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ABSTRACT

A Network Analysis of Information Use in a Public Health Organization

Jacqueline Carty Merrill-Matzner

Organizational network analysis was used to study information use in a health department. Public health performance depends on specialized information that travels throughout an organization via communication networks among employees. In most cases, the interactions that occur within these networks are poorly understood and unmanaged. The goals of this study were to determine what links existed between information use and performance, and to assess organizational network analysis as a tool for public health management.

Data on communication links among the health department's staff was obtained via survey, with a 93% response rate. Data on resources, tasks and knowledge was obtained from a concurrent research study for secondary analysis. These data were configured in matrices: agent x agent, agent x resources, agent x task, agent x knowledge, and agent x external organizations. These were analyzed as meta-matrix using Organizational Risk Analyzer (*ORA*) software. This produced reports at the individual, program, and organization level.

The results yielded graphical representations of network structure and statistical reports on: quality of the information network; employees in key positions in the network; the status of experienced staff; and an analysis of a planned merger of two divisions.

Findings revealed problems in information flow, including the likelihood that sub groups are controlling knowledge and resources; overspecialization of knowledge; potential for significant knowledge loss through retirement; little back up for personnel turnover; and informational silos. The findings suggest that the department needs greater redundancy and better cross program coordination, but has strengths such as efficient communication paths and good social density in the programs. The department's leaders offered feedback on specific strategies they intend to use to address knowledge loss, to increase shared situation awareness, and to take advantage of network strengths.

This study has demonstrated that organizational network analysis has utility for this health department. Insights from the analysis have informed strategies for improving performance. The technique has potential for public health information management. Additional research is needed to refine network analysis methods for the public health domain.

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DEDICATION

To Mary Klohr Merrill and Charles E. Merrill, Jr.

Few people are as fortunate as I, to have experienced the degree of approbation and generosity that you bestowed upon me.

It is because of you that I have realized this professional achievement.

CHAPTER 1 INTRODUCTION

This chapter presents an overview of the dissertation project. It describes the scope of the problem investigated, the project's specific aims and associated research questions, and a brief description of the research approach. The concepts upon which the research design is based are defined and a conceptual model is presented, followed by an explanation of the project's significance.

1.1 Problem Statement

Public health agencies are multi-dimensional arrangements of information processing networks that construct meaning, create knowledge, and make decisions. Thus they can be characterized as complex organizations (Principia Cybernetica, 1999). Complex organizational behavior is patterned on that of complex adaptive systems, in which structure and process emerge from interactions within and between individuals, resources, knowledge, tasks, and other organizations (Carley & Heinz, 2001). These relationships are critical to individual and organizational decision making and action. The overall structure of an organization determines how information diffuses among individuals, with consequences for the speed, quality and accuracy of organizational decisions and performance (Carley, 2002a). Thus, effective flows of information are understood as critical to performance (Galbraith, 1973; Lumpkin, 2002).

The combined collection, analysis, use, and communication of health-related information sustain all public health services (Lasker *et al.*, 1995; Lee, 2001). The use of information is an essential component of the structural capacity of health departments, and public health performance depends on the effectiveness of information use (Koo *et al.*, 2002; Turnock, 2000). Results from a survey of public health workers displayed in Table 1 illustrate the range of information public health workers indicate they need to perform more effectively. Yet, despite the importance of information to the practice of public health, the complex information needs of the public health workforce are not well met (Alpi, 2005; Association of State and Territorial Health Officials, 2004a; Hinman, 2002; Lee *et al.*, 2003; New York Academy of Medicine, 1998; Rambo *et al.*, 2001).

Table 1 Information needs of public health workers in Washington State

Public Health Information Needs (Rambo, 2000)
1) Better tools and resources for contacting experts
2) Updates on pertinent legislative issues and events
3) Structured information ("metadata") characterizing the contents of data sets
4) Outcome measures and "best practice" resources
5) Better scheduling software and event calendars
6) Standard templates for frequently used applications
7) Synthesized, knowledge-based information from external databases

The dynamics within complex systems can obscure our understanding of the real relationship between information and performance, due to frequently difficult-to-comprehend interactions among multiple elements of the organizational system (Radzicki, 1997; Sterman, 2000). For example, health department structure can contribute to unmet information needs when publicly funded mandates result in

“silos” in which different program teams might address interrelated problems, use similar interventions, or share a target population, all the while working in parallel, with little integration across program areas (Kitch & Yasnoff, 2002). A clear understanding of the flow of information in the public health organization is required to justify allocating limited public resources to manage information needs. Hence it is essential to demonstrate how information use is linked to agency performance.

Network analysis is a tool for unraveling organizational complexity. It is an empirical descriptive research method derived from social science and graph theory. When applied to an organization, network analysis allows simultaneous analysis of many interrelated elements in the organizational system. This approach reveals aspects of individual and system behavior that may not be evident to those embedded within the system. Through comprehending the complexities of how information flows between and amongst people, resources and tasks in an organization, it is possible to more accurately identify ways to improve how people access, use, and share information, with the goal of improved performance. This proposal is based on the proposition that analysis of the information network in a public health organization can describe and provide insight into relationships among the complexities described above, and suggest areas where improved flows of information can influence organizational performance.

1.2 Purpose

The research described here is an empirical, descriptive, cross-sectional analysis of the information network in a health department. The goals of this research are to afford the agency's leadership with a better understanding of the complex patterns of information use in the agency, and to contribute to general knowledge about information use in public health work. This has been accomplished by describing the information network, and by identifying links between workers, resources, tasks and knowledge that may influence agency performance. The analysis has produced network diagrams and statistical models that describe and provide insight into how information is used in the organization.

1.3 Research Objectives

The objectives of this study are to:

1. Empirically describe the structure of information flow in a health department using organizational network analysis.
2. Determine possible links between information flow and agency performance, as suggested by the network model
3. Assess the utility of the method as a diagnostic tool for public health information managers

The project's specific aims and associated research questions are displayed in Table 2.

Table 2 Study objectives, specific aims and research questions

Study Objective	Specific Aims	Research Question
1. Empirically describe the structure of information use (information flow) in a health department using organizational network analysis.	1a) Collect relational data on the agency-wide communication network 1b) Produce visual and quantitative network models that describe information flow	1. What is the structure of information flow in the health department's communication network?
2. Determine possible links between information flow and organizational performance, as suggested by the network model	2. Analyze the network visualizations and statistics to determine possible links between information flow and performance.	2. What relationships between information flow and performance are suggested by the model?
3. Assess the utility of organizational network analysis as a diagnostic tool for public health information managers	3. Collect feedback from department leadership on a) the expected impact of the analysis b) value of this method for managing information	3a) How do department leaders expect to use the findings to make an impact on information management? 3b) What is the value of network analysis for public health information managers?

1.4 Theoretical Framework

Several theories are interrelated to form the framework for this study:

organizational theory, which is extended by information processing theory; and network theory, which is informed by graph and complexity theory. These theories are briefly described here and discussed more fully in Chapter 2.

Contemporary organizational theory incorporates aspects from general systems theory (Bertalanffy, 1968) in viewing an organization as a collection of agents (usually representing human actors, but sometimes intelligent machines) that

interact and produce some form of output that is beyond the capacity of any single agent (Chang & Harrington, 2004; Wertheim, 2001). Information processing theory extends organizational theory by characterizing these interactions as an information processing network operating under conditions of uncertainty (Galbraith, 1973). Information is viewed as ubiquitous and distributed widely across multiple agents (people, groups, machines) within organizations (Carley & Wallace, 2001). Uncertainty is the difference between the amount of information needed to perform a task and the amount of information already possessed by the organization (Galbraith, 1977). This difference, and how it is managed, determine the quality of output, or performance. The greater the uncertainty of the task, the greater will be the amount of information that must be processed to achieve a given level of performance. Organizations evolve to accommodate uncertainty and to reduce the need or increase the capacity for information processing.

Network theory is based on linkages among units within a network (Wasserman & Faust, 1994). A network is an interconnected system of things or people (Princeton University Cognitive Science Laboratory, 2003). In an organization, networks are comprised of *nodes* that represent agents, knowledge, tasks, or resources, and *links* that show relationships between the nodes. Depending on the scale of analysis, an agent may represent an individual, a project team, a division, or an entire organization (Dooley, 2002). Agents have varying degrees of connectivity with other agents through which information and resources flow.

These interdependent "node-link" structures, while simple in concept, become related in multifaceted ways as networks grow and develop. The resulting complexity can be graphically displayed and analyzed using mathematical expressions that are based on the properties of graphs, i.e. graph theory.

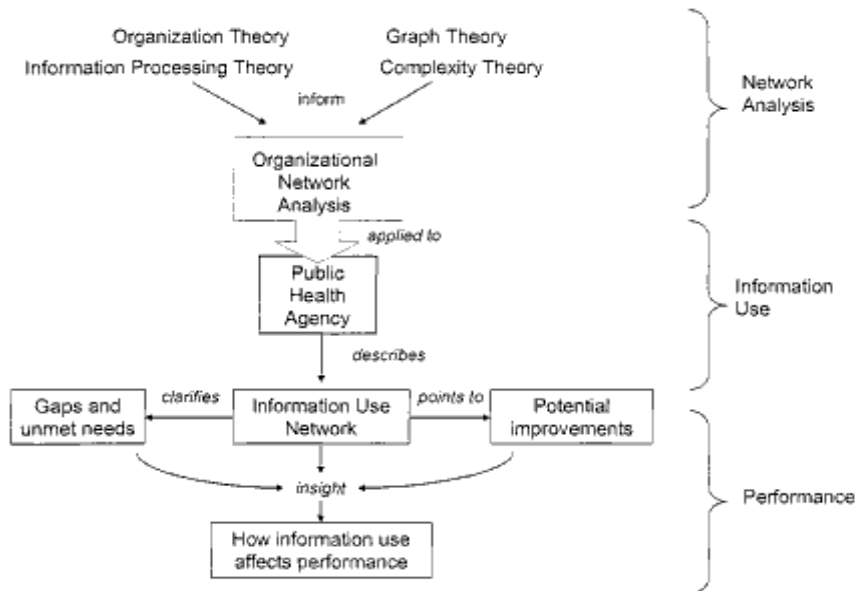
Complexity is the quality of being intricate and compounded (Princeton University Cognitive Science Laboratory, 2003) and refers to the number of connections among elements, or the rate at which relationships among elements of a system change. Complexity theory describes the uncertainty created by non-linear dynamics in systems, where small changes are amplified through many interactions with other variables so that the eventual effect is unpredictable (Pearson Education, 2004). A fundamental principle of complexity theory holds that the structure of a system gives rise to its behavior (Sterman, 2000). The study of complexity has found that the inter-related behaviors of even the simplest network are difficult or impossible to grasp by human cognition without assistance (Krackhardt, 2002).

1.5 Conceptual Model

This study is based upon three concepts. The first is the notion of organizational *network analysis*, a means for understanding complex behaviors of dynamic organizational systems. The second concept is that of *information use* in the public health organization. The interaction of these concepts creates a means to examine aspects of *performance*, which depends on how information is used in

the complex processes of a public health agency. These concepts are defined below and discussed more fully in Chapter 2. A model developed from these concepts, displayed in Figure 1, guided this research.

Figure 1 Conceptual model



Organizational Network Analysis

Organizational network analysis is an application of *social network analysis* (a method that is typically focused on connections between individuals) to an organizational entity. It is a descriptive, empirical technique for mapping and measuring relationships between people, groups, and organizations with the

resources, knowledge and tasks that are used to perform work. The technique draws upon theories of organizations, networks and complexity to produce models representing the structure of relationships that would be infeasible to describe without relational concepts (Wasserman & Faust, 1994). The results yield insight into organizational behavior.

Organizational network analysis derives from the notion that traditional organization charts and process maps fail to capture the complex web of information interactions. True patterns of information exchange are not explicit and therefore tend to be unmanaged processes in most organizations (Stephenson, 1996). Organizational network analysis provides both a graphical and a quantitative analysis of complex human systems to describe the flow of information along existing pathways in organizations (Krebs, 2005). When the results of network analysis are interpreted in relation to formal organizational hierarchies, opportunities for improvement can be discovered.

Information use

Information use, broadly interpreted, includes how information flows and how information resources and information technologies form, maintain, and serve specific communities of practice (University of Michigan School of Information, 2004). Information use is any activity involving the delivery, accessibility, collection, organization, or visualization of information; this might involve initiation of a search for information, selection of information sources, the process

of exploration for new or needed information, methods for formulating or focusing information requirements, the process of collecting information, viewing information, or presentation and delivery of information (Kuhlthau, 2001). In the context of the public health agency it can include typical business information processing such as text writing, drawing, calculating, filing and communicating information (Aalst & Hee, 2002). Information use is part of specialized tasks such as field investigations, inspections, surveillance, sample collection, or direct provision of health services. Information flow is an aspect of information use in the agency's communication network. This flow of information is essential to public health performance (Association of State and Territorial Health Officials, 2004a; Lee, 2001; Lumpkin, 2002; Ross, 1998).

Public Health Organizational Performance

Organizational performance is an interaction between *organizational knowledge* (a function of individual training, knowledge and information processing capabilities), and *organizational structure* applied to the work of the organization (Carley, 2002a). If we apply this definition to public health, then knowledge in any public health agency is a function of staff trained in public health plus public health data, information and knowledge. Accordingly, public health organizational structure is comprised of mission, structural capacity, processes and outcomes (Handler *et al.*, 2001). These elements interact to determine how well public health can perform its mission: assuring conditions in which people can be healthy (Institute of Medicine, 1988). In a given public health agency,

performance will be defined by the specific goals that fit that agency's structural capacity and that guide processes for addressing the needs and concerns of the communities served (Turnock & Handler, 2001). Network analysis allows us to describe organizational complexity within the framework of the information network. The results yield insight into how these interactions may influence performance (Carley & Hill, 2001).

Table 3 displays these concepts in relation to the measures used in this study. Measures are further explained in Chapter 3, Table 14. The formulas used to calculate these measures in *ORA* are supplied in Appendix D.

Table 3 Conceptual elements in relation to network measures

Concept	Measure
Network Analysis	Individual level Cognitive demand Degree Centrality Betweenness Centrality Eigenvector Centrality Betweenness Centrality/Degree Centrality Shared situation awareness Network level Density of the social network Complexity of the overall network Average situation awareness between agents Network Centralization Transitivity (presence of transitive groups)
Information use	Diversity of knowledge and resources Redundancy of resources, assignments, and knowledge Communication speed Efficiency of message transmission
Performance	Impact of findings on the organization Managerial Value Changes to organizational processes Redeployment of resources Function changes Cross program support

1.6 Significance

This work is important because it i) produces a model that describes the complex network that exists between public health workers and information use, and ii) provides insight into how the flow of information in a public health organization might influence performance, and iii) it demonstrates the utility of network analysis for managing information in a public health agency.

Although network analysis is a technique that has proven useful for managing information and improving performance in organizational systems (Chang & Harrington, 2004; Cross & Parker, 2004; Kilduff & Tsai, 2003; Krebs, 2005), there is no documentation of the method applied to a public health agency's organizational structure. Since many public health professionals don't have the skills to make strategic decisions about how information is managed (Mandl & Lee, 2002), they need methods to help them understand and direct these processes (Ross, 2002). The research reported here provides insight into the relationships, resources and behaviors regarding information use in a public health agency. The results distinguish between the formal organizational structure and how work actually gets done in the network. Interpretation of the results suggests how the flow of information in public health work is related to agency processes. This study tests an empirical technique to assist public health professionals in identifying the value of information management in relation to organizational performance.