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Collaborative Technology Use by Healthcare Teams

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This paper reviews the literature on the use of collaborative technologies by healthcare teams between 1980 and 2003. Multiple databases were searched with explicit inclusion criteria that yielded 17 conceptual and empirical papers. The discussions of these literatures centered on the individual, team, and technological dimensions of collaborative technology use within healthcare teams. Results show that collaborative healthcare technologies can have positive effects on team work processes at both the individual and group level. The limited number of research studies accentuates the need for additional research in this area. Future research should focus on defining team tasks; determining which type of groupware works for a particular health setting; and exploring the effects of groupware on patient care delivery and the organization. Without research in these areas, it will be difficult to harness the full advantages of using groupware technologies by collaborative healthcare teams.

KEY WORDS: health care teams; groupware; collaboration; review; group decision support systems.

INTRODUCTION

Much has been written on healthcare teams within different healthcare domains such as primary care, geriatrics, cardiovascular medicine, head and neck surgical oncology, endovascular surgery, anesthesiology, and psychiatry.(1) Recent reports including the Romanow report on the future of healthcare in Canada and the Institute of Medicine report on professional health education, both emphasize the importance of healthcare teams collaborating in the delivery of patient care.(2,3) While a great deal has been written on the subject of healthcare teams, no large obvious body of relevant research has been written on the types of groupware technologies used by healthcare teams in the delivery of patient care. The available research is scattered making it difficult for managers or practitioners to consult the literature to determine the current state of the literature. To rectify the problem of scattered research, this article aims to review the literature on the current state

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of collaborative technology use within healthcare settings. Specifically, the review will focus on the use of groupware technologies by healthcare teams in the delivery of patient care. In this paper, the term *groupware* refers to synchronous and asynchronous computer-based technologies that support the communication and collaboration between face-to-face teams and teams that are dispersed through time and space. These technologies include, but are not limited to electronic mail; discussion boards; team scheduling; team document handling; application sharing; cobrowsing; desktop sharing; white boarding; group decision support systems (GDSS); and desktop video conferencing. The term *healthcare team* is defined as a group of health professionals working for a common purpose and making complementary contributions to patient care.[4]

This paper is organized in four sections: outline of the review methodology; presentation of results; discussions, future research considerations; and conclusions.

METHODS

In reviewing the literature, computerized searches were conducted on academic databases from 1980 to 2003 on ABI Inform, Academic Search Elite, PubMed, and IEEE. A list of articles relating to the use of groupware technologies within healthcare teams was obtained from the searched academic databases. The search was based on three sets of terms related to groups or teams, groupware and its variations; and health. The author reviewed all the abstracts. An article was selected if it included information relating to healthcare teams and their use of groupware technology. The author excluded nonrelevant articles; these articles generally addressed telemedicine, collaborative research consortiums, and medical education. A total of 235 abstracts were reviewed of which 27 articles met the broad inclusion criteria. The full articles of these abstracts were retrieved for further review and analysis. Of these articles, a subset of 14 conceptual and empirical reports were included in the study. Another search was carried out using Google, a web based search engine, and one relevant article was found. The bibliographies of selected articles were reviewed for additional relevant literatures, which led to the inclusion of two additional articles. The total number of articles included in this study was 17.

The studies were divided into three broad categories—individual, team, and technology—which were derived by the author from an analysis of concepts reviewed in the literature as suggested by Webster and Watson.[5] Since the focus of this article is on the type of technologies used by healthcare teams in the delivery of patient care, the groupware technologies are discussed according to an adapted DeSanctis and Gallupe[6] (1987) classification of groupware technologies. The original model included three levels of groupware support representing an increased level of technological sophistication and intervention into the team process of information exchange. *Level 1* groupware provides technical features that are aimed at removing communication barriers to facilitate information exchange among team members. *Level 2* groupware provides more structure for the team process by reducing group decision uncertainty. *Level 3* groupware provides machine induced communication patterns within team communication. Recent advances in groupware

communication technologies (Level 1) make the DeSanctis and Gallupe groupware classification outdated. In this paper, Level 1 groupware is divided into Level 1(A) and (B). Level 1(A) groupware represents conferencing technologies that allow for text, audio, and video communication modes; discussion boards and file sharing. Level 1(B) groupware represents technologies that are more collaborative in nature such as application sharing, whiteboards, co-browsing, team scheduling, and desktop sharing. Level 2 technologies represent those technologies that provide more structure to team processes such as Group Decision Support Systems (GDSS). Level 3 groupware have been the least studied in the literature and therefore will not be included in the classification of groupware within this study.

RESULTS

Healthcare Domain

Of the 17 articles presented in this review, 7 articles focused on the clinical level, 4 on health services level, 3 on general healthcare, and 1 on representing homecare, health promotion and rehabilitation management. Papers were categorized as the clinical level if the paper focused on practitioners' use of groupware within a medical clinic or hospital. Papers were categorized as the health services level if the focus of the paper was on improving health service delivery. Three articles were categorized as general healthcare because they were not specific to a particular healthcare domain.

Technology Characteristics

The majority of articles focused on Level 1(A) and/or (B) groupware were the technologies used within a study ($n = 11$, 65%). Four of the articles specifically addressed Level 2 groupware technologies and two articles discussed both Level 1(A) and B and Level 2 groupware technologies.

Team Composition

The majority of articles focused on multi-professional teams ($n = 11$, 65%). These teams usually included a combination of physicians, nurses, social workers, psychiatrists, receptionists, administrators, and directors. Four of the articles discussed the health team in a generic sense without specifying the composition of the health team. One article focused on a nurse manager team. One article discussed specialized teams within radiation therapy in a generic sense without specifying the types of practitioners forming such a team.

Type of Articles

The majority of articles were empirical ($n = 9$, 53%) and eight articles (47%) were conceptual in nature. Studies were categorized as empirical if they included

elements usually found in empirical articles such as: a literature review, methodology, data collection, sampling techniques, and data analysis sections within the study. Conceptual articles were studies that made claims without using data to justify such claims.

Additional Areas of Focus

Individual Dimensions

A major aim of the research reviewed in this section is to isolate individual factors relating to the effects of groupware technology on individuals within the healthcare team. Concepts relating to *isolation from the team and context specific communication* are discussed.

Isolation from the team: Human nature motivates us to communicate, identify, and associate with other individuals.[7] With the use of groupware technologies, it becomes more difficult to maintain levels of communication, identification, and association that are present in face-to-face teams. As a result, team members may feel a sense of isolation from one another.

Two empirical studies have explored individual isolation within healthcare teams supported by groupware technologies. Safran *et al.*[8] examined the effects of an electronic patient record and e-mail (Level 1(A)) on the interactions among healthcare providers within a hospital setting. Using an ethnographic approach, the study found that the use of e-mail created a feeling of isolation among providers.

Conner and Finnemore[9] examined UK National Health Service teams' use of groupware technologies to improve patient experiences and speedup patient access to healthcare services by supporting administrative work teams. The results of their study demonstrated that the use of e-mail, discussion boards, file sharing (Level 1(A)) and team scheduling (Level 1(B)) groupware features helped reduce the feeling of isolation experienced within virtual teams.

Context specific communication: Groupware technology is designed to enhance team communication processes by focusing team discussion regarding the task at hand. Conner and Finnemore found that conversations using groupware communication such as e-mail (Level 1(A)) helped keep team communications "context specific" by reducing individual time spent on non-project related communication (eg. office politics).

Group Dimensions

A concept that has emerged on the team level is the effect of groupware technologies on the healthcare team collaboration process at both the clinical and managerial level.

Collaboration implies the sharing of data and other scientific resources and it can be "construed as a communal relationship that implies social trust and synergy among participation with mutual benefit as the result."[10] A precondition for collaboration to occur in a virtual environment is the existence of text, voice, or video communication.[11] Three conceptual and four empirical articles included in the review have discussed the effects of groupware on the collaboration processes of managers and practitioners.

Group collaboration process at the clinical level: In their conceptual work, Rothschild and Lapidos[12] suggest that use of virtual teams can potentially improve the collaboration among health professionals in the management of patients with chronic disease. For example, the use of e-mail can allow physicians, nurses, and other practitioners to delegate responsibilities to the appropriate health professionals in order to respond to patients' needs.

Two empirical studies included in this review discuss the effects of groupware on collaborating healthcare teams at the clinical level. Safran *et al.* studied the use of e-mail (Level 1(A)) and an electronic patient record on the interactions of healthcare providers within an outpatient primary care facility. The authors found that the use of e-mail (Level 1(A)) and an electronic patient record supported collaboration between specific experts and generic experts; nurse practitioners, preceptors, and primary care physicians regarding medical decisions; clinical nurses consulting with primary care physicians, and nurse practitioners concerning how to provide information to patients seeking advice or information; and residents consulting with physicians and preceptors.

Patel *et al.* studied the roles and patterns of interactions within healthcare teams in an ambulatory care setting. The authors found that communication modes used in the collaboration process among healthcare providers was dependent on the type of interaction. They found that synchronous communications (face-to-face, telephone, pager) were used by healthcare providers to collaborate on issues that were patient related and that asynchronous methods such as e-mail (Level 1(A)) and voice mail were more commonly used for less urgent matters such as administrative issues. Patel *et al.* also found that the most commonly used form of communication within these collaborative teams was face-to-face, followed by telephone and e-mail.

At the clinical level there seems to be two conflicting results regarding the use of e-mail as a communication tool within a collaborative health team. The empirical work of Safran *et al.* finds benefits to the use of e-mail as a communication mechanism to deliver patient information. However, the empirical work of Patel *et al.* find that e-mail is mostly used as an administrative tool. Perhaps this discrepancy can be explained by how the groupware was used in the collaborative process. Safran *et al.*'s study primarily examined the use of e-mail exclusively to share electronic patient records; however, Patel *et al.* only examined the use of e-mail for general communication purposes.

Group collaboration process at the managerial level: At the managerial level, two conceptual and two empirical articles discuss effects of groupware on collaborating healthcare teams.

In their conceptual study, Kimball and Eunice[13] recommend that collaborating teams within healthcare organizations (i.e. hospitals) can improve work practices; connect individuals into knowledge sharing networks; foster cross functional and divisional collaboration; and increase individuals' ability to initiate projects spread across organizational boundaries. For collaboration to be successful, Lange,[14] in her conceptual study on collaborating nurse managers, suggests participants must develop an environment that supports collaborative work and the groupware should "mimic" how individuals work. Lange also notes that the benefits

of groupware in supporting teamwork may not develop unless there is a collaborative environment within the organization.

In their empirical work, Conner and Finnemore found that groupware technologies such as e-mail; discussion boards, and file sharing (Level 1(A)); document management; and team scheduling (Level 1(B)) enabled teams to share and access other individuals' tacit knowledge. The authors refer to this transformation of the team collaboration from "push" to "pull." This implies that instead of team members sending information to those who may or may not use it, team members are placing the information on-line, and team members now look for information that is relevant to their task.

Dennis and Garfield[15] studied the collaboration of six medical project teams that used group decision support systems (Level 2) to improve customer service within a hospital. Half of the teams in this study used GDSS Level 2, and the remaining used traditional approaches. In the GDSS, teams members participated to a greater extent in the planning process; group leaders relinquished their leadership; GDSS captured team notes which were subsequently available to the members; the project goal emerged from team discussions; and team notes were widely available. In the traditional team, the leaders defined project goals; directed discussions; assigned tasks; and recorded and controlled team notes. The conclusion of this study was that groupware supported teams were more participatory and democratic than traditional teams.

Overall, a trend in the data suggests that the use of groupware technology in the collaboration process is different for a team working at the clinical or managerial levels. At the clinical level, e-mail (Level 1(A)) is the primary groupware communication technology used for collaboration. At the management level, a trend suggests that Level 1 (A), (B) and Level 2 are the groupware types most used.

Technology Dimensions

Nine studies within this review focus on technology related aspects of groupware. Groupware *architecture* and *design process* are the two concepts that emerge from the literature.

Groupware Architecture: In this section, the architectural design of groupware technologies are discussed at the conceptual and technical level.

Two articles in the review focus on the technical aspects of groupware architectural design. In their pilot study, Ntasis *et al.*[16] study the architecture of a groupware-supported environment for virtual simulation of radiation treatment planning. The architecture presented is based on both synchronous (Level 1(B) application sharing) and asynchronous data transfer under a secure network that is integrated within the infrastructure of the radiotherapy department. The architecture is composed of four layers, each responsible for a different set of tasks. The data layer communicates with GALINOS groupware system; the compression layer compresses the data; the security layer maintains confidentiality, integrity and authenticity of the data; the socket layer is responsible for the termination and reliable communication of data when exchanged. In evaluating the architecture, the on-line collaboration sessions via application sharing observed a latency time between the

two sites of ~1 s. Higher latency times (~3 s) were observed for rotations of 3-D images.

Mitsuishi *et al.*[17] developed a groupware (Yuitori Network) collaboration system for health professionals working within homecare in rural Japanese areas. The architecture presented in the study supported Level (A) (file sharing) and Level (B) (team scheduling) groupware. The architecture is client-server based using the computer network to connect the databases. The results of the study found that the Yuitori Network had problems accessing data on the server due to low line speed provided by the Internet Service Provider (ISP). To solve the problem, data was moved from the server to the client where data changes would be updated to the client from the server and vice-versa. Finally, the authors note that there is a need to improve the security functions when transferring patient data.

Three articles discuss the conceptual architectures for groupware technology at Level 2 Group Decision Support Systems (GDSS). In their study, Rao and Turoff[18] present a hypermedia-based group decision support system to support collaborative medical decision making (MDM). The design supports various levels of inference based medical support that range from the diagnostic to higher clinical levels. Through their analysis of MDM and GDSS theories, the authors incorporate clinical reasoning features in the system architecture. Due to the difficulties in defining the cognitive processes involved in MDM, the architecture incorporates cognitive aid structures and cognitive appropriation processes. A component, MEDICALWARE, is integrated within the GDSS and provides professionals with access to clinical algorithms, problem solving support, and expert inference support and other MDM support tools with hypermedia functionality. Rao and Turoff deem the architecture capable of providing healthcare professionals with the support necessary to determine whether they followed proper medical procedures and modify them as necessary.

Hatcher[19] developed a model for GDSS use in medical and health applications. This model is divided into four sections: information exchange; information extraction; decision philosophy; and decision tools. Each section is composed of modules to support the functionality available in each group. The first section, information exchange, is composed of three modules with the purpose of structuring how information is exchanged. These modules are: user interface; template creation; and communication. The second section, information extraction, includes a method showing how data should be extracted from people and databases. Three modules are included within the information exchange section: database access; consolidation of decision maker opinions; and nested consolidation modules. The third section, decision philosophy, represents the value system of society. The modules in this section are: rule maker/problem definition; decision makers; and facilitator. Decision tools, the last section, is used by decision-makers and the GDSS to extract data. Its three modules are: decision models; GDSS tools; and DSS tools. Hatcher's recommendation is to require that medical decision making requires the use of the following modules: *communication* and *rule maker* because of urgency in medical decisions; *database* for large data medical records; *template creation* for information storage and sharing; *decision makers* to make decisions; and *GDSS tools* to organize, prioritize, and select ideas.

Hatcher extended the same conceptual architecture in another paper.[20] In this paper, Hatcher incorporates what he called the Analytic Hierarchy Process (AHP) into his GDSS model described in Hatcher.[19] Hatcher argues that AHP can be used in the design of GDSS because it could enhance medical decision making by allowing both subjective and objective data to be used in the decision making process; producing a ratio scale when evaluating a decision, thus making the evaluation between criteria clearer and easier; addressing the multidimensionality of criteria; allowing for flexibility so that the AHP model constructed can be tailored to the problem and decision maker. For example, the author suggests that AHP could be used by healthcare providers to form decision rules to weigh the risks of drug combinations.

Greenes[21] proposed a conceptual architecture for groupware (Level 1(A) and (B)) within a healthcare setting to support a variety of services such as medical libraries, electronic publishing, and academic and professional collaboration. The technical aspects of the architecture include the following components: kernel framework; extensible tool set; modular data and knowledge entities; flexible compositional tools; and shell environments and applications. A kernel framework allows a user to access updated information by providing a collection of tools to support this process. The extensible toolset provides functions for storing, retrieving and displaying a variety of information such as hypertext, pictures, charts, and tables. Data is made into knowledge entities to provide information in the form of "chunks." Flexible compositional tools and shell environments are built over the kernel framework to allow for the organization of the entities into various structures such as page layouts and hyperlinked connections. Finally, the application is built as a layer over an appropriate shell.

Overall, a trend in the data suggests that at Level 1(A) and (B) groupware, the discussion of architectures is focused at the technical level. Groupware Level 2 (GDSS) is focused on the conceptual aspects of the system architecture. All Level 2 architectures focus on the decision-makers as a primary driver in the design of the architecture. However, for Level 1(A) and (B) articles, it seems that the focus is on the technology and how it can be used to support health professionals.

Groupware Design Process: Three articles discuss the groupware design process at the clinical level. Using a participatory action approach, Timpka and Sjoberg[22] and Timpka *et al.*[23] explored the design of groupware using (Level 1(A) electronic messaging) with electronic patient records and describe the social contexts and conditions influencing the design of groupware applications. The results suggest that the design of groupware technology occur in three social arenas: societal arena, organizational arena, and the workplace arena with each arena having its own agenda set of actors and regulation of power. Other findings relating to the design process include confusion about responsibilities and decisions that occurred; difficulty in monitoring clinical and patient processes; reluctance from the information systems department to provide support for the new technologies; and an increase in practitioner participation in the design process over time.

Using a participatory action approach, Bang *et al.*[24] developed a groupware prototype (Level 1(A)—text messaging and Level 1(B)—team scheduling) designed to support virtual rehabilitation teams. Bang *et al.* found that during design

meetings, the discussions focused on problems relating to cooperation among team members and solving general design problems as a team. Workplace ethnographies were conducted to gain a better understanding of case manager work processes. Bang *et al.* found that developing groupware is not a matter of providing functionality to support team tasks, but it is equally important to address the social requirements of team members like agreeing on goals, having similar basic values/norms, and communicating effectively. Bang *et al.* also found that it is not appropriate to develop rigid systems especially in teams that are constantly going through change. Systems in such environments need to be flexible.

An overall trend in the data suggests that a participatory action approach involving both practitioners and developers is the method used in the groupware design process; discussions occurred at the workplace, organizational, and societal levels; design of groupware was tailored to the work environment of the team; design meeting discussions focused on team co-operation and problem solving.

DISCUSSION

In comparison with literatures available on virtual teams within the business research domain, the amount of empirical research focused on the use of collaborative healthcare technologies in the delivery of patient care is relatively small. Much of this research reviewed in this study has addressed groupware at the technological level and its effects on the healthcare team. There are no existing empirical literatures included in this review that have focused on the use of groupware technology and its effects on patient health outcomes.

It is likely that a number of literatures on the use of groupware technologies within healthcare teams that could have contributed to this body of knowledge were not included in this review. While every effort was made to conduct a comprehensive literature review, the author acknowledges that the positive aspects associated with the use of collaborative technologies within healthcare teams may have been biased due to the inclusion of weak empirical studies (eg. pilot studies) and conceptual anecdotal papers. It is also acknowledged that additional reviewers would have reduced selection bias involved in the process of study inclusion.

Overall, the research results suggest that collaborative healthcare teams can benefit from the use of groupware technologies to support collaboration within a healthcare team at both the individual and team level (clinical and managerial). The literature reviewed in this paper support this conclusion. Because the broad potential of this new method of collaboration is only beginning to be tapped, it is important to persuade health professionals at the clinical and managerial levels to support the use of groupware technologies in the delivery of healthcare by healthcare teams.

Groupware technology can provide healthcare teams with innovative ways to collaborate in the delivery of patient care at both the clinical and managerial levels. The use of groupware offers unique ways for health professionals to collaborate with other health providers. For example, health teams could use groupware Level 1(A) and (B) to collaborate at the clinical level by communicating with nurses, clinicians,

and social workers synchronously and asynchronously in the management of patient care. Patient charts could be reviewed and modified using application or desktop sharing (Level 1(B)). Health teams could use synchronous communication methods such as text, audio and video to communicate with other health professionals located in different geographical regions. Using Level 2 groupware, healthcare practitioners could meet and plan how to improve workflow processes, patient management, or patient access to care. The use of Level 2 groupware helps organize, prioritize, and select individual ideas to form plans of action.

Research related to the role of groupware technology use within healthcare teams raises some important issues. A distinction needs to be made between clinical and managerial use of groupware to support team processes. On the managerial level, it is apparent that groupware at Level 1(B) and Level 2 are used more often than at the clinical level. Though business teams have traditionally used Level 1(B) and Level 2 groupware for collaboration, healthcare teams have only recently shown interest in using these technologies. With the increased focus on the formation of healthcare teams and their collaboration in the delivery of patient care, methods to facilitate team collaboration will be needed.

In the development of these technologies, it is important that the technical and conceptual architectures take into account the collaborative nature of teams and especially address the issues relating to security of information shared and the large bandwidth needed to deliver large amounts of data across networks. All teams that will be affected by the groupware intervention should be included in the design process. If the practitioners work within a dynamic environment, the groupware system should be designed according to the social structure of the work team. Problems that occur during the design process should be discussed as they come up.

Future studies should begin to explore the effects of groupware technologies on the delivery of patient care and patient outcomes. No empirical studies emerged as a result of this literature review that explored the effects of healthcare teams' use of groupware technologies and the effects on the delivery of patient care. If future studies could evaluate the use of such technologies on patient care then we will better understand how to use groupware technology to its fullest advantage as a tool to support collaboration between healthcare teams for patient care delivery.

FUTURE RESEARCH CONSIDERATIONS

Nature of Available Research

Any conclusions drawn from this literature review must consider the overall state of the available research. Clearly the volume of empirical research in this area is small. Some studies with serious methodological problems and conceptual articles were included which could have biased conclusions. Other studies may have been overlooked despite the author's effort to locate relevant material.

Insufficient Explanations of Study Procedures

Literature included in this review suffered from inadequate explanation of research methods. For example, empirical studies such as Conner and Finnemore do

not provide the basic information which should be included in any research report, such as the source and nature of the sample, the method by how it was drawn etc.

Emphasis on Descriptive Studies

Some studies included in this review (eg. Mitsuishi *et al.*, Conner and Finnemore) can be characterized as being descriptive in nature. Conner and Finnemore provide data which describe the impact of groupware on the individual and team but do not discuss the method of data collection that would have provided insight into the reasons behind the effects of groupware on the individual and team.

Research Priorities

Based on the existing knowledge levels in the literature on groupware that is discussed within the business and computing science domain, the healthcare literature lags behind in several areas.

Group Tasks

A classification of tasks within the healthcare team at the clinical and managerial level is needed. This will allow the groupware technology to be tailored to the particular task of the group.

Patient Care

Study of the impacts of groupware technologies on the delivery of patient care is needed. Such studies could shed light on the effects of groupware technology in the support of collaborative healthcare teams and on the delivery of patient care.

Types of Groupware

It is important to study the effects of Level 1(A), Level 1(B), and Level 2 groupware on healthcare teams and patient care, since any groupware technology might be more or less successful in different healthcare settings.

Organizational Impact

It will be valuable to study the effects of groupware technology on the organization. For example, what type of organizational structures support collaborative teams using groupware.

Without more research in these areas, implementation of groupware within healthcare teams may not demonstrate desired improvements in patient care.

CONCLUSIONS

The research reviewed in this paper explored the effects of groupware technology at the individual, team, and technological level. At the individual level, it was found that individuals working within a groupware environment feel a greater sense of isolation; experience delays in communication response time; and feel discussions

are more "context" specific. At the team level, there is a distinction made between clinical and administrative use of groupware for collaboration. At the clinical level, Level 1(A), specifically e-mail, is used. Administrative teams tend to use Level 1(B) and Level 2 groupware in addition to Level 1(A). At the technical level, it was found that the literature focused on the architecture and the design process of groupware systems. Future research should focus on defining team tasks, determining which type of groupware works for a particular health setting, and exploring the effects of groupware on patient care delivery and the organization. Without research in these areas, it will be difficult to harness the full advantages of using groupware technologies by collaborative healthcare teams.

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