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ABSTRACT

Despite the growing use of telemedicine technology in civilian and military health care, relatively little work has been performed in the area of evaluation. To address this deficiency, a preliminary set of telemedicine evaluation instruments (primarily surveys) was developed and pilot tested. Surveys for health care providers were administered aboard three Navy carrier groups and one remote shore station. A separate questionnaire, designed for the medical specialist consultants that were contacted via telecommunications, was administered at the consultant sites. Results suggest that providers view telemedicine as a highly effective tool, and that telemedicine consultations have their greatest impact on treatment (as opposed to diagnosis). The usefulness of "basic" telemedicine technologies, such as telephone and e-mail, was strongly supported.

INTRODUCTION

Rapid advances in information technology have allowed health care delivery services to be expanded through telemedicine.[1] Generally defined, telemedicine is the use of communications technologies to support medical care at a remote location. Some specific examples of current telemedicine use include a telephone call to 911 requesting instructions for administering artificial respiration, a paramedic transmitting an electrocardiogram from an ambulance while en route to a hospital emergency room, and an interactive video transmission via satellite allowing a physician specialist to advise during a surgical procedure being performed in another country. These scenarios illustrate the purpose of telemedicine: to provide immediate and expert health care of the highest quality to an individual in a remote location.

Telemedicine has been in use and its development progressing for nearly 40 years. As early as 1959, telemedicine was used to establish an interactive television link for psychiatric consultation between the Nebraska Psychiatric Institute in Omaha and the Norfolk State Mental hospital over 100 miles away.[2] In 1968 an interactive television microwave link (which included an electrocardiograph, stethoscope, and voice transmission capability) was established between Massachusetts General Hospital in Boston and a medical station at the city's Logan Airport.[3] During the early 1970s only 15 telemedicine sites received federal funding,[4] by the 1990s telemedicine had begun a period of rapid growth. Precipitated by significant clinical need, the medical community currently recognizes telemedicine as more than a sophisticated means of communication and exploits this technology as a new diagnostic and therapeutic modality. Medical specialties as diverse as psychiatry, radiology, dermatology, and cardiology are using telecommunications to eliminate geographic boundaries between a physician specialist and patient.[5-9]

At present, the U.S. military is a widely acknowledged leader in many aspects of telemedicine.[10] Telemedicine has particular relevance for the U. S. Navy; ships deployed to remote and isolated sites of conflict often have few resources for managing a wide range of medical conditions. Compounding these resource limitations is the fact that the majority of the medical departments on Navy ships are headed by an independent duty corpsman (IDC). IDCs, though not medical doctors, are responsible for providing all

aspects of primary health care services on the ship. Given the challenges that an IDC provider must routinely face, telecommunication can be an important source of support for difficult diagnosis and treatment decisions. Not only does the patient benefit, but the Navy avoids costly medical evacuations (medevacs) to larger ship or shore facilities (e.g., research shows that ships with IDC providers have more medevacs than ships with physician providers.[11])

There is evidence that telemedicine in the Navy has the potential to keep patient evacuations at an absolute minimum. In 1983, Nice[11] conducted a 9-month study of all U.S. Navy surface ships (N = 354), Pacific Fleet submarines (N = 42), and all ships of the Military Sealift Command (N = 54) to determine the need for telemedicine capabilities aboard ship. This study showed that in 28% of all medevacs, the senior medical department representative indicated that there was a significant probability that the medevacs could have been prevented if they had had the capability to transmit medical data via telecommunications.[11] This estimate (28%) was subsequently replicated in 1997 following an independent study by the Center for Naval Analysis (CNA).[12]

In recent years, the Navy has implemented telemedicine aboard several aircraft carriers, as well as shore facilities, such as the National Naval Medical Center in Bethesda, MD and Naval Medical Center, San Diego, CA. The Army has also recognized the potential for expanding and improving the quality of health care through telemedicine technologies and has played a major role in the military telemedicine revolution.[13] In early 1996 the Army expanded telemedicine support to include the Bosnia theater of operations. Among the primary modes of available military telecommunication support are teleradiology (x-ray images, digitized by scanning, and transmitted to a radiologist for consultation), video teleconferencing (full motion video of a patient sent to a consultant/specialist), and store and forward images (captured in digital format and sent via the Internet for diagnosis and treatment advice).

The need for evaluation. In 1994 and 1995, the Commanding Officer of the Naval Medical Information Management Center issued the Navy Telemedicine Initiative[14] and the Telemedicine Prototype Project,[15] citing the need for standardization and evaluation of naval telemedicine technology. In addition, a number of recent research articles have noted the lack of research evaluating the effectiveness of telemedicine.[16-18] In response to these concerns, the Naval Health Research Center

(NHRC) in San Diego, CA, initiated a telemedicine evaluation project. The initial effort of this project was to develop a questionnaire to assess medical care providers' experiences using existing telemedicine systems aboard three aircraft carriers: the *George Washington*, the *Enterprise*, the *Theodore Roosevelt*, and at the remote shore site at McMurdo Station, Antarctica. A separate questionnaire, designed for the medical specialist consultants that were contacted via telecommunications, was also tested. The objectives of the present report were to (1) pilot test and evaluate the medical provider and consultant questionnaires; (2) summarize providers' responses regarding the use and effectiveness of a telemedicine consultation for patient diagnosis, treatment, and disposition; and (3) match provider and consultant questionnaires in an effort to compare and contrast their respective evaluations of specific telemedicine consults. This study was the first in a planned series to determine whether telecommunications between health care providers and medical consultants/specialists were effective in supporting diagnosis and treatment during medical visits.

DESIGN AND METHODOLOGY

Two separate telemedicine questionnaires were developed at the NHRC in consultation with representatives of the National Naval Medical Center and John Hopkins University, Baltimore, MD. The questionnaires were designed to assess provider experiences and consultant experiences, respectively, with a special emphasis placed on the role of telemedicine in diagnosis and treatment. Questionnaire formats were heavily influenced by Dillman's[19] total design methodology for mail questionnaires.

1. Provider Assessment Questionnaire. The provider questionnaire solicits health care providers' comments on each telemedicine transmission. Of the 25 questions, 18 are closed-ended and 7 are open-ended. The provider questionnaire was designed to document the reason(s) for the medical transmission; whether a diagnosis, treatment plan, or disposition had been made prior to the transmission; and whether the telemedicine contact led to a change in diagnosis, treatment plan, or disposition. Five additional items are included to identify the mode of transmission, the type of information transferred, and ratings of the timeliness and ease of transmission. Last, the providers are asked to rate the telemedicine transmission's

effectiveness in providing necessary information, and to rate whether the transmission assisted their delivery of health care.

2. Consultant Assessment Questionnaire. The consultant questionnaire (21 open-ended questions and 7 closed-ended) was designed to obtain information on each telemedicine transmission at the consulting locations. The majority of consultant questions mirror those asked of the Provider, to allow comparisons. The primary difference between these two questionnaires is that the medical consultants are also asked about their satisfaction with the quality of information received from the telemedicine transmission.

Data Collection. Provider surveys were distributed aboard the three aircraft carriers, the *George Washington*, the *Enterprise*, the *Theodore Roosevelt*, and at the remote shore site at McMurdo Station, Antarctica. During the same time period, consultant surveys were distributed at the National Naval Medical Center (the consultant site for the carriers) and at Naval Medical Center, San Diego (the consultant site for McMurdo Station). Through this data collection strategy, matching provider and consultant evaluations for each patient could be obtained, allowing a comparison between the two perspectives.

Data Analysis Techniques. Upon receipt, the numerical data obtained from the closed-ended items on the questionnaires were coded and entered into a database for statistical analysis. Then, simple frequency distributions were created for the provider and consultant responses, the characteristics of the populations, and available telecommunication technologies. Next, the data were examined in various ways to determine the impact of telemedicine communications on the initial diagnosis, treatment plans, and patient disposition associated with each case.

RESULTS AND DISCUSSION

The first objective of this study was to pilot test and evaluate the provider and consultant questionnaires. Within limitations, both of these questionnaires were determined to be effective information-gathering instruments based on the data received (described as follows). The content and length were deemed appropriate, and a clear picture of most cases emerged.

The second objective of this study, to summarize medical providers' responses regarding the use and effectiveness of telemedicine consultations, was examined by considering a number of questionnaire items, beginning with items addressing which of the various telecommunication modalities were used and which type of information was transmitted. Providers returned 94 completed surveys.* Table 1 shows the various telecommunication modalities along with the frequency and percentage of usage by the medical care providers. Provider responses show that televideo and the Internet were used more than any other modality. Values for televideo usage, however, probably exceed normal levels because medical providers had been specifically encouraged to use televideo technology shortly before the present study began. Telephone communication was also frequently used. While these usage results are constrained by equipment availability on the ships in the study, the findings are nevertheless consistent with past research. For example, studies by CNA and NHRC have consistently demonstrated the advantages of "low-end" telemedicine technologies, such as e-mail and telephones.[12,16,20]

Table 1. Telecommunication Modalities, Frequency, and Percentage Used

	N	%
Televideo	44	35
Internet	44	35
Telephone	27	21
Composite Health Care System	7	6
Radiophone	3	2
Teleradiographic	2	1
Total	**127**	**100**

Table 2 shows the type of data or information that were transmitted by medical care providers to medical specialist consultants. The most frequent type of data or information transmissions involved still images, followed by conversation, and live images (televideo). These results are, of course, fairly predictable from the telecommunication modality usage rates in Table 1.

*Response rates vary by survey question, particularly since some items allowed respondents to select multiple options.

Table 2. Type of Telecommunication Data or Information Transmitted

	N	%
Still images	39	27
Conversation	31	22
Live images	25	17
Records/test results	24	17
Radiologic images	23	16
Other	2	1
Total	**144**	**100**

Ninety-five percent of the requested telemedicine consultations asked for the assistance of a specialist. Table 3 shows the medical specialties from which assistance was requested. The medical specialty with the most requests for assistance was dermatology (29%), followed by orthopedics (11%), radiology (9%), and ear/nose/throat (8%). These results support those of an Army study involving a peacekeeping unit in Macedonia which found that dermatology and orthopedics were the specialties most often consulted by Army practitioners.[13] Since these specialties also experience high consultation rates across other studies,[11,16,20] there is noteworthy consistency as to which medical specialties are contacted most often via telemedicine.

Table 3. Medical Specialties Consulted via Telecommunication

	N	%
Dermatology	25	29
Orthopedics	9	11
Radiology	8	9
Ear/Nose/Throat	7	8
Urology	6	7
Neurosurgery	5	6
Ophthalmology	4	5
Cardiology	3	4
Psychiatry	3	4
Gynecology	2	2
Oral Surgery	2	2
Gastroenterology	1	1
Hand Surgery	1	1
Infectious Disease	1	1
Internal Medicine	1	1
Rheumatology	1	1
Other	6	7
Total	**85**	**100**

Clinical Impact. Medical care providers indicated that the primary reason for initiating a telemedicine consultation was to develop or confirm a treatment plan. Specifically, there were substantially more requests for treatment assistance (46%) than for help with diagnosis (32%) or decisions on a patient's disposition (16%). Consistent with these findings, 39% of *treatment* plans changed as a result of telemedicine consultations, while *diagnosis* changed in only 9% of the cases. Our finding of a substantial telemedicine impact on treatment is supported by Army research in Macedonia, where 66% of treatment protocols were changed as a result of telemedicine consultations.[13] These specific Navy and Army findings, when combined with prior research,[11,16] strongly suggest that the major impact of telemedicine is on patient treatment rather than diagnosis or disposition.

In addition, medical care providers were asked, "overall, how effective or ineffective was this telemedicine consultation in assisting you with delivering health care to your patient?" Eighty-four percent said that the consultation was very effective, and the remaining providers

(16%) said that the consultation was somewhat effective. None of the medical providers felt that the consultations were ineffective.

Provider/Consultant Contrasts. The third objective of the study was to match provider and consultant questionnaires for each case in an effort to further evaluate all aspects of telemedicine consultations. Unfortunately, the number of provider/consultant questionnaire matches was reduced by several difficulties, including a low questionnaire return rate from consultants (N=34); incomplete consultant questionnaires, specifically, missing data in the date field; and inconsistency in terminology and/or description of medical encounters between providers and consultants. Because of these difficulties only a small percentage of the medical encounters had complete and matched provider and consultant questionnaires. For this reason, provider responses were the primary source of telemedicine data for the current effort. Nevertheless, several impressions can be gleaned from the limited consultant data. These are presented not as firm results, but rather as trends worthy of exploration in subsequent work.

For example, although too few consultant questionnaires were received to support detailed analyses, it was apparent even from our small sample that many consultants had mistaken impressions about providers' diagnosis and treatment progress. Several consultants wrote that no prior diagnosis existed at the time of the telemedicine consultation, whereas providers indicated that a diagnosis had already been made. Interestingly, mistaken consultant views about the status of a case were also found in the previously cited Army study of telemedicine operations in Macedonia.[13] In at least 4 separate cases, Army hospital consultants felt that an evacuation was avoided by a consult, whereas the medical provider was actually not contemplating evacuation at all. Taken together, these results suggest that consultants may be a relatively unreliable source of information about the clinical impact of telemedicine. This, of course, by no means diminishes the value of the medical advice that consultants offer. It simply

reflects the fact that consultants have only partial knowledge of each case and may thus occasionally make incorrect assumptions about preconsult case status.

Technical Issues. All telemedicine technologies were viewed as relatively simple to use, with the occasional exception of video teleconferencing (VTC). In one case, 10 separate attempts were required to establish a VTC link-up for a consultation, wasting valuable time and creating frustration. No similar problems were found with, for example, store and forward transmissions. Although VTC problems, including poor image quality, were the major source of technical difficulties noted in the current survey responses, these problems may ease as technology improves.

RECOMMENDATIONS

Several recommendations are suggested in light of the present study's telemedicine survey results. First, while the current sample was sufficient to draw a limited number of broad conclusions, larger samples will be needed for finer grained data analysis. Large samples are particularly important if one is to examine the effectiveness of telemedicine as a function of individual medical specialties or individual patient conditions. In the present study, only dermatology specialists received more than 10 consults, and the median number of consults for *all* specialties was approximately one. These numbers are too small for examining many critical issues, such as the usefulness of diverse telemedicine devices within and across specialties.

An alternative to large samples would involve small, targeted studies focusing on particular specialties, conditions, or technologies. Indeed, the latter approach may be the most viable because it addresses more highly focused research issues (e.g., "does VTC help

psychologists treat shipboard personnel with stress symptomatology?"). Information from small but in-depth studies could then be aggregated with broad-band surveys to provide an overall perspective with both breadth and detail.

Second, even if larger samples are sought it can be difficult to obtain an adequate response rate, particularly from consultants. It is understandable that the consultants, who are practicing physicians, may be less compliant regarding additional paperwork than the providers, who are often relatively junior enlisted personnel. Nevertheless, it would be desirable to obtain a higher consultant response rate and possible strategies to reach this goal should be explored. Perhaps consultants should be assessed through one-time interviews in which a retrospective, overall summary of telemedicine experiences is obtained. Case-by-case information could then still be obtained from medical care providers, who are the real experts on what transpired with each patient.

Finally, while the current effort has focused on changes in diagnosis and treatment, a truly complete evaluation of telemedicine must also acknowledge its benefits for training. Continuing medical education has always been a proposed use of telemedicine, and telemedicine-based training should continue to be explored as an adjunct to other state-of-the-art tools, such as computer-based patient treatment simulations and expert-system[21]medical decision aids. Various educational or training uses for telemedicine hold great promise for military health care providers.

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Despite the growing use of telemedicine technology in civilian and military health care, relatively little work has been performed in the area of evaluation. To address this deficiency, a preliminary set of telemedicine evaluation instruments (primarily surveys) was developed and pilot tested. Surveys for health care providers were administered aboard three Navy carrier groups and one remote shore station. A separate questionnaire, designed for the medical specialist consultants who were contacted via telecommunications, was administered at the consultant sites. Results suggest that providers view telemedicine as a highly effective tool, and that telemedicine consultations have their greatest impact on treatment (as opposed to diagnosis). The usefulness of "basic" telemedicine technologies, such as telephone and e-mail was strongly supported.

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