

# Original Investigations

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## Characterizing the Use of Health Care Services Delivered via Computer Networks

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**Abstract** **Objective:** Evaluators must develop methods to characterize the use of the rapidly proliferating electronic networks that link patients with health services. In this article the 4-S framework is proposed for characterizing the use of health services delivered via computer networks. The utility of the 4-S framework is illustrated using data derived from a completed, randomized field experiment in which 47 caregivers of persons who had Alzheimer's disease accessed ComputerLink, a special computer network providing information, communication, and decision support to homebound caregivers of persons who have Alzheimer's disease.

**Design:** Human-computer interaction theories characterize the use of health services delivered via computer networks in behavioral terms. The 4-S framework incorporates perspectives based on user (subject) behavior: access to and use of the total system, use of specific services, behavior within single sessions, and enduring behavioral characteristics. The 4-S framework was tested in a secondary analysis of data from over 3,800 uses of ComputerLink.

**Measurement:** The 4-S framework was instantiated using data obtained from the ComputerLink evaluation. Three types of secondary data were obtained. A passive monitor of access to the computer network provided quantitative information, such as time of day when access occurred, duration of access, and sequence of services used. Full-text messages were available from the public message postings. Subjective appraisal of use was obtained from self-reporting by users at the end of the experiment.

**Results:** The components of the 4-S framework were suitable to characterize operational aspects of ComputerLink use by Alzheimer's disease caregivers. Through application of the 4-S framework, an understanding of both quantitative use and qualitative use emerged (e.g., insight was gained into the differential use of specific services).

**Conclusions:** The 4-S framework provided a mechanism for combining various measures of use into a coherent whole. The framework promotes a precise characterization of use and thereby facilitates evaluation of health services delivered via computer networks. It is suitable for evaluation of user satisfaction, measurement of needs resolution, and ascertainment of selected clinical outcomes.

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In contemporary health care, computer networks link health professionals in their workplaces and deliver health services to patients in their homes. Networks facilitate management of communications and transmission of records. However, characterization of the use of health services delivered via computer networks remains problematic. This activity requires synthesis of the traditional measures of computer application usage, such as connect time or number of contacts, with the traditional measures employed for health care and social service utilization. This article examines the need for explicit characterization of the use of health services delivered via computer networks. A model, the 4-S framework, which is based on human-computer interaction theory, is proposed. This article illustrates the use of the 4-S framework with data from a field investigation of ComputerLink. ComputerLink is a computer network designed to provide information, communication, and decision support to homebound caregivers of persons who have Alzheimer's disease (AD).

## Background

### Delivery of Health Services via Computer Networks

Computer networks provide electronic linkages among two or more sites. Such networks are not new, having served the business, educational, and health care communities for over twenty years.<sup>1</sup> Recent developments in technology, however, coupled with expanding needs for health services, have led to uses of computer networks not envisioned two decades ago. "Telemedicine" provides remote consultation and records management via high-speed computer linkages and represents an important new network application in health care.<sup>2</sup> Other computer networks may complement existing formal health service delivery systems by serving as pathways for delivering certain types of health services. Such networks can bring many of the benefits of health care professionals and support groups to individuals too sick, too busy, or otherwise unable to leave home.<sup>3</sup> Health services effectively delivered via computer networks include counseling, social support, health education, access to health literature and databases, and clinical decision support.<sup>4</sup>

Health care computer networks can deliver a single service or can provide access to a large range of services. The "Electronic Grandparent" project, a pioneering single-service computer network, linked elders in a nursing home with children in a day care setting via computer terminals and telephone lines.<sup>5</sup> The Senior Net, funded by the Markle Foundation,<sup>6</sup>

provided elders with home-based computer interaction. Use of these systems was generally denoted by counts of contacts or duration of interaction.<sup>5,6</sup>

Two general types of multiservice computer networks are relevant to the delivery of health services. One "exclusive" type employs a dedicated computer network to give a target group access to a specific set of interrelated computer programs. For example, Computerized Health Evaluation and Social Support (CHESS) was an experimental program to promote self-care through computer-based risk appraisal, values clarification, and group interaction.<sup>7</sup> CHESS combined locally resident special-purpose programs with access to an electronic bulletin board and a messaging utility. To evaluate CHESS, a passive monitoring system recorded the extent to which users accessed specific services. The second model for network-based health services delivery is to add specific health care applications to existing computer networks. Both Prodigy and CompuServe, proprietary computer network services, support health interest groups, help lines, and access to clinical literature. The Internet, as a network of networks, permits worldwide direct access to many knowledge sources, clinical experts, forums, and special topic users groups.

Schneider demonstrated that smoking cessation training could be delivered via a computer network. He distributed his program via CompuServe<sup>8</sup> and included support for group interactions, messaging services, and individually tailored interventions. Schneider measured smoking cessation system use along both behavioral and temporal axes. Counts of access (behavioral) and system connect time (temporal) provided evidence of how the system was used. However, minutes of contact with the entire system (CompuServe) had relatively little clinical relevance because connect time (minutes of access) did not measure how the time was spent.

### Previous Methods of Characterizing Network Use

In the health informatics literature, use often connotes application, so use of computers generally means application of computers to health care. Others employ the word use to mean an encounter or access. The scope of use may be restricted to that which mechanically happens during interactive sessions, or it may be more generally defined as any human information-processing activity in which output from a computer session (whether a paper report or a screen activity) is employed in a larger cognitive process (such as decision making). This article adopts the latter, more general definition of use. Use indicates human behavior, both mechanical and intellectual, pursuant to interaction with computer systems.

System use is a key variable in information systems research. For analytic purposes, system use can be treated as either an independent variable or a dependent variable. For example, in studies of the impact of computer network services on behavior and task fulfillment, use can be an independent variable.<sup>9</sup> System use can be the dependent variable in studies of user acceptance and innovation diffusion, in which case user characteristics and aspects of the innovation may be considered predictive of use.<sup>1</sup> Other approaches to characterizing the use of computer network services emphasize the capture of system characteristics,<sup>10</sup> interpersonal behavior of users,<sup>11</sup> and connect time. Previous efforts to define and measure system use often suffered from inconsistencies and imprecision. Measurement schemes were driven more by system monitoring capabilities than by congruence with operational definitions. Ideally, conceptual and operational definitions of system use should correspond with the reference theory guiding an investigation or a study.<sup>12</sup> Such an operational definition of use is not without drawbacks, however. Defining use in a manner peculiar to each individual study often precludes aggregation and integration of findings across multiple studies.<sup>13</sup>

Delivery of health services via a computer network involves both the user (client or patient—a person) and the computer system. Characterization of use must therefore address aspects of both the technology and the user.<sup>14,15</sup> Theories for understanding human-computer interaction from a human factors perspective are relevant. Other theoretical frameworks, such as human information processing<sup>16</sup> and symbolic interactionism,<sup>17</sup> while relevant, may be deficient because they address only the person using the computer and ignore salient dimensions of the technology. Similarly, transaction-processing models<sup>10</sup> restrict characterization of use to measures of system workload and do not adequately measure human cognitive responses. Transaction-processing models can be of value when the computer network provides administrative support to the care process. However, when the computer network serves an integral role in health care delivery, broader conceptualizations of use are needed.

Human-computer interaction theories form the most appropriate basis for characterizing health care delivery system use. In the human-computer interaction framework, system use is viewed as a function of the system and the user. A general framework for characterizing use must be both complementary and subservient to the theoretical models that guide research studies in linking use to predictors or consequences.<sup>18</sup> Human factors models incorporate essen-

tial details consistent with innovation-diffusion theory,<sup>19</sup> in which characteristics of an innovation and of the user's reaction to it form a central variable of interest.

Many objectives for characterizing the use of computer network services are congruent with those for evaluating health care and social service delivery. Both require methods for determination of adequacy and effectiveness, establishment of a constellation of services necessary to ensure successful outcomes of care, and a basis for allocating charges. Recent approaches to characterizing health care use or social service use include number and duration of contacts<sup>20,21</sup> and volume of services delivered by specific providers.<sup>22</sup> Enumeration of service contacts is simple to use, is highly reliable, and facilitates comparison. Some authors have focused on the number of persons using a specific service,<sup>23,24</sup> while others have proposed grouping services into "like" categories such as health services or social services.<sup>25</sup>

Traditional measures of use of computer systems include self-reporting and passive monitoring. Variables used in the measurement of computer network usage range from simple dichotomous indicators to complex structures that characterize the degree of integration of computer network services into daily practices. Often, economic and operational constraints have led researchers to employ retrospective self-reporting of usage. Srinivasan compared such self-reporting with more objective measures of usage and found significant discrepancies between the two measures.<sup>26</sup> In a field experiment involving 404 users, comparisons between self-reporting of usage and actual usage based on data generated from a system monitor indicated that managers and professional workers tended to systematically overestimate usage. Other evidence<sup>19</sup> confirms that self-reported use generally exceeds actual use. Machine logging and other automated approaches to capturing system use data avoid the recall bias associated with self-reporting and have the additional advantage of not interrupting interaction sessions for data collection.<sup>5</sup> Thus, a major problem of characterizing health care and social service use—the need to rely on recall or on other strategies intrusive to the clinical encounter—may be avoided. However, without conceptual clarity regarding the nature of use, machine logging can lead to erroneous pictures as well.

It is plausible that the differences observed between self-reporting and automated logging of computer use may be related to different conceptualizations of use or differences in the time frame of reference, rather than to erroneous results of one method or

the other. The methods may be reporting different definition-based aspects of use. Frames of reference may vary as a function of time (the period to which the use is referring) and as a function of a specific set of behaviors. A user logging onto a system to check mail may not conceptualize (and therefore may not report) that encounter as the same type of use as one in which the user performs a set of functions and then sends mail, even though both involve use of electronic mail. Lee<sup>18</sup> documented that different measures of use provided different pictures of a computer system and therefore led to different conclusions. He also documented that use varied by individual and type of program, indicating the need to tailor measures of use to system features.

Other data capture strategies relevant to health services may augment passive monitoring and self-reporting methods. For example, analysis of session transcripts can provide insight into both how often a person uses an interactive health service and for what purpose he or she uses it. Appropriate characterization of the use of health services delivered via computer networks requires data capture relevant to each perspective envisioned by the human-computer interaction approach.

It is not necessary to employ a single, standard definition of use across all studies; rather, a framework for linking the various definitions of use into a coherent whole is needed. A framework that links measures of use can provide the starting point for generalizations about the role and impact of computer networks in the delivery of health care. The next section provides pragmatic details of how a human-computer interaction framework could be employed to capture and measure aspects of system use for an actual health service delivered via computer network.

### ComputerLink

ComputerLink comprised a set of network-delivered, computer-based utilities that provide health services to homebound persons. ComputerLink represented the first effort to systematically replicate, for vulnerable populations, functions provided by formal support services: peer support, professional advice, education, and counseling. The ComputerLink program was developed using the "C" programming language at Case Western Reserve University (CWRU) and remained operational in an experimental version from 1989 through 1991. ComputerLink delivered, at no charge to the user, network-based home care assistance to caregivers of persons who had AD.<sup>27</sup> Caregivers accessed ComputerLink via Wyse 30 (Wyse Technology, Inc., San Jose, CA) terminals and 1200-baud modems placed in their homes.

AD caregivers face complex demands in the presence of multiple health, socioeconomic, and emotional challenges.<sup>28</sup> ComputerLink provided caregivers with information resources via an electronic encyclopedia. The electronic encyclopedia contained factual information about AD, self-care techniques, and home-based management. ComputerLink also attempted to support caregivers through decision modeling,<sup>29</sup> an analysis strategy that helped users focus on relevant values and trade-offs in making difficult choices. The ComputerLink communication module facilitated public and private communications among users via an unrestricted bulletin board. The unrestricted bulletin board provided caregivers with assistance similar to that provided by face-to-face interaction support groups.<sup>30</sup> ComputerLink also included a private electronic mail channel to a project nurse and other caregivers. The project nurse also served as the moderator of a second bulletin board, on which selected, globally relevant questions posed by caregivers were posted in an anonymous fashion, along with answers. The nurse-moderator read all public bulletin board areas daily and maintained the currency of the electronic encyclopedia. The nurse-moderator also provided technical support, health-related support, and training for study participants.

The data reported here were gathered as part of a study evaluating the effect of ComputerLink on caregivers' decision making and isolation. In that study, 102 AD caregivers, selected by convenience sampling, were randomized to receive either the ComputerLink intervention or more standard telephone support. All subjects completed interviews at 1 and 12 months and received monthly telephone calls to assess clinical service use and to maintain participation. Additionally, subjects were asked to respond to a forced-choice questionnaire assessing the number of times they used ComputerLink.

Results from the overall evaluation of ComputerLink were positive.<sup>27,31</sup> Two subjects withdrew due to difficulty in installing telephone lines, one withdrew due to personal illness before ComputerLink was installed, and a fourth subject asked to have the computer removed after the first week. Subjects were similar in age ( $\bar{x}$  = 60 years; SD 14.4 years); gender (33% were male), race (28% were African American), years of education (86% had completed high school), prior experience with computers, and months of supporting the person who had AD (31 for ComputerLink vs 38 for telephone groups). Anecdotal reports from the study indicate that the system provided strong interpersonal support.<sup>31</sup> ComputerLink improved confidence in decision making but did not alter measures of decision skill or sense of isolation.<sup>27</sup>

During the initial evaluation study,<sup>27,31</sup> access to ComputerLink consisted of connecting, via modem, from the caregiver's home terminal to the central ComputerLink computer, and selecting desired functions. Use of the ComputerLink system was recorded by a passive monitoring system that was activated each time the caregiver accessed the system. Data elements recorded for each encounter included time of day, date, functions accessed, duration within each selected function, and activities performed (e.g., posting messages, reading messages, reading from the electronic encyclopedia, analyzing a decision). The data set provides information about what function an individual used and for how long, and also the extent to which the individual was an "active participant" during the session (e.g., typing messages, analyzing a decision) or a "passive observer" (e.g., reading messages, reading information). A validation study of the passive monitoring system verified that it captured 100% of the system use data.

### The 4-S Framework for Characterizing Use

During evaluation of ComputerLink, recognition of the limitations of traditional, atheoretical approaches to characterizing system use led the author and members of the ComputerLink project team to develop the 4-S framework for characterizing the use of health care services delivered via computer networks. Conceptual models contributing to the 4-S framework included human-computer interaction,<sup>14</sup> clinical services and personal (i.e., noninstrumental) motivations for computer use,<sup>6,26</sup> and the frequently encountered disparity between what a clinician perceives as helpful to a patient and what the patient perceives.<sup>32</sup>

It is important to separate the definition of use from its measurement. It is essential to characterize use in a manner that allows careful analysis of the relationships among use, needs satisfaction, problem resolution, and subsequent health outcomes. ComputerLink study participants recognized that it was important to characterize system use by both individuals and groups of users, e.g., it would be useful to characterize the nature of the group present on ComputerLink during the time that a single individual might have been reading messages and interacting with others present on the system.

The ComputerLink project team, having completed and analyzed its initial evaluation,<sup>27,31</sup> evolved a new perspective on network-based system evaluation that was loosely tied to the concept of unit of analysis. Relative to computer network use, there are four

perspectives, or units of analysis: system-level, service-level, session-level, and subject-level. Therefore, the new model was named the 4-S framework. The 4-S framework can be employed to organize and describe behavioral dimensions of use of health services delivered via computer networks. There are multiple options for constructing measures of use within each perspective of the 4-S framework; the choice of the exact metric rests with the investigator and the purpose of the larger work.

### System-level Evaluation

System-level analysis enumerates accesses to the computer network, including counts and duration of access. Other system-level characteristics include target group behavior (the proportion of potential users who actually access the system, and the interval between accesses<sup>1</sup>), as well as network performance, which characterizes the length of time a network is available to users. System-level use is a gross behavioral measurement, akin to the number of admissions to a hospital, individual lengths of stay (not aggregated by diagnosis), or days of attendance at educational programs per year. Such measures provide an anchor for estimation of potential exposure to a system. When a network system offers multiple relevant services to users, use should be characterized on the level of service, as well as the system level, in order to determine users' exposure to each specific system component. In circumstances where computer networks offer only a single service, such as a single-topic bulletin board system, the system level and the service level of use are identical.

In the ComputerLink evaluation,<sup>27,31</sup> system-level use measurement indicated how often all the caregivers accessed the system. The 47 experimental group members accessed ComputerLink 3,875 times over the course of the experiment. System-level information regarding use included time stamps, so that the project nurse could determine how many of the total group of eligible individuals were actually using the system at any given time. Examination of system-level use also allowed the project nurse to evaluate the relationship between events external to the study and activities on the ComputerLink network. For example, use of ComputerLink increased during the Christmas holiday period. The system-level statistics can point out potentially interesting variability, but, per se, do not allow insight into whether increased use during this time represented that users perceived a need for additional contact or support, or that users had more free time to access the system due to other extraneous factors, such as additional support from relatives.

### Service-level Evaluation

Multifunction computer networks can provide a set of services potentially beneficial to health care providers. As such, multifunction networks represent a considerable improvement over single-purpose applications.<sup>5,7</sup> Specific, service-level evaluation measures the number and duration of accesses to distinct functions, programs, utilities, or applications available within a multifunction computer network. Service-level use can indicate whether services were used on a constant or an episodic basis throughout the period of activation. Service measures reveal the extent to which selected services are actually used, but cannot record the number of times that users experience appropriate needs for use that are not translated into actual use. Service-level usage data can help to determine whether the computer network use can be treated as a whole, or whether it must be reduced to its component parts based on the utilization of component services relative to one other.

Service-level measurement requires consideration of the unique features of a service when establishing appropriate units of use. For example, minimally interactive services, such as full-text literature systems (online books) and certain other databases, may be best characterized by counts of access to specific sections. More fully interactive services, such as bulletin boards or online user conferences, may be better represented by time duration measurements. Measures of service use should also be tailored to the nature of the service; topical analysis for communication services and search pathways for literature databases are two examples of tailored measures of service use.

In the ComputerLink evaluation, service use was operationally defined in terms of access counts for a specific service, and as duration of time spent connected to a service. Table 1 summarizes ComputerLink service use.

Not all services were used equally by the caregivers. Subjects accessed the communication areas most often, spending an average of 10 minutes of each encounter reading the Forum area. The decision-making area received the smallest amount of attention; however, most of the subjects accessed this section at least once, and one subject used it 38 times. The caregivers sought information from the electronic encyclopedia over 500 times, and spent an average of 10 minutes reading in this area each time they entered it. During any encyclopedia session, the caregivers could access as many sections as they desired. The caregivers reviewed the information about caring for oneself 143 times, caring for the person who had AD 241 times, and services 107 times, and they reviewed general

Table 1 ■

Use of ComputerLink Services by Alzheimer's Disease Caregivers

Service	Number of Encounters	Duration in Minutes (SD)
Decision making	91	9.06 (7.86)
Private mail	1,888	5.92 (9.4)
Forum	2,856	10.08 (12.13)
Question and answer	868	3.14 (5.16)
Electronic encyclopedia	518	9.36 (10.42)

information about AD 159 times. Private mail was used extensively (over 200 of the 1,000 connect hours were spent in this area). Messages from the private mail were declared unavailable for analysis out of respect for the privacy of the users. Thirty-five questions were posted on the Question and Answer (Q and A) area. Four main themes emerged in the questions: managing the person who has the disease,<sup>6</sup> traveling with the person who has AD,<sup>5</sup> managing one's own feelings,<sup>6</sup> and preparing for death.<sup>7</sup> Other topics, including handling legal issues and individual member concerns, consumed the remainder of the posted questions. Despite the low number of posted questions, subjects accessed this area over 800 times. The caregivers posted over 800 messages in the public Forum. In this area the caregivers could initiate a new topic or respond to another member's contribution. Within this particular service, it is useful to look not only at the number and timing of accesses, but also at the content of the messages. Discussion topics included the behavior of the person who has AD, choosing care sites (including nursing homes), local news events, and reminiscing about family events. A sample dialogue is included in Figure 1.

### Session-level Evaluation

Session-level evaluation addresses the timing and sequence of events within a single encounter. It draws attention to the behavior, to the manner in which users sequence activities within a particular encounter. A session represents a specific, time-limited encounter initiated by the user and terminated by the user. Behaviors of interest include the number, types, and sequences of services accessed within the session, as well as the duration of the session and accesses to specific services. Session-level use corresponds to the most common approach to computer use evaluation,<sup>26,33</sup> in which behavior during an encounter is monitored.

Typical ComputerLink sessions lasted 13 minutes and involved subjects' access of two services. Commu-

From: Dorothy                      Subject: Idle time

My husband is in the middle stages of the disease and I would like some suggestions on how to occupy his time other than walking. When he doesn't have anything to do, he seems to want to nap during the day.

From: e.k                              Subject: Re: Idle time

Dorothy I also have a problem with my wife who likes to walk and gets bored! She loves to rearrange her draws in her dresser! I fix and she rearranges them it gives her something to do! They always seem to want to be occupied and want to help but is a hard for her! do your best on this subject

From: SB                                Subject: Re: Idle time

Hi, this is Sue (login Sb). I noticed a reply to Idle Time. Idle time is a real tough one. My mother-in-law is in day care 5 days a week which helps during the day. She is in middle stages. She always wants to be doing something when she is home. I have a real hard time trying to figure things for her to do. She loves to go shopping. I try doing that a few times during the week or I take her for a ride. I have children books we try reading. I have her read and sort playing cards. These are a few things that I do. I take her for walks, she does dishes (they generally have to be done again, but it is something for her to do. It sounds like I have found a few things to occupy her time but believe me it is not enough. The weekends are the worse. Are there things for them to do without you or I should say me having to be right with them. Are there things for them to do without you or I should say me having to be right with them. That is the problem!! There are things to do, but I have to be with her to do them and I can't get anything done of my own.

Has anyone out there found something for our love ones' to do on their own? I spend 2 to 5 hours a day entertaining her and sometimes it is a drain. My mother-in-law once she sees me she is pretty much attached to me looking to me to occupy her time.

**Figure 1** A sample dialogue among some of the Alzheimer's disease caregivers in the Forum area of ComputerLink. Reproduced in modified form with permission from Brennan PF, Moore SM, Smyth K. ComputerLink: electronic support for the home caregiver. *Adv Nurs Sci*. 1991;13:14-27, Copyright © 1991 Aspen Publishers, Inc.

nication services were accessed at almost every encounter. System-level evaluation data indicated that ComputerLink sessions occurred at every hour of the day, but primarily between 10 AM and 1 PM and again between 10 PM and midnight. Sessions occurring early in the day lasted longer than did those occurring in the evening.

### Subject-level Evaluation

Subject-level evaluation describes individual user behavior. Aspects of subject-level use include number

of accesses, timing of accesses, intervals between accesses, duration of accesses, nature of accesses, and reasons for accesses. Relevant considerations also include individual attributes, such as age, gender, language, and education, that may affect use communication strategies. Subjects accessed the Computer-Link a mean of 83 times; one subject accessed the system over 590 times. For all subjects, the mean interval between encounters with ComputerLink was 3 days (range, 1 hour to 6 months), with a median of once a day. Examples of behavioral differences among subjects included accessing the system at certain consistent times each day or using ComputerLink only to read messages posted on the Forum.

Similar to the experiences of other investigators, the caregivers' self-reported use of ComputerLink differed from the actual use. Table 2 compares self-reported use with counts of access obtained from the passive monitoring system. Subjects underestimated use at the lower end and overestimated use at the higher end of the range of use behavior.

## Discussion

The primary utility of the 4-S framework lies in its ability to delineate use of services delivered via computer networks from four different perspectives: system, service, session, and subject. The four overlapping perspectives incorporate behavioral measures of computer network use<sup>26</sup> and are applicable to health services research, which requires behavioral measures of outcomes.<sup>34</sup>

The 4-S framework allows for explicit modeling of the use of the health services provided by a computer network. Preliminary examination of the effects of ComputerLink rested entirely on a system-level approach to measuring use—counts of user accesses over the period of the experiment.<sup>27</sup> The 4-S framework allowed a more explicit modeling of the exposure of the caregivers to the various components of ComputerLink. The 4-S framework increased the

Table 2 ■

Comparison of Self-report of ComputerLink Access with Actual Use by a Group of Alzheimer's Disease Caregivers

Self-report	No. of Users	Use Behavior	
		Average	Range
Fewer than 8 uses	10	54	3-19
Once a month	13	170	7-61
Once a week	16	275	9-79
Once a day	7	234	31-147
More than once a day	1	590	—

ability to link findings from this study to those from other investigations. The service behavior of the caregivers on ComputerLink, emphasizing communication use, paralleled that displayed by users of CHESS.<sup>35</sup> Subsequent analyses within the 4-S framework will provide a more accurate evaluation of the impact of ComputerLink on health states and needs satisfaction.

The 4-S framework is a first step in organizing information regarding innovative health care services delivered via computer networks. It offers investigators several options for characterizing use and for investigating in rich detail the nature of use from various perspectives. The four perspectives presented here are not discrete; they can be combined, as in examining service use within subjects. Characterizing use from one perspective, for example, system level, provides a benchmark against which use characterized from another perspective may be compared.

Each of the four perspectives provides elements suitable for constructing detailed profiles and complex models of patterns of use. For example, one can examine session behavior by subject to determine whether a subject demonstrates a stable, enduring pattern of use. With the use of the 4-S framework, it was possible to determine that ComputerLink users displayed typical individual behaviors that appeared to endure over time. Some users demonstrated a great deal of activity, posting messages, writing private mail, and conducting decision analyses. These users can be considered active. Other users assumed a more passive observational role, rarely posting messages or writing mail, but instead reading and reviewing material present on the system.

The 4-S framework provides a starting point for examining previously unexplored characteristics of computer network use. The 4-S framework is not intended as a mandatory prescription that always involves characterization using all four perspectives. Instead, the model is proposed as a conceptual framework within which various approaches to characterizing use can be organized. It is possible to use the 4-S framework to organize data obtained through self-reporting, passive monitoring schemes, and topical analysis. Analytic strategies such as statistical modeling, graphic analysis, and tabular displays may be applied to data within each of the four perspectives. The efficiency and appropriateness of data capture and data analysis strategies may vary across the perspectives. Analysis within the framework can be designed to optimally fit with the perspectives, data capture mechanisms, and analytic strategies of a given project.

The proposed 4-S model measures only actual use. In some studies, such as those exploring information needs or optimal decision making, it may be necessary to supplement actual use statistics with evidence regarding "missed opportunities for use." For example, to explore the value of ComputerLink as part of a potential repertoire for supporting AD caregivers, it would be useful to know how many times AD caregivers in the ComputerLink study had problems that they might have addressed using ComputerLink, but for which they did not use the system. Reasons for lack of such use (e.g., incomplete understanding of system relevance to health problems, users' preoccupation with other concerns, or users' disdain for system characteristics making use inconvenient) could provide valuable insight to system builders and to health care providers promoting such systems. The 4-S framework is grounded in a behavior that represents only one of a potentially larger set of actions that an individual could take to fulfill specific needs.

Measurement of the use of health services delivered via computer networks provides only one dimension of the evidence necessary to establish the utility and value of technology-based interventions in health care. Additional evidence must be drawn from other perspectives, such as measuring system quality, grading success in accomplishing tasks, monitoring resolution of information needs, and assessing user satisfaction. The 4-S framework, because it offers precision in characterizing use, facilitates linking theoretically relevant antecedents, consequences, and covariates with the appropriate level(s) of use. Through explicit characterization of service use, it will be possible to use the 4-S framework to determine whether the improvement in decision-making confidence found among ComputerLink subjects resulted from access to ComputerLink or encounters with the decision support systems.

## Conclusion and Recommendations

The appropriate strategy for characterizing the use of health services delivered via computer networks is the one that best meets the goals initially held for exploring the intervention. The 4-S framework presented here provides a way to organize and relate various measures of use. This article argues not for a single measure of use, but, rather, for the need to recognize that various metrics for use exist, each of which may have unique value as a predictor and unique consequences. Appropriate interpretation of various measures of use will facilitate determining service units of computer networks employed in the



delivery of health care. Multidimensional characterization of use will enable researchers to compare findings across studies and develop a way to represent use as an input to other processes. This, in turn, will pave the way for determining how to monitor, charge, pay, or reimburse for health services delivered via computer networks and for establishing the relative contribution of health services delivered via computer networks to the overall constellation of health services. The problem of characterizing the use of health services delivered via computer networks is one of selecting from a range of operational definitions and appropriate metrics. These metrics can later be employed to evaluate the computer network itself, the specific services provided on the network, the motivation for use, and the impact of the computer network and its services on selected outcomes.

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