

Diffusion of technology innovation

Within the context of nursing informatics as a field that addresses the use of information technology by nurses as they care for patients, carry out administrative tasks in health facilities, and educate others in the discipline, this article presents the theoretic perspectives of the adoption and implementation of such technologies. Research in the area of diffusion of innovations is reviewed from the perspective of classical diffusion theory and organizational theory. The state of the art and methodological issues of research in this area are addressed. Areas for future study are proposed.

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NEW TECHNIQUES of disease prevention, diagnosis, and treatment have clearly had a significant impact on the nation's health. In addition, new methods for improving the effectiveness and efficiency of health care delivery systems have been consistently pursued, particularly in the past decade of rising health care costs. Although technical innovations in health care are not viewed as a panacea, they are certainly a central part of the effort to improve health care services and delivery. Because health care is information intensive and because up to 35% of a nurse's time is believed to be consumed in information-related activities, information technologies are of particular interest. Nursing informatics is a field that addresses the use of information technologies by nurses as they care for patients, carry out administrative tasks at health facilities, and educate others in the discipline.¹ The existence of technology per se, however, does not ensure that it will be adopted or incorporated into an environment.

As concern with the adequacy of the health care system increases, and as it is recognized that some effective innovations diffuse slowly while other less effective or harmful ones diffuse quickly, the importance of understanding how technologic innovations become incorporated is apparent.² As demand rises for creative strategies to fix the sick health care system, nurses as the largest provider group in that system need to be aware of the processes for diffusing innovations, especially those related to information technologies. Research in this area has been conducted from the perspective of classical diffusion theory, organizational theory, and political issues involved in decision making. This article reviews the research and the state-of-the-art information on the diffusion of technology innovations.

DEFINITIONS

An innovation is defined as an idea, practice, or objective perceived as new by an individual, a group, or an organization.³ Shortell and Kaluzny⁴ note that the concept of innovation is more restrictive than the generic concept of change; that is, all innovation is considered change, whereas not all change is innovation. An innovation presents an individual or organization with new alternatives or new means for solving problems. The probability of an innovation being superior to previous practice is usually not known. Problem solvers are thus motivated to seek new information about the innovation to cope with the uncertainty it creates.³

The Office of Technology Assessment⁵ defines technology in the broadest sense as the practical application of science, whether the results are tools and devices or social

instruments exemplified by processes and systems. In health care, technology refers to the drugs, devices, and procedures used in the delivery of health care and the organizational or administrative systems that support its use. Diffusion is defined as the process by which technology is communicated through certain channels over time among members of a social system.

THE CLASSICAL DIFFUSION MODEL

The study of diffusion of new ideas or innovation began in the late 1930s when sociologists investigated the spread of hybrid seed corn from agricultural scientists to Iowa farmers. Subsequently, over 3,000 research publications investigated ways in which ideas spread among such varied audiences as physicians, housewives, industrial plant managers, and Australian aborigines.² Central to diffusion research are four elements: (1) the innovation, (2) communication channels, (3) time, and (4) members of a social system.

Although all *innovations* are not equivalent, the five most frequently studied attributes perceived by potential users and noted to affect the rate of adoption of the innovation are: (1) relative advantage, (2) compatibility with existing values and experiences, (3) complexity, (4) ability to be tested, and (5) visibility of results. The essence of the diffusion process is the interaction by which

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one person (source) communicates a new idea to another (receiver). The relationship between source and receiver influences the “telling” as does the *communication channel* used.

Time is the most important element in the study of diffusion and includes consideration of the innovation-decision process. This decision process is essentially an information-seeking and information-processing activity in which an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation. The innovation-decision process can lead to either adoption or rejection of an innovation. Researchers propose that the innovation decision process has four stages: knowledge, persuasion, decision, and confirmation. The time element also includes study of an individual’s creativity and the innovation’s rate of adoption.

The structure of the *social system* is the fourth element that affects an innovation’s diffusion. Investigators have studied it in terms of diffusion boundaries, roles of opinion leaders, and types of relationships of system members.³

Classical studies from nonhealth fields have laid the basis for innovation diffusion research in the health fields. Rural sociologists studying agricultural diffusion found that commercial channels of information had an important impact at the knowledge awareness stage of decision making. The influence of these channels lessened, however, as peer communications became more salient.⁶ Ryan and Gross⁶ identified different types of adopters, and their study influenced the understanding of an individual’s role in diffusion.

The education field has produced a large amount of research on the diffusion of inno-

vation. Hearn⁷ suggested that increasing the visibility of program outcomes does not always lead to successful adoption, but educators have paid little attention to concepts related to organizational theory.

Research on diffusion of innovation in industry focuses on both the diffusion of technology and the transition from research to development and experimentation. Research on diffusion in industry has a strong economic orientation, and adoption decisions in this field are based on the potential payoff and costs of an innovation. Mansfield’s⁸ classic study of the decision-making processes in this field underlines the importance of two factors not previously studied: characteristics of the overall organizational system (ie, size), and the intraorganizational processes that lead to adoption decisions.

Diffusion research in the health sciences began in the late 1950s when Coleman et al⁹ studied prescription writing patterns after the introduction of a new drug. They found that physicians used two communication channels before adopting a new drug—commercial channels for information and professional channels for validation. The faster adopters often identified outside institutions as their source of medical knowledge, frequently attended professional meetings, and subscribed to a large number of medical journals. Becker¹⁰ and Kaluzny et al¹¹ divided innovations into those with high and low risks. They found that the cosmopolitanism of organizational members and staff training strongly predicted the adoption of new programs in local health departments when the programs did not diverge sharply from traditional activities. In contrast, they found that adoption of risky innovation followed no clear pattern.

Mohr¹² placed a professional's motivation to innovate into organizational context, and noted that motivation will be successful in direct ratio to availability of resources and in inverse ratio to the obstacles to innovate. He also noted that health officials were motivated to innovate by a desire to obtain professional status. These motives, however, had little impact on actual utilization of the innovation when resources were unavailable and staff training was absent. Anderson et al¹³ reported a two-step process whereby physicians learn about and try out an innovation and subsequently influence others to adopt it. Physicians who heavily used computer information systems were more involved with outside professional activities, more centrally located in the group's professional networks, and had more frequent contacts with other users of the innovation. Scientists view these findings as demonstrating the importance of peer influence in the introduction of medical technology and in attempts to modify clinical practice, supporting the organizational perspective that action is externally controlled.

Classical diffusion theory focuses on individual responses to innovation and on the circulation of information relevant to innovations among professionals. It suggests that professional norms that reward innovations, coupled with a desire by professionals to achieve status, result in the predictable adoption of low-risk innovation by professionals.¹⁴ One of the major criticisms of this classical view is that the research uses the individual, not the organization, as the unit of analysis, and ignores the effects of organizational variables on individuals. The underlying assumptions of the traditional diffusion model posit that knowledge flows from scientist to professional practitioner

via communications and contacts, and that professionals make an individual decision to adopt or reject a new idea. These assumptions, although appropriate in some situations, are inconsistent with the state of modern research and the present complexity of health care environments.¹⁵

Most early studies in this field assume the organization's perspective on action to be purposive, intentional, goal directed, and rational. Evidence of the rational model can be seen in the assertion of a linear diffusion process with stages of adoption. The innovation is viewed as meeting the needs of professionals who purposefully choose to adopt the new technology. With members of a social system as the unit of analysis, the main independent and dependent variables studied include the effects of

- the characteristics of individual members of a social system (ie, cosmopolitanism, communication behavior) on early knowledge about an innovation,
- the perceived attributes of an innovation on the rate of adoption,
- the characteristics of members and system variables on innovativeness of members and on opinion leadership, and
- the existence of a network link between two members of a system and the nature of their interaction on innovation adoption.²

ORGANIZATIONAL THEORY

Several factors limit the applicability of classical theory to organizations. It is impossible to assume an organizational identity among all participants in a complex system such as a hospital or health department.

Classical theory can be applied to organizations only if one assumes that individuals in positions of formal authority act on behalf of organizations or if one asserts that organizations behave as individuals. If one assumes that organizational wholes adopt innovation, however, then organizational theory must be incorporated into research. Investigators have cited several variables of organizational structure as important to the diffusion of innovations.

Studies viewed as consistent with Shortell and Kaluzny's⁴ rational model of organizations are those that focus on structural contingency theory. Hage and Aiken¹⁶ reported that the organizational properties of complexity, centralization, formalization, and morale were related to the rate of adoption of new programs in 16 social welfare organizations. A high degree of participation in decisions, low job codification, and high job satisfaction were found to be associated with a high rate of program change. In contrast, Zaltman et al¹⁷ suggested that decentralized decisions and low formalization inhibit the adoption of innovations. Hage and Dewer¹⁸ noted that structural variables of complexity, centralization, and formalization, as well as the executive director's values, were less effective than the values of the elite inner circle of strategic decision makers in predicting innovations.

The resource dependency model emphasizes the organization's dependency on a larger social system for resources such as information. The process of acquiring the resources from the environment is a critical issue in this model. Information about an innovation must penetrate an organization's boundaries before a decision to adopt can be made. Kimberly¹⁹ used a resource dependency model to examine the role of integra-

tion into external information environments on hospital adoption of innovation. He notes that variability in hospital adoption of an innovation can be partially accounted for by variability in mechanisms that provide access to information about an innovation. The integration of information was found to be a necessary, but not sufficient, condition for adoption. Variability in an organization's internal structure and decision making accounted for a large measure of variance in this study.

Greer²⁰ studied the decisions of 25 hospitals concerning twelve potential adoptions of technology. The analysis focused on identification of the decision makers, their values and the purpose guiding them, and the people who adopt the innovation. She identified three "decision systems" for technology adoption. Greer found that the *medical individualistic decision system* dominated an evaluation of new clinical tools for treating patients and was closely related to prior studies of factors affecting adoption by individuals. Although decisions were made in an organizational context, physicians' decisions in this study were rarely challenged. The *fiscal management decision system* applied to the replacement and accretion of technologies in hospital departments such as radiology. Decision makers here (chief executive officers, chief financial officers, department heads) acted out of concern for the organization and patient aggregates. Important factors included expense, speed, volume, pricing potential, and quality of services.

The third decision system, *strategic-institutional dominated*, involved innovation proposals that implied major change in the nature or future of the hospital, such as the introduction of coronary artery bypass sur-

gery. These decisions were made by governing boards; resistance to them was anticipated because they redistribute resources and power of relationships. Greer suggested that failure to differentiate these three decision systems allows the blurring of actors, motivations, and adoption processes. This study clearly asserts that an organization's perspective on action is triggered and depends on processes and social constructions.

Kaluzny et al²¹ contrasted two types of program innovations within a hospital: those that improve nonacute services and those that improve organizational efficiency. Researchers studied differences in the process and antecedents of adoption of these programs. The results indicated that when implementation was measured empirically and in judgmental terms, staff training was the most common predictor for both programs. Formalization of positions and organizational size were predictor variables of health services programs but not administrative ones. Although this study contrasted different types of innovations, the researchers used structural contingency theory to assess organizational predictor variables.

In an attempt to study innovation in the context of organizations, Kimberly and Evanisko²² examined the combined effect of individual, organizational, and contextual variables on organizational adoption of two types of innovations. One type related to the organization's core activity and one related to administrative concerns. The study analyzed a large number of hospitals using an existing data set and sought to examine previously established relationships in a multivariate framework. Three major findings were reported: the individual, organizational, and contextual variables were much better predictors of the adoption of nonad-

ministrative innovations; the educational level of the hospital administrator, the size of the organization, and the presence of competition in the local environment were significant predictors in the administrative innovations; and organizational variables were indisputably better predictors of both types of innovations. Taking an eclectic approach, this study borrowed from both the rational model of organizational theory and the perspective of organizational action as externally constrained.

NURSING RESEARCH

A review of the nursing literature shows a dearth of studies addressing the adoption or diffusion of innovation. Chang's²³ study of the willingness of nurses to adopt computer technology after attending a computer workshop applied Hall and Louckes's²⁴ six-stage approach. The researchers noted that those nurses with favorable responses and expectations of computers were more willing to interact with the devices. The study was not framed in an organizational context, but it is viewed as related to expectancy theory in the rational model of organizational theory, which addresses an individual's goal directedness and purposefulness in making choices.

Kirchoff²⁵ and Brett²⁶ used Rogers's³ model of diffusion to study the dissemination and use of research findings. Kirchoff

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surveyed 600 nurses to assess the impact of published studies on the practice of restricting ice water and measuring rectal temperatures in coronary patients. Although research has cast doubt on these practices, the study showed they were commonly in use. These findings suggested that diffusion of new knowledge and adoption of new practices had not occurred. It was noted, however, that the number of hours spent reading and the number of journals read correlated strongly with greater levels of awareness among nurses that such restrictions were in question.

Building on this work and controlling for organizational size, Brett²⁶ surveyed 216 nurses to determine their awareness of, persuasion about, and use of the findings of 14 nursing studies. No relationships were found between the adoption of innovations and the organizational characteristics of size, location, kind of institution, affiliation with a school of nursing, director's position or tenure, or the percentage of nurses with different educational preparations. The investigators noted that a nurse's perceptions about the existence of organizational policy correlated strongly with adoption of the innovations.

Brett²⁷ attempted to validate Kimberly's¹⁹ findings that organizational integrative mechanisms (activities and structures that potentially increase information flow into an organization) influence the adoption of innovations. Using 14 research findings as innovations, she sampled 216 nurses from a pool of 19 hospitals to assess the existence of five categories of integrative mechanisms and the nurses' awareness of innovations. The study found that in small hospitals, the amount of publication and research was related to innovation adoption. In larger hospi-

tals, however, the existence of conferences and presentations, committees responsible for communicating research, and publications were significantly but negatively related to adoption. This result is explained because existence does not necessarily infer active participation by members of the organization.

The nursing literature, although limited, exemplifies the classical diffusion approach to the study of innovation with the focus on the individual. Nursing studies have not examined innovation diffusion from the organizational perspective. The studies found in the nursing literature focused on use of new knowledge. Although the Conduct and Utilization of Research in Nursing Project (1975–1980) conceptualized research integration as a process combining elements of the problem-solving and social-interaction models of knowledge utilization, nursing research has rarely addressed these perspectives.²⁸

STATE OF THE ART

In a review of 3,000 studies, Rogers³ noted that research in the diffusion of innovation has been conducted by the disciplines of education, communication, marketing, general sociology, public health, medical sociology, and anthropology. Scientists have observed that the fields where research has expanded most since the 1970s are marketing, sociology, public health, and medical sociology. Studies are reported in a variety of journals and books from the sociology, management, and health services literature. Only four studies were found in the nursing literature reported by nurses in the 1980s. The major theoretic perspectives in earlier

studies included diffusion theory with a focus on individuals; more recent studies, however, tend to increasingly move from the rational model of organizations to the contingency and resource dependency frame of reference with more of an eclectic approach and multiple variable assessment. This trend did not surface in the nursing literature that focused on the classical diffusion model.

Most of the studies reviewed were case studies that give a detailed analysis of phenomena but offer limited generalization of results. Several studies used comparative cross-sectional analysis that demonstrate association between sets of variables, but are limited in their ability to infer causality. The only longitudinal study¹⁸ found reported a relationship between variables after three years of research. This finding suggests that one use caution in the interpretation of cross-sectional studies.

Methodologic problems identified in this body of literature include the lack of convincing evidence to validate measurement techniques and the incongruence between a concept and its empirical indicators. At the conceptual level, the difference between innovation as a process of organizational change and innovation as a new idea or technology is not always differentiated. None of the studies focus on the process of innovation per se. As a dependent variable, innovativeness was usually measured by the number of innovations that were adopted. Difficulty existed with the measurement of independent variables as well, particularly when the organization was the unit of analysis. For example, measurement of centralization differs from one study to another.²

It is also noted that the terms "adoption" and "diffusion" are frequently confused or used interchangeably, and the boundaries of

each are unclear. That is, when does adoption end and diffusion begin or vice versa? Rogers³ asserts that adoption is the final step of the innovation-decision process, which is one element of the diffusion model. In contrast, Hall and Louckes²⁴ assert diffusion is a component of a six-stage adoption process. Clarity is also lacking regarding who adopts an innovation and what constitutes adoption. Lack of differentiation also exists between interorganizational and intraorganizational diffusion.

Studies have generally identified two sets of factors that appear to affect diffusion: characteristics of organizational members, and characteristics of the organization's structure. The innovating elite are noted to be well-educated and cosmopolitan, to view change with favor, and to prefer the goal of quality health care to that of maximum economic efficiency. There is, however, some evidence of an interactive effect among these characteristics, the nature of the innovation, and other variables.¹² Although research has not produced clear or consistent results, the key organizational variables of complexity, centralization, and visibility of consequences have been identified in large-scale surveys as powerful predictors of innovation. There is some evidence that interorganizational factors are relevant to diffusion, but little research has been done on this topic and organization-environment interaction is not well understood.²

AREAS FOR FUTURE STUDY

A review of the literature in organizational innovation reveals that data are conflicting and contradictory. One explanation asserts that organizational variables are related to

innovation in one direction during the adoption decision phase of diffusion, and in the opposite direction during implementation of an innovation. For example, the variable of complexity encourages organizational members to propose innovations, but this same variable may make it difficult to achieve consensus about implementing them.³ One area for future study includes analyzing the subprocesses of the innovation process to understand the sequence of events. Rogers³ proposes that the innovation process be divided into (1) initiation, which includes the information gathering, conceptualizing and planning leading up to adoption decisions; and (2) implementation, which includes actions and decisions involved in putting an innovation into use. This approach would replace the tradition of correlating independent structural variables with organizational innovation in cross-section.

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tional data analysis and would help explore the process of innovation.

Another area for future study is an investigation of the similarities and differences in innovation adoption between leaders and members of an organization. Previous studies have depended solely on data from top leaders and assumed they adopt innovations on behalf of an organization. This approach raises questions of how fully the study results can describe an organization's behavior.

A third area for further study needs to address a major shortcoming of diffusion research—its pro-innovation bias. This bias implies that innovations should be diffused and adopted by all members of a social system.³ The bias leads researchers to ignore the rejection or discontinuance of innovations or the antidiffusion process that prevents the integration of “bad” innovations, such as street drugs.

Consequences are the changes that occur to an individual or to a social system as a result of the adoption or rejection of an innovation. An innovation has little effect until it is distributed to and used by members of a system. Rogers³ asserts that diffusion is a means to an ultimate end: the consequences from adopting an innovation. Despite their importance, consequences have received little attention by researchers. Past studies have assumed that the adoption of new ideas or technologies will produce only beneficial results. Consequences that can be studied include changes in production or effectiveness, revenues or cost savings, efficiency, distribution of resources, and cost/benefit ratios.

A final area for further study includes focusing on the political approaches to decision making related to technology innovations. Greer's²⁰ report of three decision systems for technology adoption suggests that innovation diffusion should be studied from a political perspective with a marked departure from the rational model of organizational theory. If health organizations are viewed as pluralistic decision-making bodies, then innovations can be studied from the perspective of determining the values and goals of parties interested in the introduction of an innovation, such as nurses, physicians, administrators, or governing boards. In addition,

tion, identifying resources that different groups command, alliances they make, and the processes used for decision making would help clarify the diffusion processes and identify predictors of adoption or rejection of technology innovations. It is recognized that different decision processes are activated for different types of innovations. The Office of Technology Assessment's classification of technologies into drugs, devices, procedures, and organizational or administrative systems could be used so that study results could be compared within categories. This approach would eliminate the effects that the type of innovation itself would have on the dependent variables studied.

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Research on the diffusion of technology innovations has been extensive but only several dozen studies have been conducted on health-related technologies, with fewer than six focusing on nursing. The classical

diffusion model, although helpful in some respects, is inappropriate to the study of the complexity of multifaceted health care organizations. Previous studies may have resulted in inconclusive findings because the "wrong" questions were asked using the "wrong" organizational perspective. A more aggressive approach to the study of this area using a resource dependency or emergent perspective of organizations seems appropriate. As organizations struggle for survival with pressures to compete in turbulent times, with external demands for cost containment, with the coexistence of professional goals and administrative business strategies, and with the reality that technical change and innovation are ever present, the diffusion of technology innovations will be of increasing concern in health care environments. This area of study merits the explicit attention of researchers, especially nurse researchers who have neglected this topic in the past: future effectiveness of the health care delivery system demands it.

REFERENCES

1. Hannah K. Nursing informatics: Defining the boundaries. In: Peterson H, Gerdin-Jelger U, eds. *Preparing Nursing for Using Informatic Systems: Recommended Informatics Competencies*. New York, NY: National League for Nursing Pub No. 1402234; 1988.
2. Gordon G, Fisher GL. *The Diffusion of Medical Technology: Policy and Research Planning Perspectives*. Cambridge, Mass: Ballinger Publishing Co; 1975.
3. Rogers EM. *Diffusion of Innovations*. 3rd ed. New York, NY: The Free Press; 1983.
4. Shortell S, Kaluzny A. *Health Care Management*. New York, NY: Wiley; 1988.
5. *Strategies for Medical Technology Assessment*. Washington, DC: Office of Technology Assessment. Government Printing Office OTA-H-181; September 1982.
6. Ryan B, Gross N. The diffusion of hybrid seed corn in two Iowa communities. *Rural Sociol.* 1943;8:14-24.
7. Hearn N. Adoption rate of Title III innovations after the end of federal funding. *Educational Technol.* November 1970; 43-45.
8. Mansfield E. Technical change and the rate of imitation. *Econometrics.* 1961;29:741-766.
9. Coleman JS, Katz E, Menzel H. *Medical Innovation: A Diffusion Study*. New York, NY: Bobbs-Merrill; 1966.
10. Becker MH. Sociometric location and innovativeness: Reformulation and extension of the diffusion model. *Am Sociol Rev.* 1970;35:267-282.
11. Kaluzny AD, Gentry JT, Veney JE. Innovation of health services: A comparative study of hospitals and health departments. *Milbank Mem Fund Q.* 1974;52:51-82.

12. Mohr LB. Determinants of innovation in organizations. *Am Political Sci Rev.* 1969;63:111–126.
13. Anderson J, Joy S, Hackman E. The role of physician networks in the diffusion of clinical applications of computers. *Int J Biomed Comput.* 1982;14:195–202.
14. Greer AL. Advances in the study of diffusion of innovation in health care organization. *Milbank Mem Fund Q.* 1977;55:505–532.
15. Fennell ML, Warnecke RB. *The Diffusion of Medical Innovations—An Applied Network Analysis.* New York, NY: Plenum; 1988.
16. Hage J, Aiken M. Program change and organizational properties: A comparative analysis. *Am J Sociol.* 1967;72:503–519.
17. Zaltman G, Duncan R, Holbeck J. *Innovations and Organizations.* New York, NY: Wiley; 1973.
18. Hage J, Dewer R. Elite values versus organizational structure in predicting innovation. *Administrative Sci Q.* 1973;18:279–290.
19. Kimberly JR. Hospital adoption of innovations: The role of integration into external information environments. *J Health Soc Behav.* 1978;19:361–373.
20. Greer AL. Adoption of medical technology. *Int J Technol Assess Health Care.* 1985;1(3):669–680.
21. Kaluzny A, Veney J, Smith D. Predicting two types of hospital innovation. *Hosp Health Services Admin.* 1976;Spring:24–43.
22. Kimberly J, Evanisko MJ. Organizational innovation: The influence of individual, organizational, and contextual factors on hospital adoption of technological and administrative innovations. *Acad Manag J.* 1981;24:689–713.
23. Chang B. Adoption of innovations. *Comput Nurs.* 1984;2(6):229–235.
24. Hall GE, Louckes S. Teacher concerns as a basis for facilitating and personalizing staff development. In: Liebermann A, Miller L, eds. *Staff Development, New Demands, New Realities, New Perspectives.* New York, NY: Teacher College Press; 1979.
25. Kirchhoff K. A diffusion survey of coronary precautions. *Nurs Res.* 1982;31(4):196–201.
26. Brett J. Use of nursing practice research findings. *Nurs Res.* 1987;36(6):344–349.
27. Brett J. Organizational integrative mechanisms and adoption of innovations by nurses. *Nurs Res.* 1989;38(2):105–110.