

The Influence of Management and Environment on Local Health Department Organizational Structure and Adaptation: A Longitudinal Network Analysis

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Objective: The nation's 2862 local health departments (LHDs) are the primary means for assuring public health services for all populations. The objective of this study is to assess the effect of organizational network analysis on management decisions in LHDs and to demonstrate the technique's ability to detect organizational adaptation over time. **Design and Setting:** We conducted a longitudinal network analysis in a full-service LHD with 113 employees serving about 187 000 persons. Network survey data were collected from employees at 3 times: months 0, 8, and 34. At time 1 the initial analysis was presented to LHD managers as an intervention with information on evidence-based management strategies to address the findings. At times 2 and 3 interviews documented managers' decision making and events in the task environment. **Results:** Response rates for the 3 network analyses were 90%, 97%, and 83%. Postintervention (time 2) results showed beneficial changes in network measures of communication and integration. Screening and case identification increased for chlamydia and for gonorrhea. Outbreak mitigation was accelerated by cross-divisional teaming. Network measurements at time 3 showed LHD adaptation to H1N1 and budget constraints with increased centralization. Task redundancy increased dramatically after National Incident Management System training.

Conclusions: Organizational network analysis supports LHD management with empirical evidence that can be translated into strategic decisions about communication, allocation of resources, and addressing knowledge gaps. Specific population health outcomes were traced directly to management decisions based on network evidence. The technique can help managers

improve how LHDs function as organizations and contribute to our understanding of public health systems.

KEY WORDS: network analysis, performance improvement, public health informatics, public health systems

The current environment of dynamic change in population health needs and resource availability is challenging local health departments' (LHDs) efforts to assure that quality public health (PH) services are accessible to all.¹⁻⁴ One approach to optimizing PH service delivery is through management strategies that enhance how LHDs function as organizations.⁵ Like all organizations, LHDs consist of employee networks through which specialized information is conveyed, resources are distributed, and tasks are accomplished. Similarly, all LHDs must also adapt to a *task environment* dictated by external events and circumstances that affect population health needs. The task environment in any jurisdiction can change rapidly and stress channels of communication.^{6,7} Relevant information and resources may not always be available when needed for employees to perform their tasks.⁸ This can lead to communication gaps and duplication of effort.

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This study was supported by the Robert Wood Johnson Foundation grant ID 59946. Keeling is supported by National Library of Medicine grant T15-LM007079.

The authors thank the employees of the Champaign-Urbana Public Health Department for participating in this research.

The authors declare no conflicts of interest.

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DOI: 10.1097/PHH.0b013e3182544800

Organizational network analysis is a technique that combines mathematics and social science to detect patterns in how LHDs operate by examining the ties between employees and their work.⁹ The method produces measurements and visualizations that are interpreted on the basis of organizational and management theory. The result is evidence that informs and supports managers' decisions to improve organizational adaptation and performance around key factors such as integration and coordination. The method is an example of an emerging paradigm that aims to support decision making by creating contextual meaning to promote cognitive understanding.¹⁰

Our objective in presenting this longitudinal network analysis is 3-fold. First, we describe how organizational network analysis is applied in an LHD. Second, we describe the decisions made by LHD managers on the basis of evidence from network analysis and assess the effect of those decisions on service delivery and population health outcomes. Third, we demonstrate how network measurements reflected the LHD's adaptation to environmental conditions over a period of 34 months.

● Materials and Methods

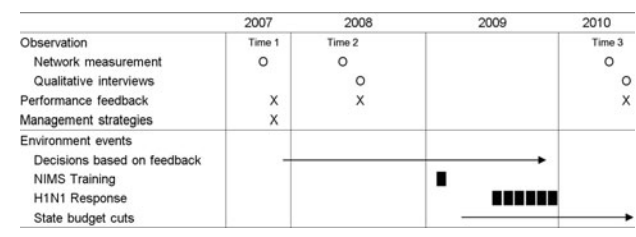
Study population

The study was conducted in a full-service LHD, which provides health promotion, injury prevention, and environmental services to an urban/suburban population of about 187 000 persons.¹¹ The LHD size was on average 113 full time employees. It consisted of a main facility and an off-site satellite clinic. The LHD was administratively structured into 6 divisions: administration, dental, environmental health, infectious disease control, maternal and child health (MCH), and wellness and health.

Study design

An opportunistic longitudinal design was used. Network data were collected at 3 time points via an online survey, as shown in the Figure 1. At time 1 (September 2007), data collection was followed 1 month later by a face-to-face intervention in which 2 forms of evidence were presented: (1) network performance feedback and (2) targeted management strategies. Network data were again collected via survey 8 months later at time 2 (June 2008), and 34 months later at time 3 (August 2010). Web presentations of network performance were conducted within 2 weeks after each survey, and semistructured phone and Web interviews were conducted with managers. The 8-month duration

FIGURE 1 ● A Longitudinal Network Analysis Conducted Over 34 Months With Observations Taken at 3 Time Points



Observations consisted of organizational network measurements and semistructured interviews with managers. Performance feedback consisted of network measurements and visualizations. At time 1, performance feedback was presented with evidence-based management strategies. The timeline of local health department managers' internal decisions and events in the external task environment during the study period are also shown.

between time 1 and time 2 was chosen to give the LHD a period of time to enact organizational change. The 26 months between time 2 and time 3 was a result of the administrator's request for a repeat analysis after the H1N1 response and recession-related budget constraints. The study was approved by the Columbia University institutional review board.

Network survey

All LHD employees were asked to complete a standard online network survey (at 3 time points) that was previously developed by the researchers.¹² Section I of the survey asked about *employee-to-employee communication*, defined as giving or receiving information about PH work, including e-mail and phone calls. Each employee was asked to classify communication between themselves and each other employee as *routine and frequent* (daily or weekly), *routine but not frequent* (monthly or quarterly); or *nonroutine* (communication would be unusual). Section II of the survey was based on a taxonomy of essential PH work identified in a previous study.¹³ Each employee was asked to indicate from a list of

- *44 tasks*, those (a) assigned to him or her as part of normal work and (b) not assigned but he or she could perform if needed.
- *53 knowledge items*, those for which he or she possessed better than average knowledge
- *54 resources*, those (a) readily available when needed for daily work and (b) either completely unavailable or accessing the resource delayed work

Intervention

The intervention occurred at time 1. It consisted of a 2-hour face-to-face meeting during which the researchers

presented network performance feedback and management strategies to the LHD management team. The network measurements and visualizations presented described communication, integration, and coordination within the LHD.¹⁴ The network evidence was interpreted through discussion with the managers to place each measurement in context for that LHD. Five evidence-based management strategies that have been empirically demonstrated to improve organizational integration and coordination were described during this discussion.¹⁵ These were selected on the basis of relevance to PH organizations and strength of the evidence supporting them: cross functional teams¹⁶⁻¹⁹; cross training²⁰⁻²³; formal and informal communication methods²⁴⁻²⁸; knowledge transfer²⁹⁻³²; and methods to increase transactive memory (ie, who knows what).³³⁻³⁸ These strategies aim to improve flexibility and control in areas of functional overlap, information access, knowledge search and transfer, and decision making throughout the organization.

Follow-up interviews

Semistructured interviews of the LHD management were conducted by the researchers at time 2 and time 3 to document decisions the managers made in response to the network performance feedback and to document events in the task environment. Managers described specific decisions, evidence of outcomes they associated with their decisions, and the perceived effect of external events on the LHD.

Data analysis

The Organizational Risk Analyzer (ORA) computer program developed at Carnegie Mellon University was used for analysis.³⁹ Responses to section I of the survey produced 2 employee communication networks: one representing frequent and infrequent communication, or “all ties”; the second representing *only* frequent communication, or “strongest ties.” Nonroutine communication was not analyzed. Responses to section II of the survey produced 5 networks: employees in relationship to (1) tasks assigned; (2) task backup; (3) resources available; (4) resources needed; and (5) knowledge. From these networks, we calculated a set of 8 network measurements.⁴⁰ The definition, interpretation, and results of these network measurements are shown in the Table. Measurements were compared at 3 time points. To contextualize the network results, baseline data from a prior study of 10 LHDs⁴¹ are used for comparison and displayed in the Table.

● Results

The response rates to the network surveys at times 1, 2, and 3 were 90%, 97%, and 83%, respectively. Employee turnover was 5% between times 1 and 2, and 17% between times 1 and 3. The LHD size, with turnover, was between 102 and 115 employees during the study. The management team did not change. When compared with a national sample of 10 LHDs, on average, this LHD had a greater number of employees aged 18 to 55 years (91% vs 73%) and fewer aged 56 to 69 years (8% vs 26%).⁴¹ Also, when compared with our national sample, on average, this LHD had more employees with 0 to 19 years of PH work experience (98% vs 82%) and fewer with 20 years of experience (2% vs 18%) or more. The differences were significant at $P < .05$.

Organizational change: time 1 to time 2

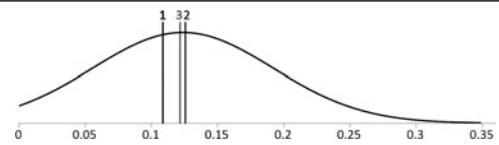
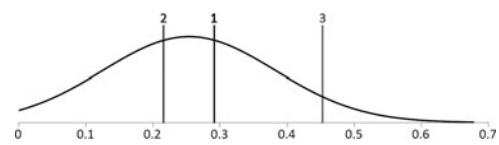
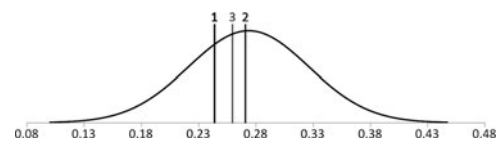
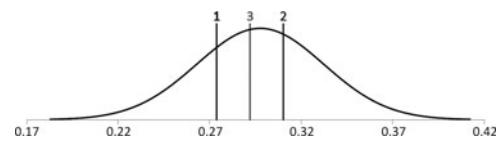
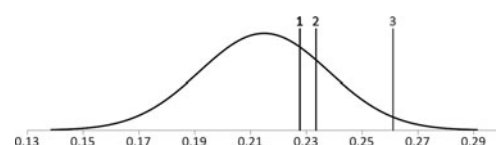
Interviews with managers recorded the decisions and changes they made during the 8-month postintervention period based on the feedback and strategies they received at time 1. Their decisions were aimed at increasing communication, collaboration between divisions, and access to resources and knowledge. For example, monthly staff meetings were instituted, during which divisional reports were shared. The director’s office was physically relocated to increase staff access and opportunities for feedback. Those whose ideas were implemented were recognized for their efforts. An e-mail listserve was started for team building and to disseminate knowledge on PH topics and roles. Finally, an intranet was established for employees to post and access resources.

Between time 1 and time 2 communication density in the *all ties* and *strongest ties* networks increased by 22% and 16%, respectively. Network centralization was unchanged in the *all ties* network but decreased by 26% in the *strongest ties* network. Complexity improved suggesting more integration within the LHD. Redundancy of tasks assigned, knowledge, and resource available increased.

Population health outcomes

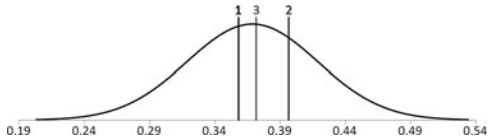
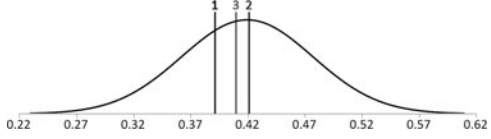
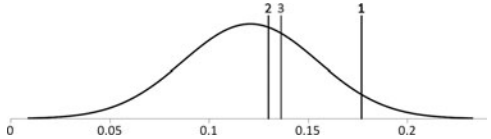
As communication increased, employees became more aware of activities in the LHD that affected their work. This resulted in a partnership between the infectious disease and the MCH divisions to extend sexually transmitted infection (STI) screening to urine specimens collected during MCH clinic visits. An additional 460 women were screened. Of these, 43 (9%) women were positive for Chlamydia and 5 (1%) for Gonorrhea. All were asymptomatic and likely would not have sought testing or treatment. Treatment of the women

TABLE ● Definitions and Interpretation for 8 Network Measures Presented With Longitudinal Results for the Strongest Ties (Daily/Weekly) Network at 3 Time Points^a

Measure	Definition/Interpretation	Results
Density	<p>Proportion of communication links present versus the maximum number of links possible between employees. If all employees are connected, the density is 1. Measurements closer to 1 suggest inefficient or repetitive communication. Density closer to 0 suggests gaps in communication. Complex work typically requires higher density than simple work.</p>	 <p>A relatively low proportion of communication links at time 1 improved at time 2, attributed to communication initiatives. This gain was maintained at time 3.</p>
Centralization	<p>Reflects the extent to which communication is controlled by a core group, in this case, the leadership team. Measurements around 0.5 and more indicate hierarchical communication, where decisions are made in a “command and control” style. Measurements closer to 0 suggest distributed communication where decisions are made closer to the point of service.</p>	 <p>Communication became more distributed between time 1 and time 2. Communication became markedly more centralized at time 3, attributed to the H1N1 response.</p>
Complexity	<p>Proportion of links present versus maximum possible links in all 4 matrices: employee × employee; employee × knowledge; employee × task; and employee × resource. Complexity approximates organizational integration. Lower values suggest inefficient coordination. Higher values are beneficial until a (unknown) point when dependencies are so high that one error leads to subsequent errors across areas.</p>	 <p>Complexity improved between time 1 and time 2. Some of these gains were lost at time 3, driven by decreases in the task and knowledge networks.</p>
Task redundancy	<p>The proportion of 44 tasks assigned to the average employee. Reflects the degree of system back up and capacity for reliable service as conditions change in the task environment. Lower values, closer to 0, suggest limited ability for an organization to rapidly adapt, whereas values closer to 1 suggest wasteful duplication of effort.</p>	 <p>A beneficial increase in task redundancy between time 1 and time 2 was attributed to increased collaboration. A decrease at time 3 was attributed to budget constraints that narrowed divisional focus.</p>
Task backup	<p>The proportion of 44 tasks not assigned, but that the average employee could perform <i>if needed</i>. Like task redundancy, this measure reflects organizational adaptability to changing conditions. Measurements closer to 1 indicate potentially unnecessary cross training. Measurements closer to 0 signify limited ability to adapt to absences or staff turnover.</p>	 <p>An increase in public health knowledge from the listserve training initiative, and increased collaboration improved task backup capability at time 2. NIMS training led to a marked increase in task backup capability at time 3.</p>

(continues)

TABLE ● Definitions and Interpretation for 8 Network Measures Presented With Longitudinal Results for the Strongest Ties (Daily/Weekly) Network at 3 Time Points^a (Continued)

Measure	Definition/Interpretation	Results
Knowledge redundancy	The proportion of 53 knowledge items for which the average employee possessed “better than average” knowledge. Measurements closer to 1 suggest a broad knowledge base with limited specialization. Measurements closer to 0 suggest limited breadth of knowledge for performing complex work.	 <p data-bbox="853 411 1360 566">Knowledge increased between time 1 and time 2 as communication and resource availability improved. The decrease at time 3 was attributed to budget constraints that narrowed program focus and the emphasis on H1N1 preparedness.</p>
Resource available	The proportion of 54 resources to which the average employee has access. When measurements are closer to 0, it may signify limited availability of resources with possible delays in work. When measurements are closer to 1, it may signify possible waste.	 <p data-bbox="853 712 1360 803">Resources became more available between time 1 and time 2 as communication and knowledge increased. A slight decrease at time 3 was attributed to budget restrictions.</p>
Resource needed	The proportion of 54 resources not available when needed, or getting them delays work. Measurements closer to 0 signify adequate access to resources. Measurements closer to 1 signify gaps in resources.	 <p data-bbox="853 977 1360 1136">Employees indicated fewer resources that were not available between time 1 and time 2, which local health department managers attributed to better communication and management. A slight increase at time 3 was attributed to budget constraints.</p>

^aResults are plotted against normal curves approximated using the mean and standard deviation for network measurements from a national sample of 10 local health departments.⁴⁶ All measurements are standardized to fall between 0 and 1.

and their partners resulted in a population health improvement through prevention of STI sequelae.

Increased communication also produced a cross-divisional outbreak investigation team. When a report came in on a Sunday morning of widespread vomiting and diarrhea at a congregate living facility for teenagers, the preassembled team addressed the situation that day. Although cross-disciplinary investigation teams are not novel, forming this particular team was a direct result of management decisions to increase inter-divisional collaboration on the basis of evidence from the network intervention.

Organizational adaptation: time 2 to time 3

The period between time 2 and time 3 was concurrent with the 2008 economic recession and the 2009 H1N1 pandemic. Interviews with managers at time 3 recorded how the LHD adapted to these changes in the task environment.

Shortly before time 3, the LHD participated in National Incident Management System training consisting of Federal Emergency Management Agency courses that outline responsibilities and activities for public agency managers in emergencies.⁴² The LHD completed “3-deep” training, the goal of which is to have at least 3 employees able to complete each critical task in an emergency. Between time 2 and time 3, the *task backup* network density increased an additional 12% over previous gains.

During the H1N1 response, the management team was relocated to an emergency operations center for 6 months and separated from the LHD staff. At this location, the LHD managers applied insights gained through network analysis to external partnerships by initiating an online resource for communication between their response partners, which augmented the community’s overall H1N1 response with enhanced support for PH countermeasures.⁴³ The LHD was recognized by the Centers for Disease Control

and Prevention as a national exemplar for its H1N1 response.⁴⁴

However, at time 3, many of the management strategies prompted by the time 1 evidence were negatively affected and network gains were lost. Relocation of the management staff during H1N1 response disrupted communication. A marked change occurred in the *strongest ties* network where centralization increased by 110% reflecting the “command and control” communication required by the H1N1 response. Budget constraints^{45,46} led to the loss of 11 employees, and there was a shift in focus to core service delivery over collaboration. The MCH/STI screening program ended. Network density and complexity decreased.

● Discussion

This longitudinal network analysis of one LHD describes the effect of an intervention consisting of organizational network analysis, network performance feedback, and management strategies to improve integration and coordination. This approach is novel because it supports managers in applying evidence to improve performance rather than simply assessing performance.^{47,48} Significantly, through detailed interviews, the researchers traced management decisions made between times 1 and 2 directly to improved service delivery and to a specific population health outcome.

Prior to the intervention suboptimal communication may have been creating work inefficiencies. Network measurements at time 1 suggest information silos between the divisions.⁸ At time 2, network centralization was reduced, which reflects more ties among divisions rather than directed toward the administrative core. Increased complexity suggests that management was successful in increasing organizational coordination and integration. Improvements in the task, knowledge, and resource networks suggest increased employee capability in these areas. Increased density in the *strongest ties* network suggests new lines of day-to-day communication that support distributed decision making at the point of service.

A reduction in *resources needed* by simply instituting an intranet suggests that the analysis revealed unknown/unreported problems to the management team. Managers identified this as a lack of feedback from employees and implemented policies to address it. The management team took advantage of lessons learned from the analysis to improve the external H1N1 response, suggesting a solid grasp of communication strategies. Our previous research found improved communication density and complexity associated with improved performance mobilizing community partner-

ships and linking people to health services, which are essential in any response.⁴¹

The changes in network structure between times 2 and 3 were likely influenced by known factors including elapsed time since the initial network analysis, state-wide budget reductions, and organizational stressors associated with the H1N1 response. The marked increase in centralization seen at time 3 is an example of how network analysis can document organizational adaptation, in this case, through reduced collaboration and a retreat to defined programmatic services. This contributes evidence about the effects of public sector resource allocation and corroborates other research showing that during economy-related funding reductions, cross-cutting PH functions are vulnerable.^{49,50}

Public health performance initiatives often focus on allocation of funds and resources to improve programs and service delivery.^{51,52} Management is the core service that integrates and coordinates all other services required to meet population health needs. Local health department managers control and direct programs and service delivery but typically have little access to management science.^{47,48} Organizational network analysis supports LHD management with empirical evidence that can be translated into strategic decisions about communication, allocation of resources, and addressing knowledge gaps. Network evidence produces decisions grounded in cognitive understanding of the interactions within the organization, not simply based on rules or prescriptive frameworks. Despite wide use in the private sector, few LHDs have taken advantage of this management technique.^{53,54} Reasons may include lack of awareness or perceived need, limited time and manpower, or costs of hiring consultants to perform the analysis. Because of the direct and actionable benefit network analysis provides to LHD managers, it may not be more costly in terms of resources allocated than current performance initiatives. It is an opportune time to introduce this technique to PH with an accreditation process recently initiated and with provisions in the Patient Protection and Affordable Care Act of 2010 intended to restructure and improve the capacity of PH organizations.^{55,56}

Limitations

This study represents findings from a single health department, which limits its generalizability to other LHDs. There was significant turnover in the LHD prior to this analysis. As a result, employees were significantly younger and less experienced than in other LHDs where we have applied this method. For this reason, they may have used the findings and made management decisions differently than other LHDs. Interviews relied on managers self-report, which could have

been biased. However, triangulation of quantitative network measurements with sequential explanatory data from qualitative interviews reduced this threat to credibility.

● Conclusion

This study demonstrates that management is as critical for LHDs as it is for any organization. It makes credible the notion that LHD managers can benefit from strategies and techniques such as network analysis that are used in the private sector. The LHD managers asserted that the network analysis “changed their thinking” about the role of management. They compared the insights they gained from visual representation of the LHD networks to insights gained about disease distribution from geographic information systems.⁵⁷ Specific changes in health department management, communication, and internal partnerships are a strong indication that network analysis can make major contributions to our understanding of PH systems and our ability to improve them.

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