sampling bias. However, because participants may forget agencies with which they connect infrequently, information about weaker ties may be lost.

This study combined both methodologies. The researchers used reputational snowball sampling to identify organizations involved with nutrition activities in the community.^{15,16} Sample generation began with key informants at 6 agencies known to provide nutrition education to different ethnic groups in this community. Each was interviewed about their agency's nutrition activities and then asked to identify all other agencies involved in nutrition activities in this neighborhood, along with a contact person knowledgeable about the agency's nutrition activities. Those contacts were interviewed and this process was repeated until further interviews yielded no new agency names. This generated a list of 28 agencies, providing the initial fixed list sample for the network survey. During fielding, 1 evangelical church indicated that it did not view nutrition as part of its mission; thus, it was removed from the study, which resulted in a final fixed list sample of 27 agencies.

Network Survey Procedures

Participants were contacted by phone and e-mail and were e-mailed a link to an online survey using Qualtrics survey software (Qualtrics Research Suite, Qualtrics Labs, Inc, Provo, UT, 2011). Up to 6 follow-up contacts were made to encourage survey completion, resulting in an 85% response rate.

Survey Measures

The survey asked participants to identify from a close-ended list their orga-

nization's primary activities and the populations they served, the frequency of communication and degree of collaboration between their agency and each of the other agencies in the sample, and the degree to which they felt that their agency shared goals with each of these other agencies.

Communication and collaboration questions were used to develop matrices for the network analysis. Participants were asked to identify how often their agency communicated (including meetings, phone calls, and e-mails) with each of the other agencies in the sample, using a 5-item ordinal scale that ranged from *not at all* to *once a week or more*. Participants were asked to define the relationship between their agency and each of the other agencies, using an ordinal 7-item collaboration measure adapted from the work of Slonim et al.¹⁷

Data Analysis

Data cleaning and resolution of missing values. Survey data were exported into SPSS (IBM SPSS Statistics for Windows, version 20.0, Armonk, NY, 2011) for cleaning and data exploration. Data on each agency's primary activities and mission were used to create a variable assigning that agency to an agency type. Agencies were grouped by type and descriptive statistics were generated showing the percentage of agencies within each agency type that engaged in each activity.

Because network measures required that each agency rate its frequency of communication and level of collaboration with every other agency, 2 responses were generated for each agency pairing and merged to create a single value representing the agency dyad. In network studies, it is common to find discrepancy in response between respondents in a dyad. Two methods are customarily used to reconcile these differences: averaging and reconstruction.¹⁰ In this study, the authors used averaging to resolve small discrepancies. For example, if Agency A said its agency communicated with Agency B weekly (5 on the communication scale) but Agency B said its agencies communicated quarterly (3 on the communication scale), the midpoint between the responses

Table 1. Percentage of Agencies Within Each Agency Type That Report Engaging in Specified Activities

Agency Type	n	Activity (%)									
		Education	Social Service	Volunteer Service	Youth Development	Ethnic Community	Faith-Based	Health Care	Profession/Business	Recreation	Child Care
Health center	3	100	67	33	33	67	0	100	67	33	33
Education	2	100	0	50	0	50	0	0	50	0	0
Social service	4	50	100	100	50	0	50	0	0	0	0
State or county government	5	80	20	20	40	40	0	60	0	40	0
Child care or youth	5	80	80	60	80	60	20	0	20	40	60
Nonprofit funder	2	50	50	100	50	0	0	0	50	0	0
Public housing	1	0	100	100	0	100	0	0	100	0	0
Church	5	67	100	67	67	33	100	0	0	33	0
Total	27	74	61	57	48	43	26	26	26	26	17

(4) was used to represent the dyad. If the discrepancy was > 3 points on the scale, both respondents were re-contacted to resolve the discrepancy. Reconstruction was performed if data on one half of a dyad were missing, by imputing the partner agency's response to replace the missing data. In network analysis, studies have shown that reconstruction is valid when < 20% of data are missing^{18,19}; this study had 15% missing.

The communication and integration matrices were imported into a network analysis software package (Pajek, version 1.13, Vladimir Batagelj and Andrej Mrvar, Ljubljana, Slovenia, 2011) for visualization and analysis. Each agency was defined as a network vertex and the communication and collaboration data were used to generate links between agencies that reported contact at least quarterly (communication) or worked together toward common goals (collaboration). Resulting networks were visualized using the Fruchterman–Reingold energy protocol.²⁰ To identify patterns of connection between multiethnic and mono-ethnic agencies, the researchers chose vertex colors to identify the specific population served. Vertex size was determined by betweenness centrality (a measure of the degree to which that agency served as the primary connector between other agencies).

After maps identifying links between individual organizations were generated, each network was partitioned by agency type, aggregating the data on agencies with similar core missions, and new network maps were generated showing the underlying pattern of connections between agencies of different types.

The researchers conducted subgroup analysis by partitioning each network iteratively into k-cores (groups of interconnected agencies in which each agency has at least “k” number of connections with other agencies in the grouping). The network then was fragmented into cliques. Cliques are highly interconnected groups with few outside connections. Clique members are likely to share information or collaborate only within their group, and to have 1 member who serves as the broker between the clique and the larger network.

Table 2. Structure of Communication and Collaboration Networks

	Communication Network	Collaboration Network
Network density (measures extent of interconnection among agencies in network: range is 0.0 [none] to 1.0 [completely interconnected])	0.32	0.10
Network diameter (smallest number of intermediary agencies in line connecting 2 agencies farthest apart in network map)	3	8
Average number of connections per agency	8.2	2.7
Network betweenness centralization (measures brokerage, or degree to which 1 or a few agencies serve as primary link between other agencies in network: range is 0.0 [no agency is only connecting link between 2 others in network] to 1.0 [all connections between agencies in network are made through only 1 agency])	0.14	0.18

RESULTS

Profile of Participating Organizations

Eight agency types were identified: churches, health care centers, child care/youth services, social services, voluntary/nonprofit funding agencies, public housing, education, the state's Expanded Food and Nutrition Education Program, the state department of health, and the county Parks and Recreation Department. As shown in [Table 1](#), despite differences in core mission, most agencies engaged in similar activities, with churches, health care centers, and child care/youth services exhibiting the widest range of activities overall. Churches reported shared goals with almost all other agencies (92%) but only half of the other organizations (50%) reported shared goals with churches.

Communication and Collaboration Network Density and Centrality

Network density measures the degree of interconnection between agencies; it is measured on a scale of 0–1 scale, where 0 = no connections between agencies and 1 = every agency connected with every other agency. As may be seen in [Table 2](#), the communication network was moderately connected (density between 0.4 and 0.2) whereas the collaboration network was weakly connected (density < 0.2). Betweenness centralization measures the extent of brokerage within a network. Brokerage occurs when 1 agency serves as the gatekeeper or primary connection point between other

agencies. A network with high levels of brokerage is one in which most organizations in the network are linked primarily through their mutual connections to a few key agencies. In both networks, betweenness centralization was low overall.

Betweenness centrality is an individual or agency-level measure that shows the extent to which an individual agency serves as a key link between other agencies in the network. Although betweenness centrality was low overall, these data were used to determine the node size in developing the network maps, to permit visual identification of critical links within the networks.

Communication Network Visualization and Subgroup Analysis

The communication network shown in [Figure 1](#) showed a dense cluster of highly connected organizations, linked primarily through health centers (HEALTH-2) and social services (SOCSVC-2) and bridged by child care/youth services organizations. A network's diameter is calculated by identifying the shortest path (number of connections through intervening agencies) between agencies that are farthest apart in the network map. The communication network's diameter was 3, which suggests that whereas the network is diffuse, communication pathways are relatively short. Agencies serving multiple ethnic groups were found in the center of the network, whereas those serving individual Filipino, Pacific Islander, and Native Hawaiian

populations were located along the periphery.

In the communication network, the k-core analysis found that child care/youth services organizations, health centers, governmental agencies, and nonprofit funders were interconnected within a 6-core (a subgroup of agencies that share at least 6 links with other agencies in the cluster). Most social service agencies were contained within a smaller 3-core. Churches were not included in either subgroup. No cliques were identified.

The communication network was partitioned by agency type ([Figure 2](#)). This partition generated a star-shaped network formed by links to a central axis of child care/youth services organizations and health centers, and a secondary axis linking these agencies to social service agencies. Agencies positioned at the center of a star pattern are usually the central organizing force within a network.

Collaboration Network Visualization and Subgroup Analysis

[Figure 3](#) displays the network of agencies reporting informal or formal partnerships. This collaboration network shows many isolated and minimally connected agencies. The network's diameter was 8, which suggests that the shortest route to collaboration between some of the agencies in this network could require linking through as many as 6 intervening agencies. A visual inspection of the network structure suggested 3 potential

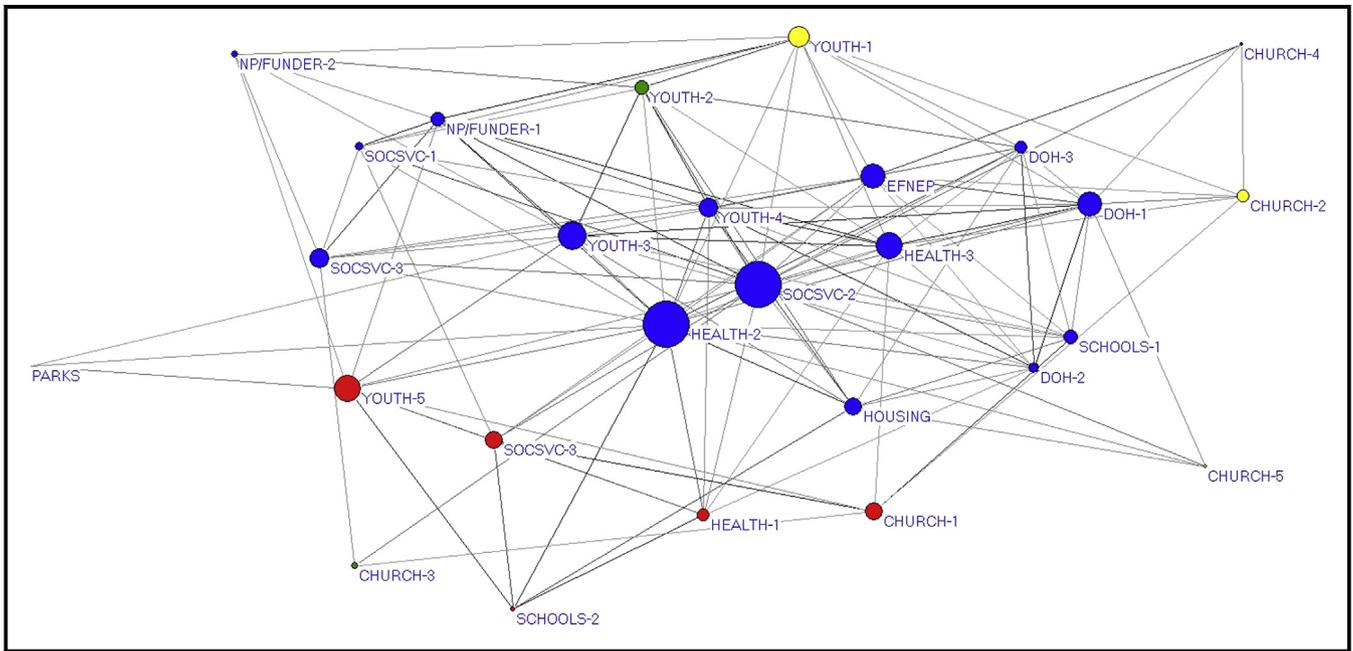


Figure 1. Network of communication among community agencies. Circle size reflects the betweenness centrality of the agency within the network. Circle color reflects the ethnic community served by the agency: blue = multiethnic; red = native Hawaiian; yellow = Filipino; green = Pacific Islander. Agency types: CHURCH = church or faith-based organization; DOH = state department of health unit; EDUC = school- or university-based program; EFNEP = state Expanded Food and Nutrition Education Program agency; HEALTH = community health center; NP/FUNDER, nonprofit funding agency such as United Way; PARKS = county parks and recreation department; SOCSVC = social service agency; YOUTH = organization serving at-risk children and youth. Note. Numbers used for anonymization of the multiple agencies within each category.

sub-groupings: Native Hawaiian-serving institutions, social service organizations, and state/county agencies. However, no k-cores or cliques were found in the subgroup analysis.

When the collaboration network was partitioned by agency type (Figure 4), child care/youth services

organizations again emerged as the central link in the network. Secondary connections occurred through health centers, social services, and education. Churches, housing, state/county government agencies, and ethnic agencies serving Filipinos and Pacific Islanders were peripheral.

DISCUSSION

This study explored communication and collaboration among organizations working to address nutrition needs within a low-income, ethnically diverse community. Many agencies reported similar activities and goals, suggesting opportunities for partnership and resource sharing. However, as the researchers hypothesized they might find in this multiethnic neighborhood, the networks were diffuse and weakly connected, particularly among agencies that served different ethnic populations. Within these networks, information is likely to travel slowly between agencies, and opportunities for collaboration may be missed.

These networks differ substantially from networks found in prior assessments of collaborations involving state health departments and agencies working to promote physical activity or tobacco control.^{10,11} Instead, they more closely resembled the diffuse webs of connection found in multinational research collaborations²¹ or in connections between agencies providing different types of services to individuals with human immunodeficiency virus or chronic disease.^{22,23} This may be

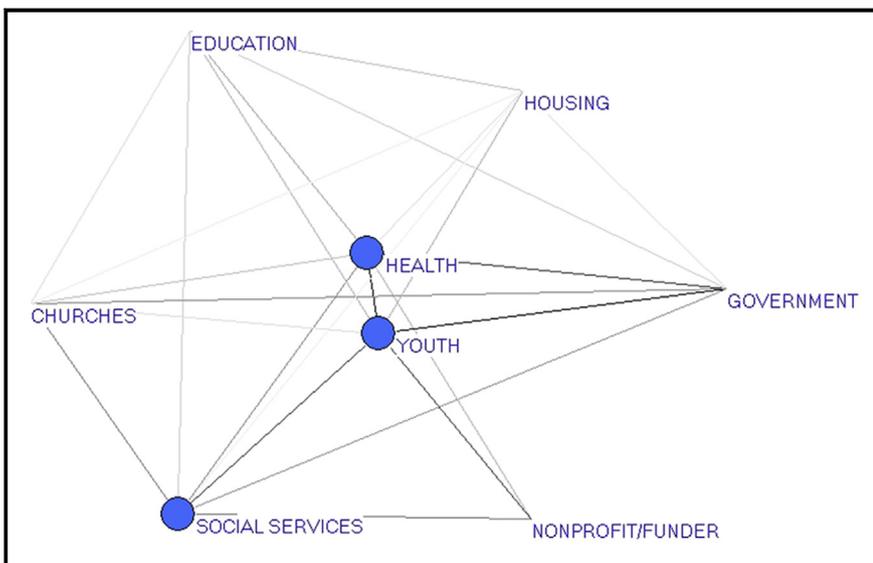


Figure 2. Network of communication among different agency types. Circle size reflects the betweenness centrality of this type of agency within the network.

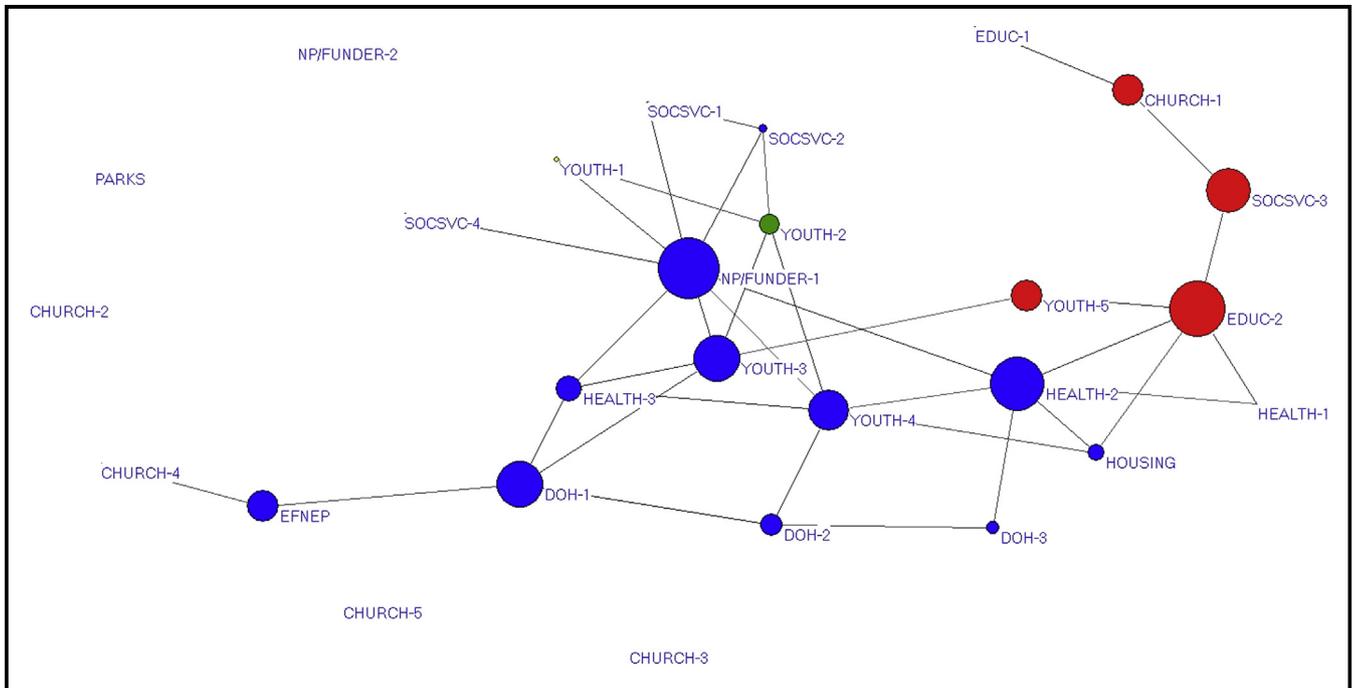


Figure 3. Network of collaboration among community agencies. Circle color reflects the ethnic community served by the agency: blue = multiethnic; red = native Hawaiian; yellow = Filipino; green = Pacific Islander. Agency types: CHURCH = church or faith-based organization; DOH = state department of health unit; EDUC = school- or university-based program; EFNEP = state Expanded Food and Nutrition Education Program agency; HEALTH = community health center; NP/FUNDER, nonprofit funding agency such as United Way; PARKS = county parks and recreation department; SOCSVC = social service agency; YOUTH = organization serving at-risk children and youth. Note. Numbers used for anonymization of the multiple agencies within each category.

what happens when agencies with differing missions share overlapping concerns, but there has been no concerted effort to build collaboration. The pattern of diffuse clusters connected by links between a few key agencies also bears similarity to the initial collaboration patterns identified by Cross et al²⁴ in their study of inter-agency collaboration for youth develop-

ment. The results of that long-term study showed that targeted efforts to build connections created significantly increased partnership around shared concerns among these organizations.

Examination of these networks suggests multiple opportunities for strengthening communication and collaboration on nutrition issues. Child care and youth services agencies

appeared to be key connectors in both communication and collaboration networks in this study. In a qualitative study of the brokerage role of child care organizations, child care agencies were found to have a critical role in connecting low-income individuals to community resources.²⁵ The central placement of the child care/youth services agencies within these network maps suggests that the agencies' ability to work across ethnic boundaries and link together agencies with different missions may be what makes them effective in helping families access resources.

The peripheral position of religious organizations within the network maps is concerning, as is low awareness among other organizations of churches as a potential partner in nutrition activities. Involving faith-based communities has been shown to be particularly effective not just at initiating dietary change among participants,²⁶ but also in providing social and environmental support that enable individuals to sustain behavior change over time.²⁷⁻³¹ In this study, each church reached a different ethnic

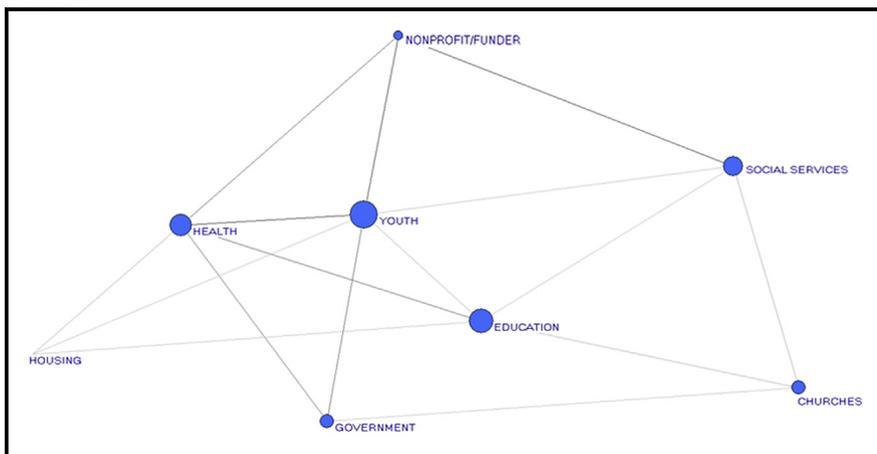


Figure 4. Network of collaboration among different agency types. Circle size reflects the betweenness centrality of this type of agency within the network.

population. It appears that churches may be an overlooked resource for linking nutrition activities across diverse communities.

Limitations

Because this study was conducted in Hawai'i, results may not be generalizable to other states or other multicultural communities. A snowball sample was used to identify organizations for the network study but some community organizations important for smaller groups may have been missed. However, a validity check on the sample was included as a final question in the survey; this generated no indication of important missing agencies. Data from key informants were used to identify a single respondent at each agency who was most likely to know that agency's involvement in community nutrition activities. At larger agencies there may have been interagency connections with which the respondent was unaware. Duplication of data by interviewing both halves of the dyad, along with reconciliation of divergent responses, may have helped to control for this.

The use of network analysis to assess community collaboration is a new field. There are no established standards for what constitutes a strong or a weak network structure. In addition, some network measures such as density are affected by network size and may not be directly comparable across networks with substantially different structures.

IMPLICATION FOR RESEARCH AND PRACTICE

Building partnerships for nutrition-related activities within a multiethnic community is a complex task. This study suggests that organizations working on nutrition within a multiethnic community may be fragmented along both ethnic community and agency mission lines. Although many organizations engage in similar activities, interagency communication and collaboration may be diffuse and uncentralized. As a result, opportunities for collaboration may go unnoticed

and duplication of services can occur, wasting these communities' limited resources.³²

The results of this study suggest that network analysis can be a fruitful tool for identifying ways to strengthen community partnership and collaboration. Mapping existing patterns and then sharing this information with participating agencies can help agencies build strategic partnerships. State agencies, with their broad responsibilities and connection to funding resources, can have an important role in promoting this collaborative nutrition network. Recent changes to the US Department of Agriculture's guidance for SNAP-Ed programming specifically encourage SNAP-Ed agencies to partner with others to address environmental issues affecting nutrition in low-income communities.³³ State SNAP-Ed organizations may be particularly well positioned to support the development of collaboration among diverse agencies with shared interest in nutrition outcomes.

Notable in this fledgling nutrition network was the linking role of child care/youth services organizations and the marginalization of faith-based institutions in the network. Both organizational types link low-income families with community resources; they may be under-recognized assets in building collaboration.

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CONFLICT OF INTEREST

The authors have not stated any conflicts of interest.