Topology of Local Health Officials' Advice Networks: Mind the Gaps

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Objective: To determine how a health officials' advice network might contribute to a high-performing public health systems by facilitating diffusion of innovation and best practices. **Design:** A secondary analysis of cross-sectional data obtained from the National Association of County and City Health Officials 2010 Profile of local health departments (LHDs) using network analysis. **Setting:** The Profile survey is distributed biannually to all 2565 LHDs in the United States. In 2010, it included a network question: "In thinking about your peers who lead other local health departments in the U.S., list the five LHDs whose leaders you communicate with most frequently about administrative, professional, and leadership issues in public health." **Participants:** The network question was answered only by the top executive. The subjects are 1522 health officials who answered the network question plus 477 named as contacts (n = 1999). **Main Outcome Measures:** Measurements to assess network topology were density, centralization, transitivity, and reciprocity. At the node level, average centrality, clustering, effective network size, and clique count were measured. The convergence of iterated correlations algorithm was used to detect subgroups. **Results:** A sparsely connected core periphery network exhibited minimal evidence of unified communication. Mutually connected small groups tend to clump within state boundaries suggesting gaps in information flow. The pattern persisted at the regional level with an average health official having an effective network of only 2 others. **Conclusions:** Communication between peers may not be the primary way professional information diffuses among local health officials. National groups involved in performance improvement may wish to consider strategies to increase the diffusion of best practices and innovations through this network.

KEY WORDS: communities of practice, diffusion of innovation, network analysis, public health systems

Advice networks sustain professional values in a given field.[1,2] Social studies have shown that when individuals interact in a network of social relations, their attitudes and beliefs about what is important, effective, and desirable tend to converge.[3-5] An evolving environment, introduction of technologies, or novel approaches to work can introduce new ideas that may lead to change in professional values.[6,7] Social networks are recognized as an important process for adopting innovations and the spread of ideas because the network is a vehicle for partnership and collaboration. Social network analysis can describe the relationships between people, groups, or organizations that participate in a network.[8] The technique empirically measures how the network is structured, and through interpretation suggest how the structural properties may affect the behavior of participants[9,10]

Recent emphasis in public health systems on performance improvement, evidence-based programs, and service delivery, and health care reform are innovations

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with potential to change the professional outlook of leaders in public health organizations and the actual practice of public health.[11-15] This has led to an interest in how the communication network between health officials can facilitate or impede the spread of ideas and support adoption of innovation.

The study presented here is an investigation of the network through which top executives in local health departments communicate about substantive issues they face in public health. The overall object is to determine how this *health officials' advice network* (HOAN) might serve as a means to develop high-performing public health systems through promoting innovation and best practices.[16] We describe the network topology (structural pattern of communication), measure the level of network cohesion, and investigate how subgroups may influence information flow. Finally, we suggest how these findings might be applied to promote innovation in performance and practice.

Methods

Design

We conducted a secondary analysis of cross-sectional data obtained from the National Association of County and City Health Officials (NACCHO) Profile of local health departments (LHDs). The Profile survey is distributed biannually to all LHDs in the United States. It is a comprehensive source of data on the characteristics of local health systems and the health officials that lead them.[17]

In 2010, the core survey contained 64 questions in 6 domains: governance, funding, characteristics of the health official, workforce, PH activities, community health assessment, and planning. For the first time the survey included a network question: "In thinking about your peers who lead other local health departments in the U.S., list the five LHDs whose leaders you communicate with most frequently about administrative, professional, and leadership issues in public health."[17(p50)] Respondents were instructed that the network question be answered only by the top executive, and that only LHDs (not individuals) be named in the response.

Procedures for network analysis

Responses to the network question were entered into a square matrix in which the rows and columns represented LHDs (nodes) and the value of the cells represented presence or absence of a communication tie (link) between LHDs (1 = tie, 0 = no tie). These data were augmented with geographical attributes including region, state, and latitude and longitude. Analysis was conducted using the ORA software program.[18]

We used 4 network-level measures to assess overall topology: *density*, *centralization*, *transitivity*, and *reciprocity*. We used 4 node-level measures to assess the average health official's communication network: *total degree centrality*, *clustering coefficient*, *effective network size*, and *clique count*. These measures are defined in the Table.

We employed these measurements to examine local patterns by partitioning the network according to 10 geographical regions defined by the US Department of Health and Human Services for the purposes of planning and service implementation.[19]

We applied the convergence of iterated correlations (CONCOR) grouping algorithm to the network detect any subgroups or communities of health officials in the network. CONCOR groups nodes having a similar pattern of the ties between them, a principal known as structural equivalence.[20] It is calculated by arranging the rows and columns of the network matrix to show subsets of adjacent nodes that have identical rows and columns link entries.[21] Finally, we created visualizations to examine patterns and geographic distribution of ties in the network.

Results

There are 2565 LHDs in the United States that received the NACCHO Profile survey. Of those, 2107 responded, and of those, 1522 surveys (or 60%) had usable responses to the network question. Five contacts were named by 814 LHDS, 4 contacts by 131 LHDs, 3 contacts by 153 LHDs, 2 contacts by 111 LHDs, and 1 contact by 322 LHDs. Among the contacts named were 196 LHDs that did not respond to the NACCHO survey, and 148 LHDs that did. Responses that named organizations that were not LHDs (eg, a state health department or a local health officials' association) were removed (n = 9 LHDs and 73 line responses). This produced a network consisting of 1999 nodes, representing 78% of local health officials in the United States (Figure 1).

Topology at the network level

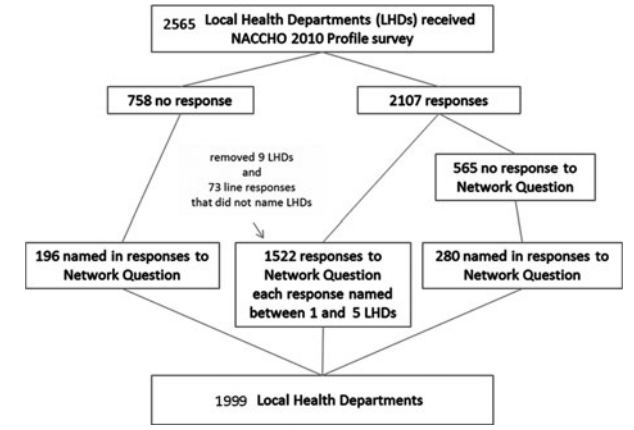
The HOAN can be characterized as a sparsely connected core/periphery structure. We defined the periphery of the network as the 1002 health officials with either an incoming or an outgoing tie to another health official in the network. The periphery has a very low density of 0.001.[22] We defined the core as the 996 LHDs that are more central by virtue of having both in and outgoing ties with other LHDs.[23-25] The core has a sim-

TABLE ● Comparison of Network Measurements[a] in the HOAN at the National and Regional Levels

			DHHS Regions Ordered by Number of Nodes									
		HOAN	**5**	**4**	**7**	**1**	**6**	**8**	**2**	**3**	**10**	**9**
Number of nodes		**1999**	459	308	296	215	164	155	153	113	71	65
Network-level measures												
Density	Proportion of existing ties to all possible ties between LHDs. Values close to 0 suggests sparse ties, or gaps in communication.	**0.001**	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.04	0.04
Centralization, total degree	Extent that communication between LHDs is directed to and from a central group. Measurements close to 0 suggest dispersed communication	**0.003**	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.04	0.08
Transitivity	Proportion of health official pairs (a,b)(b,c) where (a,c) also has a tie. Represents the potential for shared communication and transfer of ideas through the network.	**0.32**	0.30	0.30	0.38	0.31	0.32	0.40	0.32	0.48	0.27	0.31
Reciprocal link count	The percentage of links between health officials where both indicate a link to each other. Reflects ties are perceived as shared or mutual aid.	**0.15**	0.16	0.11	0.19	0.10	0.07	0.18	0.16	0.24	0.18	0.16
Node-level measures												
Centrality, total degree	The average of all health officials' sum of ties to and from others. Nodes with many ties have more access to ideas, thoughts, beliefs of others.	**0.001**	0.003	0.004	0.005	0.004	0.007	0.009	0.008	0.012	0.020	0.038
Clustering coefficient	The average proportion of ties between a health official and his or her direct neighbors divided by all ties possible between them. Reflects potential for local diffusion of information.	**0.20**	0.21	0.16	0.25	0.13	0.17	0.20	0.20	0.30	0.18	0.22
Effective network size	The ties to others that a health official has minus redundant links via other network members. Reflects the actual size of an average health official's network.	**2.1**	2.2	2	2	1.5	1.9	2	2	1.8	2.3	1.8
Clique count	Average number of fully connected subgroups to which a health official belongs. A clique is a group of 3 or more with many connections to each other and relatively few connections to other groups. Cliques support shared perspectives.	**2**	2.4	2	2.1	1	1.4	2.6	2.1	1.9	2.6	2

Abbreviations: DHHS, US Department of Health and Human Services; HOAN, health officials' advice network.
[a]Measurements are normalized between 0 and 1, *except* effective network size and clique count, which are counts.

FIGURE 1 ● Data Sources for Analysis of the Health Officials' Advice Network.



NACCHO indicates National Association of County and City Health Officials.

ilarly low density of 0.003. Centralization of links between LHDs in network was also very low, at 0.005 at the core and 0.003 at the periphery. The very low density and centralization in the core and periphery indicate little to no unified communication structure in the HOAN. Visual inspection of the graph in Figure 2A confirms minimal differentiation in the pattern of LHDs meeting the definition of core and periphery.

Transitivity in the HOAN is 0.32, indicating that about a third of the health officials in this network communicate within connected groups that are beneficial for circulating information.[20] In the authors' experience, this measurement is close to the mean typically observed in social networks.[26] In the presence of very low density and centralization such transitivity suggests a communication pattern of localized clumps with gaps between them. Visual inspection of the network diagrams in Figure 2 confirms this. The reciprocal link count (0.15) indicate that about 15% of health official pairs mutually named each other, suggesting a perception of equal status in communicating about issues in public health.[27] This measurement may be somewhat lower than actual because it only represents those who responded to the network question (ie, 1522 of the 1999 represented in the HOAN).

The network at the node level

The average health official in the HOAN has a total degree centrality of 0.001, indicating extremely few ties *across* the network. The clustering coefficient of 0.20 indicates an average health official does communicate with about 20% of his or her neighbors suggesting, for example, that an average health official might communicate with 2 of the 10 counties surrounding his or her jurisdiction.[28] This is corroborated by the average health official's effective network size of just 2.1 peers and membership in just 2 cliques. The distribution of cliques showed that nearly 900 of the 1999 members of the HOAN participate in small cliques of 3 health officials. About 250 participate in cliques of 4, and less than 50 participate in cliques of 5 or 6 health officials.

Regional networks

The pattern observed at the national network level is sustained in the 10 US Department of Health and Human Services regions, as shown in the Table . Although density and centralization are a level of magnitude greater than nationally the measurements are still very low. For example, density in the regions indicates that just 1% to 4% of possible ties between health officials are present. Regional transitivity remains in a range typical for social networks ranging from 0.30 to 0.48. Regional reciprocity shows slight variation (0.11-0.24)

Likewise, at the node level, the regional pattern of measurement varies very little in comparison to the national network. Total degree centrality is quite low (0.003-0.038). The regional clustering coefficients range between 0.13 and 0.25. The effective network sizes are between 1.5 and 2.3, and the regional clique counts show the average health official participating in just 1 to 2.6 cliques. This compares to research which shows that individual support networks range between 2 and 11 persons with membership in around 5 cliques.[29-32]

Subgroup analysis

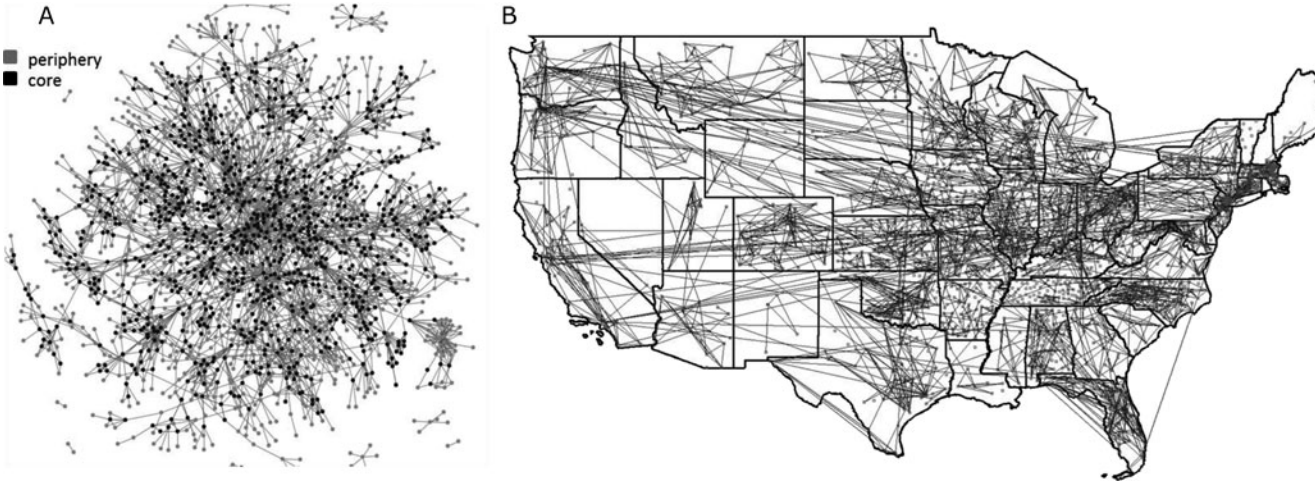
The CONCOR calculation produced about 5 large homomorphic groups that ranged in size from 93 to 786 LHDs. Four of these structural groupings exhibited no discernible pattern in the mix of states represented neither in the mix of states in the group nor in per capita income of the jurisdictions represented. One of the groups had a larger mean population served than other groupings because of presence of a few large urban counties (eg, New York, Los Angeles, Chicago). When CONCOR was applied to the regional sub networks, the groupings arranged ties between LHDs almost exclusively within states, with minimal evidence of overlap across those boundaries.

● Discussion

Limitations

The analysis has several limitations that must be considered. First, the data are cross-sectional and changes may have occurred in the network since the data were collected in 2010. The data represent 78% of LHDs, and

FIGURE 2 ● The Health Officials' Advice Network Showing a Sparsely Connected Core Periphery Structure (A) and Geographical Distribution of the Network (B) Note the "Clump And Gap" Pattern That Characterizes The Network In Both Images.



the patterns we found only reflect this subset of the full network. The data represent only communication between local health officials. Communication with state health departments or state associations of health officials, and the role those organizations have in diffusing information is not considered here, nor was communication that may occur between program staff in LHDs part of this investigation. Finally, respondents were allowed to name only 5 contacts, and the 814 health officials who did so may communicate with more of their peers.

Summary

We examined a large part of the network through which local health officials communicate. Overall, we found a sparse core periphery network with little evidence of unified communication, but with a localized transitive structure within which health officials on average communicate with just 2 of their peers. Examination of regional networks and subgroup analysis showed a clumping communication pattern that largely follows state boundaries.

In a core periphery network, the main diffusion of ideas occurs at the core, where there are more ties to foster communication. Health officials at the periphery would then depend on communication diffusing from the core. In this case, because ties are sparse at both the core and the periphery there are likely limits to how efficiently ideas can diffuse. Further, low centralization suggests there is no group of health officials serving as thought leaders or coordinating the flow of information within the HOAN. The social science theory associated with network transitivity suggests that mutual links in groups lead to interpersonal trust, greater cooperation, and enforcement of norms.[33,34] In this measurement, HOAN is similar to most social networks, but transitivity should be considered in the context of the tendency to form ties with similar others,[5] which in HOAN appear to be formed on the basis of location versus factors such as jurisdictional similarity. This pattern likely limits the flow of ideas, and contributes to pervasive gaps in the network. The reciprocal link count of 15% may reflect the response rate and question limit of 5 contacts. Yet it is low enough to suggest that most health officials do not perceive themselves of equal status when communicating about professional issues in public health.[35] At the node level, measurements show an average health official who has few ties to peers, limited group membership, and a small effective network, even within his or her local area.

Implications

Overall, the gaps in information flow implied by this topology suggest that a direct peer-to-peer network is likely *not* the primary way local health officials communicate about administrative, professional, and leadership issues in public health. As it is currently structured, the HOAN may make only a limited contribution to facilitating innovation and the spread of best practices.

Among possible explanations is that health officials communicate about professional issues via other methods, such as through state associations of local health officials, and perceive no need to communicate otherwise. They may be pressed for time, or factors such as newness to the job may impede their ability to develop and sustain trusting professional communication networks. They may resist communicating for fear of appearing professionally weak or inexperienced.

As a professional advice network the HOAN potentially can provide channels to coordinate activities and reinforce best practices[1] and to diffuse of information about best practices and other innovations.[36] To do so efficiently, greater structural embeddedness is needed. This network property can be defined as the extent to which health officials' mutual contacts are connected to one another. Structural embeddedness is a function of how many participants interact with one another, how likely future interactions are, and how likely participants are to talk about their interactions.[37,38] The more structural embeddedness there is in the network, the more information each health official knows about the public health practices of their peers, and the more influences there are on health officials' behavior.[39] Information and influence might focus on professional issues such as culture change regarding quality improvement, enhanced leadership techniques, or improved business practices.

One approach might be to take advantage of the transitive groupings that naturally occur in the HOAN through an initiative that purposively partners LHDs in groups of at least 3, the members of which cross local boundaries. This could be initiated singularly or in partnership by national organizations invested in PH system improvement, such as the Association of State and Territorial Health Officials; NACCHO; the Office for State, Tribal, Local and Territorial Support at the Centers for Disease Control and Prevention; or the Public Health Accreditation Board.

Events in public health systems may accomplish this task naturally. The national accreditation process may encourage health officials to seek out the experiences of peers who are early "adopters" of accreditation and not among their customary local communication ties. New requirements for 501(c)(3) hospitals under the Affordable Care Act call for engagement in community health assessments.[40] Such assessment is a core function of public health systems and it is expected that clinical/public health partnerships will surge around this activity. Communication may increase among LHDs seeking to learn from each other how to proceed. Health officials may reach beyond their proximal communication partners to those LHDs with early experience in this practice. The situation is dynamic and we expect subsequent evaluation of the HOAN will show evidence of increasing communication ties, and the diffusion of innovation which that implies.

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