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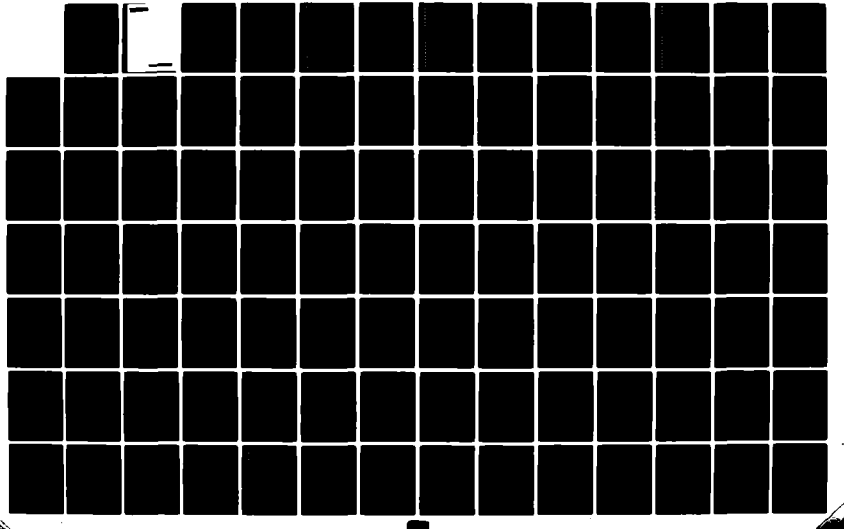

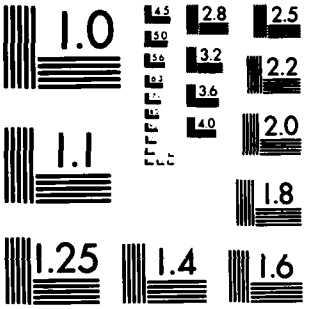

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FUNCTIONAL EVALUATION OF THE WASHINGTON-AREA TELERADIOLOGY DEMONSTRATION PROJECT

ARTHUR D. LITTLE, INC.
Acorn Park
Cambridge, Massachusetts 02140

Final Report for Period 6/1/81 - 12/29/82

December 29, 1982

Prepared for

TRIMIS Program Office
6917 Arlington Road
Bethesda, Maryland 20014

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Arthur D Little, Inc.

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Study of the performance of a teleradiology system in five hospitals and clinics in the Washington, D.C. area. The purpose of the study was to assess the utility of teleradiology in medical practice in small health care facilities that do not have a full-time staff radiologist.

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SUMMARY OF FINDINGS

A. INTRODUCTION

Teleradiology is an automated system whereby an electronic representation of an X-ray image is transmitted via telephone wires from one location to another. The TRIMIS Program Office (Department of Defense) and the Bureau of Radiological Health (Public Health Service) have conducted a six-month field trial of a Teleradiology system. The system, which was designed by the MITRE Corporation, was studied to evaluate its performance in a routine medical practice setting.

In the fall of 1980, four small clinics in the Washington, D.C. area were chosen as transmitter sites for the trial and a large radiology department was selected as the central receiver site. Training for site personnel began in the fall of 1981. The system was installed in January of 1982, becoming fully operational in late March, and remaining so through June. Baseline (pre-implementation) data collection for the functional evaluation of the Teleradiology system was conducted by the Bureau of Radiological Health for two weeks in February of 1981 and by Arthur D. Little, Inc. for two weeks in September of that year. Post-implementation data were collected by Arthur D. Little, Inc. for two weeks in June of 1982.

The Teleradiology system was experimental and, hence, was not used as a replacement for normal film interpretation of X-ray exams during the field trial. The "manual" systems used by each of the transmitter clinics continued to be used in parallel with Teleradiology. Because of the parallel use of Teleradiology and "manual" methods for obtaining interpretations, many of the data collected for the functional evaluation were designed to estimate the system's potential impact, rather than to directly measure its impact in the experimental setting.

Data were collected concerning:

- the potential impact of the system on patient care;
- the acceptability of the system to users;

- the potential feasibility of using the system in routine practice settings; and
- the potential impact of the system on costs of transmitter site X-ray services.

B. THE STUDY SETTING

The central receiver site for the Teleradiology field trial was the Radiology Department at Malcolm Grow Medical Center at Andrews Air Force Base in Maryland. During the field trial, this large radiology department continued, for the most part, to operate as it had before. The Teleradiology equipment was physically separated from the other viewing rooms in the department; the transcriptionists who used the system were especially hired for the project; and the radiologists who interpreted teleradiology images were recruited from several hospitals in the area and used the system on a part-time, scheduled, volunteer basis.

The four medical facilities used as transmitter sites during the field trial were:

- Bolling Air Force Base Clinic, Washington, D.C.;
- Fort Detrick Army Clinic, Frederick, Maryland;
- Patuxent Naval Air Station Hospital, Lexington Park, Maryland; and
- Central Virginia Community Health Center, New Canton, Virginia.

These clinics and their X-ray departments are quite small and are oriented primarily toward the delivery of outpatient services. The clinics vary in workload from 21,000 outpatient visits per year to 85,000. Their X-ray departments range from having one technician, one X-ray room and examining 1,400 patients per year to four technicians, two rooms and 7,000 patients per year. Each of the four sites has standard arrangements with specific medical centers for secondary and tertiary care referrals. Their distance to these medical centers varies from 10 to 90 miles. Normally, two of the four clinics send their X-ray films by courier to medical centers for interpretation;

one employs a part-time radiologist to perform film interpretations; and the fourth sends films away every other week, employing a visiting radiologist during the off-weeks.

During the field trial, the transmitter departments continued to have their films read "manually," as they had before. At each of four of the transmitter sites, the regular technicians were trained to use the Teleradiology system and did operate it. However, at three of the sites, additional temporary personnel were also hired to accommodate system use.

C. RESULTS: REAL AND POTENTIAL IMPACTS

1. Impact on Patient Care

The potential impact of Teleradiology on patient care was studied in two ways. First, turnaround time of interpretation reports was measured for all exams ordered during the two study periods (before and after the Teleradiology system was installed). And second, a study was conducted of how radiographs and X-ray interpretations were used in patient care at the transmitter facilities. All data regarding turnaround time and patient care impacts were collected using a self-administered survey form, which followed each X-ray through the various stages of the X-ray request/report cycle and was completed by clinic staff. Data were collected regarding a total of 418 patients (453 exams) before system implementation and for 618 patients (695 exams) during system operation.

a. Turnaround Time: X-Ray Request/Report Cycle

Most of the X-rays at each of the four clinics and during both data collection periods were performed within two hours of being ordered. However, delays of several days often occurred between the exam's performance and its interpretation by a radiologist and between this interpretation and its review by the referring provider.

The total mean turnaround time required for "manual" film interpretation reports before system implementation was found to range from 88 hours to 108 hours at the four study sites. During system operation, mean turnaround time for "manual" film interpretation

reports was somewhat longer, ranging, at the the four sites, from 121 to 233 hours. This increase in turnaround time may be associated with:

- the parallel use of the two interpretation modalities during the post-implementation data collection period; and
- miscellaneous breakdowns in the "manual" interpretation systems during the post-implementation data collection period.

The total mean turnaround time required for automated Teleradiology interpretations was even longer than that for manual services. This mean varied from 181 to 212 hours at the four sites. Delays for receipt of Teleradiology interpretations were largely attributable to the fact that the system was only used experimentally:

- the system did not initially function reliably;
- X-ray images were not always input regularly or on a daily basis;
- radiologists were generally available to perform Teleradiology interpretations only during morning hours five days each week;
- "manual" interpretation reports were often received prior to Teleradiology interpretations of the same exam, and, hence, were not always read promptly.

In order to project the impact of a refined Teleradiology system in routine use (a non-experimental setting), it is assumed that the system would be implemented and utilized quite differently. For example:

- a non-experimental system would probably be more reliable;
- if the system were used routinely, a protocol would probably be established for inputting films into the system regularly;
- a radiologist would probably be available on a full-time basis; and
- no parallel "manual" system would be available.

Based on these assumptions, the data collected during the post-implementation period suggest that in a non-experimental situation,

turnaround time for teleradiology interpretation reports could be much shorter than that observed during the field trial. Inputting of films requires approximately 10 minutes per exam, and telephone line transmission takes an additional 15 to 30 minutes per exam. As soon as transmission is complete, interpretation may be performed, and either the telephone or the tele-typewriter may be used to communicate findings immediately to remote providers. We project that a 24-hour total turnaround would be possible for routine exams and that a 1-hour turnaround could be accomplished for STAT exams.

The field trial figures demonstrate, however, that installation of the teleradiology technology does not, itself, result in reduced turnaround time. Although system operation is neither extremely time-consuming nor very complex, for the system to be used effectively, protocols must be established for inputting films regularly, radiologists must be available to interpret images on a routine basis, and, as under any reporting system, if one's goal is to minimize time delays, reports must be delivered to providers promptly and read by providers upon receipt.

b. Impact on Patient Care

Data were collected concerning the types of X-rays performed during the two study periods at the transmitter site X-ray departments. Also, for each X-ray ordered during the study periods, referring providers were asked to answer three different questions concerning the use of interpretations in patient care. These questions concerned the relative significance of prompt receipt of a radiologist's interpretation; the role of X-ray film viewing in patient care decisions; and the role of the radiologist's report in these decisions. Little variation existed between the two data collection periods in the types of exams performed and the patterns of provider response to "patient care" questions. Hence, these data have been pooled for presentation.

The X-ray exams performed at the study sites were grouped into four categories corresponding to various clinical uses:

- Routine physical chest exams;
- Emergency exams associated with acute trauma;
- Diagnostic exams not associated with acute trauma; and
- X-rays taken "for the record" or as follow-up exams.

The case mix in the X-ray departments at each of the transmitter facilities is quite limited, as would be expected in primary care clinics. Also, the distribution of X-rays performed at the military sites is somewhat different from that at the civilian clinic, Central Virginia Community Health Center (CVCHC). During the two study periods, 23% of the X-rays performed at the military sites were associated with routine physicals (compared with 6% at CVCHC); 40% were associated with acute trauma (compared with 28% at CVCHC); 17% were other "diagnostic" exams (compared with 50% at CVCHC); and 20% were performed "for the record" or as follow-up procedures (versus 16% at CVCHC).

At the time that the exam was requested, providers were asked to categorize how significant a prompt receipt of a radiologist's interpretation would be in patient care. In 73% of cases, providers indicated that prompt receipt of a radiologist's interpretation would have some effect on their opinions or decisions regarding patient care. Timely interpretation receipt was considered "very significant: essential to patient care decisions" in only 8% of cases. Rapid interpretation turnaround was felt to be most important for exams associated with trauma and other diagnostic exams and least significant for routine physicals.

After X-rays were performed at the transmitter facilities, the requesting providers viewed the films themselves in a majority of cases. Providers were most likely to review exams associated with acute trauma (77%), followed by non-emergency exams that they considered diagnostic (69%) and radiographs performed "for the record" or as follow-up procedures (62%). They seldom viewed routine physical chest exams (10%).

If and when the referring provider viewed the films that he had ordered, he was asked to categorize how he felt this viewing had affected his handling of the case. Usually (in 65% of cases) the viewing of radiographs served to "increase the clinical confidence" of providers. Sometimes -- primarily in trauma cases or for other diagnostic exams -- providers reported that the film viewing had had a major effect on handling of the case (16% and 21% of cases, respectively). It was least likely to have had a major effect for routine physicals (4% of cases).

At the time the provider reviewed the radiologist's film or Teleradiology interpretation report, he was asked what effect the specialist's report had made on patient treatment/disposition decisions. At the transmitter sites radiologists' interpretations were almost always received several days after the X-ray had been performed and the patient treated and sent home (see above). Reports received after so long a delay would not be expected to have much effect on patient care unless their findings differed substantially from those made earlier by the referring provider. Indeed, by the time radiologists' reports were reviewed, they were felt to have had no effect on patient care for 42% of cases. Forty-three percent of radiologists' reports were felt to have "increased the clinical confidence" of the providers. It is interesting to note, however, that in each X-ray category, some radiologists' reports were reported to have had a major effect on care (6% for routine physicals; 8% for emergency exams; 10% for other diagnostic exams; and 7% for exams performed "for the record" or as follow-up procedures).

2. User Acceptance

During the post-implementation data collection period, system users were questioned regarding their opinions of the system and its utility. The response rate for each survey was over 90%.

a. Acceptance by Primary Care Providers

Overall, providers' comments were positive. Most of their enthusiasm, however, was derived from the system's potential utility rather than actual benefits realized during the field trial.

Providers believed that the system could be valuable where turnaround time reduced to a few hours or to a single day. Also, at some of the sites, providers felt that 24-hour availability of interpretation services was important.

b. Acceptance by Receiving Site Radiologists

The radiologists who had participated in the field trial at Malcolm Grow Medical Center completed a written questionnaire regarding their experience with the system. The radiologists' comments were enthusiastic. They felt that the quality of images received was generally good and that image resolution was usually adequate.

c. Acceptance by Technicians and System Operators

Each technician who used the system at the transmitter sites was interviewed. All felt that once the system had become reliable, it had been easy to use. This opinion was expressed both by trained radiology technicians and by the non-technician system operators. The non-technicians did require somewhat more time to become accustomed to the system -- to learn the correct positioning and focusing of films -- but soon became very adept at its operation.

Transmitter site personnel did criticize some aspects of system design, primarily complaining that the film inputting activity was tedious and time-consuming.

3. Feasibility of Routine Use

In order to determine the feasibility of using the Teleradiology system in routine medical practice settings, its potential impact on the daily routines was studied at both the transmitter sites and at the central receiver site.

Several days of work sampling were performed at each of the four transmitter sites both before and after system implementation. During both study periods, approximately fifty percent of X-ray department staff time was spent in activities unrelated to X-ray department work. (Workload is extremely uneven in these small departments, and much of this time was spent "on-call" for X-ray duty during non-busy times.) Performing and processing each X-ray and doing the paperwork and

filing associated with radiographs took between 20 minutes and 40 minutes per exam; inputting Teleradiology images required an additional 10 minutes per exam. It is assumed that these figures are good estimates of the amount of time that would be required were the system in routine use. Although all but one of the transmitter sites did increase their staff between our first and second study periods, the data fail to show that these staff increases would be required to accommodate routine system operation.

Time studies performed on radiologists interpreting X-ray films were conducted before system implementation and similar studies were conducted under Teleradiology. It was determined that video viewing is only slightly more time-consuming than film viewing.

From these work sampling and time study data, one could infer that small moderately busy X-ray departments should be able to accommodate Teleradiology system operation into their daily schedules without an increase in staff. Large radiology departments who currently accommodate interpretations of X-ray films, could similarly accommodate interpretations of the Teleradiology images of the films.

4. System Costs

To determine the potential impact of Teleradiology on X-ray department costs, the estimated costs of the Teleradiology system at the four transmitter clinics were compared with the two "manual" methods for obtaining radiologists' interpretations of X-rays performed at these clinics. These two "manual" methods are (1) using a courier to transport films and (2) employing a part-time visiting radiologist. In the field trial transmitter sites, the equipment and staff necessary to perform and process X-ray exams are essentially the same regardless of which of the three systems is used. Hence attention was focused only on the incremental costs associated with the three alternatives. The cost of using the experimental Teleradiology system in the field trial sites was found to be approximately $7 per X-ray exam, compared with an estimated $2.50 per exam when a part-time visiting radiologist is employed and $0.50 when a courier system is used. These relative costs would, of course, vary in different settings.

D. SUMMARY AND CONCLUSIONS

A refined Teleradiology system would make available to remote clinics the same access to radiologists' interpretation services as is currently available to large hospital outpatient departments. The remote clinics would have routine interpretations returned to providers within a day or two and "wet readings" of films would be accessible at any time during the day. Primary responsibility for radiological interpretation would be shifted from the primary care provider to the radiologist.

At clinics typified by the four transmitter sites involved in the field trial, it appears that Teleradiology can provide a much more rapid turnaround of radiologists' interpretation reports than can either of the standard "manual" methods for obtaining film interpretations. The system appears feasible to use in small transmitter site X-ray departments and a large central receiving site. It has been demonstrated to be acceptable to users. At the field trial sites, alternative methods for obtaining interpretations were readily available, and were less expensive than using Teleradiology.

In the majority of cases, providers in transmitter clinics expressed a preference for receiving expert interpretations promptly rather than relying on their own readings of films. However, the importance of X-ray examinations and the significance of prompt receipt of radiologists' interpretations were found to vary with X-ray exam type. Providers indicated most often that radiographic findings were relevant to immediate care in trauma cases, less often that findings were critical for other diagnostic exams, followed by examinations performed "for the record" or for follow-up, and, finally, they were least often felt to be immediately relevant for routine physical examinations.

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ACKNOWLEDGMENTS

The project described in this report was conducted by staff from Arthur D. Little, Inc. The major contributors to the project -- Nicola Moore, Philip Drew and Erica Drazen -- were assisted in the conduct of this evaluation by Nina Green, Carol Lumm, Kevin Lucey, Coleen McGinnis, Jane Metzger, and Beverly Phelan.

We wish to thank Lt. Col. Joseph Begin, Lt. Col. Avrom Nadel and Mr. Randall Koran of the TRIMIS Program Office; Col. Robert Allman, Consultant in Radiology to the TRIMIS Program Office; Dr. Barbara Kerlin and Dr. Michael Harrington of the MITRE Corporation; and the Teleradiology Steering Committee, for their assistance and support. We also wish to thank the numerous study site personnel -- technicians, providers, administrative staff and system operators -- for their cooperation.

I. INTRODUCTION

This report presents the final results of an evaluation conducted by Arthur D. Little, Inc., concerning the functional performance of the Washington-area Teleradiology Field Trial System. The evaluation was designed to assess the utility of teleradiology in medical practice.

A. BACKGROUND

Many small health care facilities, especially those located in remote areas, do not have a full-time staff radiologist, but do provide X-ray services to their patients. Most examinations performed at such facilities are, nevertheless, interpreted by a radiologist. There are two reasons for this practice:

- the specialist's review is considered important for the provision of good quality diagnostic care; and
- a radiologist's interpretation is recommended by the Joint Commission on Accreditation of Hospitals.

There are two common methods for accomplishing radiologist's review of exams performed at small X-ray departments:

- the films are transported from the small site to a radiologist's workplace; or
- a radiologist is transported to the small site on a part-time basis.

Compared with the situation of having a full-time staff radiologist, each of these methods of obtaining interpretations has limitations:

- a significant time interval often exists between the request for an X-ray examination and when a radiologist's interpretation is available for use by the primary care provider in medical decision-making;
- there is a cost associated with the packaging and transport of films, the transport of personnel and patients, and non-productive time spent by personnel and by patients in transit; and
- X-ray films and reports may be lost in transit.

B. THE TELERADIOLOGY FIELD TRIAL

"Teleradiology" is an automated system whereby an electronic representation of an X-ray image is transmitted via telephone wires from one location to another. The system allows a radiologist at one central site to interpret X-ray examinations from several small or remote sites. Teleradiology interpretation can occur in a more timely fashion than film interpretation; also the system does not require the transportation of films, personnel or patients. It thus has the potential for:

- increasing access to radiologists' interpretation services at small or remote facilities by reducing the interval between the time when an X-ray examination is requested and the time when a radiologist's interpretation is available for use by the primary care provider in medical decision-making; and
- reducing the dollar costs of providing X-ray services at small or remote sites by centralizing interpretation services and by eliminating the costs associated with transportation, with non-productive time spent by personnel and patients in transit and with film and report losses.

In order to evaluate the utility of teleradiology in routine medical practice, a teleradiology system (designed by the MITRE Corporation) was installed and studied in the Washington, D.C. area. This field trial lasted 6 months. It was undertaken with the support of the Public Health Service and the Tri-Service Medical Information System (TRIMIS) Program Office. Evaluation activities were conducted by the Bureau of Radiological Health (Public Health Service), by the MITRE Corporation and by Arthur D. Little, Inc.

The teleradiology system was installed in January 1982, became fully operational in March, and remained so through June. It allowed transmission of X-ray images from each of four small transmitter sites to one central reading site. The transmitter sites involved in the teleradiology field trial were:

- Bolling Air Force Base Clinic in Washington, D.C.;
- Fort Detrick Army Clinic in Frederick, Maryland;
- Patuxent Naval Air Station Hospital in Lexington Park, Maryland; and
- Central Virginia Community Health Clinic in New Canton, Virginia.

The central reading site for the field trial was Malcolm Grow Medical Center on Andrews Air Force Base in Maryland.

Because the teleradiology system was experimental, it was not used as a replacement for normal film interpretation of X-ray exams during the field trial. At each transmitter site, the "manual" methods for obtaining interpretations that had been used prior to teleradiology continued to be used in parallel with the automated system.

C. EVALUATION OBJECTIVES

The field trial of teleradiology had two goals:

(1) to determine if teleradiology allows a radiologist to interpret X-ray images accurately; i.e., to discover how well the system performs technically; and

(2) to determine whether, given a certain level of technical performance, teleradiology is useful in a clinical setting; e.g., to discover how well the system performs functionally.

The technical evaluation (Goal 1) was conducted by the MITRE Corporation and the Bureau of Radiological Health, and will not be specifically discussed here.

The functional evaluation (Goal 2) was conducted by Arthur D. Little, Inc., and is the subject of this report. The functional evaluation was conducted as a modified before-and-after study: one stage of data collection was performed before the teleradiology system was implemented (baseline or Period X) and one was performed while the system was operating in parallel with manual methods (post-implementation or Period Y). In addition, Arthur D. Little, Inc., staff were involved in monitoring the implementation of the system.

A summary of the data collected by Arthur D. Little, Inc., is presented in the following chapters. Also, conclusions concerning the functional utility of teleradiology are presented in this report. These were drawn from a comparison of information collected in Periods X and Y and concern:

- the extent to which teleradiology has the potential to improve patient care and alter patient disposition;
- the potential feasibility of using teleradiology in routine medical practice;
- the potential acceptability of teleradiology to users; and
- estimates of the incremental costs of using teleradiology versus the manual alternatives.

D. DATA COLLECTION ACTIVITIES

1. Schedule

Baseline data were collected through the entire month of October and the first weeks of November, 1981, and post-implementation data were collected through the month of June and into July, 1982. The primary data collection instruments, the X-ray time history forms, were used to track two weeks of X-rays at each site during each data collection period. A schedule of data collection activities is presented in Table 1, and the data collection instruments are presented in Appendix A.

2. The Data

a. Data collection instruments X-1 and Y-1

Time History: X-Ray Request/Report Cycle

These instruments were used to collect descriptive information regarding the X-ray patients seen and X-ray examinations performed during the study periods. Also, opinions of referring providers regarding how each exam was used in patient care and the significance of prompt receipt of each interpretation report were gathered; and the time that various events in the request/report cycle occurred was noted. Separate portions of this form were completed by providers, X-ray department staff, radiologists, and of Arthur D. Little, Inc., staff.

TABLE 1

DATA COLLECTION ACTIVITIES
FUNCTIONAL EVALUATION BY TRANSMITTER SITE
TELERADIOLOGY FIELD TRIAL

Facility	Data Collection Period	Schedule	Sample Sizes					
			DCI-1 (Usable Forms)[a]	DCI-3 (Hours of Work Sampling)	DCI-4 (Forms)	DCI-5 (Forms)	DCI-6 (Forms)	DCI-7 (Interviews)
Bolling	Baseline (Period X)	9/28/81 - 10/12/81	90	15.7	26	-	-	-
	Post-Implementation (Period Y)	6/10/82 - 6/24/82	235	32.0	NA	8	-	2
Detrick	Baseline (Period X)	10/6/81 - 10/20/81	133	39.6	0	-	-	-
	Post-Implementation (Period Y)	6/8/82 - 6/22/82	200	85.0	NA	5	-	4
Patuxent	Baseline (Period X)	10/6/81 - 10/20/81	172	88.0	5	-	-	-
	Post-Implementation (Period Y)	6/8/82 - 6/22/82	392	67.2	NA	11	-	4
Central Virginia Community Health Center	Baseline (Period X)	10/2/81 - 10/16/81	58	8.5	24	-	-	-
	Post-Implementation (Period Y)	6/4/82 - 6/18/82	88	19.3	NA	4	-	2
Malcolm Grow Medical Center	Post-Implementation (Period Y)	6/15/82 - 7/15/82	-	-	-	-	26	-
TOTAL	Baseline (Period X)		453	151.8	64 (~400 exams)	-	-	-
	Post-Implementation (Period Y)		915	203.5	22 (~900 exams)	28	26	12

[a] Represent total usable forms: a number of these were not totally complete.

b. Data collection instruments X-2 and Y-2

Cost Data Collection Form

One copy of each of the cost data collection forms was used by Arthur D. Little, Inc., staff at each site to record the elements of the cost of operating the transmitter X-ray departments. These data were summed and extrapolated to produce total costs per year, per patient, and per examination, and to estimate the costs of using teleradiology versus manual methods for obtaining X-ray interpretations.

c. Data collection instruments X-3 and Y-3

Work Analysis for Each X-Ray Technologist and Other Relevant Personnel

Arthur D. Little, Inc., staff used these forms to observe and to record the activities of X-ray department staff at regular intervals, in order to determine the distribution of staff time among various functions.

d. Data collection instruments X-4 and Y-4

Radiologist: X-Ray Interpretation Time Study

These forms were designed to provide information concerning the amount of time required for interpretation of X-ray films and X-ray images from the transmitter sites. During the baseline period, radiologists interpreting X-ray examinations performed at the transmitter sites were asked to complete the time study form, while during the post-implementation period, Arthur D. Little, Inc., staff completed this form using data collected by the system.

e. Data collection instrument Y-5

Provider Questionnaire

This form was distributed during the post-implementation data collection period to the health care providers who order X-rays at the transmitter sites. It was designed to gather their impressions of the teleradiology system and their overall opinions of X-ray department operations at their facilities.

f. Data collection instrument Y-6

Radiologist Questionnaire

This form was mailed to all radiologists who had interpreted teleradiology images at the central receiver site. It was designed to gather radiologists' impressions of the system.

g. Data collection instrument Y-7

Interview Guide

This form was used as a guide for interviews conducted during the post-implementation period with all system operators and project officers involved in the field trial at the transmitter sites. The interviews concerned users' impressions of the system.

II. SETTING

The central reading site for the teleradiology field trial was the Malcolm Grow Medical Center (MGMC). Four transmitter sites were involved in the field trial:

- Bolling Air Force Base Clinic (Bolling);
- Fort Detrick Army Clinic (Detrick);
- Patuxent Naval Air Station Hospital (Patuxent); and
- Central Virginia Community Health Center (CVCHC).

Images of the X-ray exams performed at the transmitter sites were interpreted by a radiologist situated at the central reading site. His interpretation was then sent back to the appropriate transmitter site for use in patient management and care there.

This chapter provides an overview of the characteristics of the teleradiology system and its operation, followed by a brief description of each of the five study sites and their X-ray departments.[1] Characteristics of the transmitter sites and their X-ray departments are summarized in Tables 2 and 3. The operations of the transmitter departments are described in greater detail in Appendix B of this report.

A. THE TELERADIOLOGY SYSTEM

1. Transmitter Units

At each of the four transmitter sites the following system components were installed:

- a large, horizontally placed lightbox;
- a video camera and zoom lens for image capture (located several feet above the lightbox);
- a 14" video monitor on which images visible through the camera could be viewed;
- a 512x512 frame freeze device for image processing;
- a CRT screen and keyboard for entering patient and image data;

[1] The specific system components are also listed in Tables C-10 and C-11 in the Appendix.

TABLE 2

CHARACTERISTICS OF TRANSMITTER SITE FACILITIES
TELERADIOLOGY FIELD TRIAL

Facility	Outpatient Visits/Yr.	Total Facility Staff (including M.D.s, P.A.s, & N.P.s)	Patient Composition				Total Size of Facility (ft^2)	Inpatient Services
			AD[a]	ADD[b]	RET+D[c]	Civ.[d]		
Bolling	52,000[e]	6-8	46%	42%	12%	-	29,600	None
Detrick	21,000[e]	2-3	15%	30%	55%	-	27,000	10-bed Limited
Patuxent	85,000[e]	18	33%	46%	16%	5%	56,300	23-bed
CVCHC	25,000[f]	5	-	-	-	100%	14,500	None

[a] Active duty military personnel

[b] Dependents of active duty military personnel

[c] Retired military personnel and dependents of retired military personnel

[d] Civilians

[e] FY81

[f] FY80

TABLE 3

CHARACTERISTICS OF TRANSMITTER SITE X-RAY DEPARTMENTS
TELERADIOLOGY FIELD TRIAL

Facility	X-Ray Patients/Yrs.	No. of Full-Time Equivalent X-Ray Technicians	Size (ft^2)	No. of Rooms	Equipment	Emergency Services	Radiologist Present
Bolling	3,417[a]	1-2	1400	1	1 Gen'l purpose X-ray	None	Never
Detrick	4,059[a]	2-3	1000	2	1 Gen'l purpose X-ray 1 Rad & Fluoro 1 Mobile X-ray	None	2 days/wk.
Patuxent	7,109[a]	4	1200	2	1 Gen'l purpose X-ray 1 Rad & Fluoro 2 Mobile X-ray	24-hour	4 days/ fortnight
CVCHC	1,370[b]	1.1	1000	1	1 R & F	None	Never

[a] FY81
[b] FY80

- a control processor/convertor for processing image data;
- a 200 Megabyte disk for data storage;
- a data error corrector;
- a modem for information transmission; and
- a word processor printer.

These components occupied a vertical rack (approximately 5'x3'x2') and the surface of a medium-sized desk.

To use the system at a transmitter site, the system operator:

a. entered relevant patient data via the keyboard (in response to prompts that appeared on the CRT screen);
b. keyed in certain commands;
c. placed an X-ray film on the lightbox;
d. adjusted controls on the camera and on the monitor until the image appearing on the monitor screen was clear and in focus;
e. keyed in an additional code, commanding the system to capture and save an image of the X-ray film.
f. repeated steps b. through e. until all relevant images were captured.

The process of inputting the images for one exam took between 5 and 10 minutes, depending upon the nature of the exam and the number of films to be input. Radiologists' interpretation reports were later received at the transmitter site via the word processor printer.

2. Receiver Unit

At the central reading site, there were:

- four 9600 baud modems and four disk drives for receiving and storing data from the transmitter sites;
- a data error corrector;
- a control processor for routing information through the system;
- an image processing and display system;
- a CRT and keyboard;
- three video monitors for viewing X-ray images;
- a word processor; and
- a word processor printer.

The first three components occupied three vertical racks (each approximately 5'x3'x2'); the video monitors and CRT occupied a large desk and a small table. The word processor printer was placed nearby the CRT; the word processor was located in a separate room.

To interpret images at the central receiver site, the radiologist entered certain commands via the CRT keyboard, thereby selecting the images that he wished to view from a menu list appearing on the CRT screen. The selected images appeared on the three viewing monitors and patient data that had been entered at the transmitter site were printed at the word processor printer and were available for the radiologist to use in interpretation.

When interpretation had been completed -- a process taking about as long as film interpretation -- the radiologist dictated his interpretation and "called up" the next case. The dictated interpretation was transcribed into the word processor by a typist and transmitted back to the transmitter site. Cases from each transmitter site were interpreted in the order of input; the system was programmed to queue the cases depending upon the number of cases stored on disk from a given site. Approximately 6 weeks before the end of the trial, a PRIORITY mode was installed. This allowed individual cases to circumvent the standard queuing process once the central site operator had been alerted by telephone.

B. THE CENTRAL READING SITE

Malcolm Grow Medical Center (MGMC), the central reading site, is a 280-bed tertiary medical center, with a large outpatient workload. It is located on Andrews Air Force Base in Maryland, 10 miles southeast of Washington, D.C. MGMC has a large radiology department, staffed by five or six radiologists and 33 technicians. Radiologists in the department interpret the X-rays from Bolling Air Force Base Clinic, the Pentagon, and the Air Force Clinic in the Azores as part of the daily workload.

During the field trial the MGMC radiology department continued, for the most part, to operate as it had before. The teleradiology receiver equipment was physically separated from the other viewing

rooms in the department; the transcriptionists who used the system were especially hired for the project; and the radiologists who interpreted teleradiology images were recruited from several hospitals in the area and used the system on a part-time, scheduled, volunteer basis.

C. THE TRANSMITTER SITES

1. Bolling Air Force Base Clinic

Bolling Air Force Base Clinic (Bolling) is a family practice clinic located on Bolling Air Force Base in Washington, D.C. The clinic provides primary care services to Air Force active-duty personnel and their dependents who reside on or nearby the base and has approximately 52,000 outpatient visits each year. It is a satellite facility of the Malcolm Grow Medical Center at Andrews Air Force Base, located 10 miles away, and relies on MGMC for secondary and tertiary care referrals.

The X-ray department at Bolling is staffed by one or two X-ray technicians and approximately 3,400 patients are examined there each year. All X-ray examinations performed at the clinic are sent to MGMC for interpretation.

During the first half of the field trial (from January to March 1982), Bolling was located in temporary quarters. During this period the clinic provided limited clinical services and no X-ray services to its patients. Bolling patients who required X-rays were referred to MGMC. Bolling's teleradiology transmitter equipment was temporarily installed at MGMC and films taken at MGMC of Bolling patients were input into the system at MGMC by MGMC X-ray technicians.

During the latter half of the trial, the Bolling clinic did provide X-ray services. X-rays performed at Bolling were input into the teleradiology transmitter equipment located in a room adjacent to the X-ray department. Most inputting was performed by a system operator, specially hired for the project, who input for several hours 2 days each week. On a few occasions, the Bolling technicians input films themselves.

2. Fort Detrick Army Clinic

The Fort Detrick Army Clinic (Detrick) is a primary care clinic located on Fort Detrick Army Base within the facility of the United States Army Medical Research Institute for Infectious Diseases in Frederick, Maryland. It serves the large community of retired military personnel and their dependents in the area, and the active-duty personnel and their dependents who are stationed at the several small Army bases nearby. The clinic has approximately 21,000 outpatient visits each year. The X-ray department and laboratory of the clinic also serve staff associated with the Litton Bionetics installation on base, and perform some tests related to the research activities in the building.

Detrick is a satellite of the Walter Reed Army Medical Center (WRAMC) and relies on WRAMC for secondary and tertiary care back-up. The clinic is physically connected to a 10-bed inpatient ward, which provides limited hospital services. This inpatient unit is available for admissions from the clinic and provides 24-hour emergency care for eligible patients. It is primarily used for research activities unrelated to the clinic and is usually staffed by physicians who do not work in the clinic.

The X-ray department at Detrick has two or three X-ray technicians and sees approximately 4,000 patients each year. All X-rays performed at Detrick are interpreted there by a radiology resident from WRAMC, who works at the clinic 2 days each week.

During the field trial all exams performed at Detrick were input into the teleradiology transmitter equipment located in the X-ray film viewing room there. The regular staff in the X-ray department was assisted first by a MITRE staff member, who input films into the system for a few hours 2 days each week, and later by a temporary full-time, active-duty X-ray technician, who was especially assigned to Detrick for the latter half of the field trial (April - June 1982).

3. Patuxent Naval Air Station Hospital

The Patuxent Naval Air Station Hospital (Patuxent) is located on the grounds of the Naval Air Station in Patuxent River, Maryland. It

is the only hospital in the immediate area and provides medical care to active-duty personnel and their dependents stationed at the Air Station. This hospital is primarily an outpatient facility, seeing 85,000 outpatients each year, but also has 20 inpatient beds, two surgical suites, and a 24-hour emergency room. Patients requiring specialized care are referred to the National Naval Medical Center (NNMC) in Bethesda, 90 miles away.

The X-ray department at the hospital has four X-ray technicians and sees approximately 7,000 patients each year. Every other week, a radiology resident from NNMC works at the hospital from Monday through Thursday; during the off weeks, X-ray examinations are sent by courier three times each week to NNMC for interpretation.

During the field trial, all exams performed at Patuxent were input into the teleradiology transmitter equipment located approximately 40 feet from the X-ray department, in a room adjacent to the hospital's operating room. The Patuxent system was primarily operated by a full-time clerk especially hired by MITRE for the field trial. Regular X-ray department staff members assisted this clerk most afternoons, and input some films themselves.

4. Central Virginia Community Health Center

The Central Virginia Community Health Center (CVCHC) is a Public Health Service-sponsored community health clinic located in the rural area of New Canton, Virginia, approximately 30 miles southwest of Charlottesville. It provides primary care and dental services to area residents; 25,000 outpatients are seen there each year. The clinic is not formally affiliated with any other health care institutions, but maintains close ties with the University of Virginia Medical Center (UVMC) in Charlottesville, which provides several specialized services on a contractual basis. Patients in need of secondary or tertiary care are referred to one of several hospitals in the surrounding area.

The X-ray department at the clinic has one radiology technician and one X-ray room; approximately 1,400 patients are examined there each year. All X-ray examinations performed at the clinic are sent to UVMC for interpretation.

During the field trial, the technician at CVCHC input all X-ray films performed there into the CVCHC transmitter equipment located in the X-ray department.

III. METHODOLOGY

A. THE APPROACH

Teleradiology is intended to improve access to radiologists' interpretation services at small or remote facilities, thus improving patient care, altering patient disposition, and reducing the costs of providing X-ray services. The teleradiology system used during the Washington-area field trial was experimental, and was used for a limited period of time. It was hence used in parallel with, rather than as a replacement for, manual methods for obtaining radiologists' interpretations. In this context, the system was not expected to have major effects on patient care, on patient disposition patterns, or on operating costs during the field trial.

The methodology used for the functional evaluation took account of these aspects of the field trial project. Instead of employing a pure before/after study design, the approach used was exploratory. The study was intended, in part, to measure actual impacts that occurred in the experimental setting, but was designed primarily to estimate potential impacts, which would be expected to occur if the system were in routine operation.

It was determined that four general impact areas could be studied in the experimental setting:

- the extent to which teleradiology could potentially alter patient care or alter patient disposition;
- the potential feasibility of using teleradiology in routine medical practice;
- the acceptability of teleradiology to its users; and
- the estimated incremental costs of using teleradiology versus the manual alternatives.

Each of these areas was addressed in the course of the functional evaluation effort.

B. THE STUDY QUESTIONS

In order to determine the impacts of teleradiology on the four areas enumerated above, the following study questions were formulated:

1. Patient Care and Disposition

- If teleradiology resulted in a change in the time lapse between X-ray request and report review, would this change alter patient care or alter patient disposition at the transmitter sites?
- If technical limitations of the teleradiology system resulted in X-ray images being more difficult to interpret than X-ray films[2,3] and, consequently, resulted in a reduction in the accuracy of interpretation, would such a reduction affect patient care or disposition at the transmitter sites?

2. Feasibility of Routine Use

Would use of the teleradiology system alter the amount of transmitter site and receiver site staff time spent in X-ray processing functions?

3. Acceptability to Users

Would teleradiology be acceptable to system users?

4. Costs

What would be the incremental costs of using the teleradiology system?

C. THE EVALUATION MEASURES AND TECHNIQUES

In order to answer the study questions, a set of evaluation measures and data collection techniques were devised. These are

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[2] Data gathered in an experimental evaluation of the teleradiology system indicated that the accuracy of interpretation varies between films and video readings of the same X-ray. In both interpretation modes, accuracy diminished with increased 'difficulty' of the case and the difference between the levels of accuracy of the two modes also increased with increased difficulty. In addition, certain types of examinations were associated with lower levels of accuracy and greater inter-modal differences in accuracy "scores." In essence, for simpler cases and for more routine types of exams, the system appeared to perform better than it did for complex or difficult cases.

[3] Harrington, M., et al. A Laboratory Evaluation of the Teleradiology System: Summer, 1980: MITRE Corporation, 1981, Tables 3.1.2 and 3.1.3.

summarized in Table 4. The data collection instruments used are contained in Appendix A. In addition to specific evaluation measures, information was collected regarding two independent variables.

1. Data were collected for each examination during the study period concerning patient and examination characteristics. After being distilled into four X-ray categories (described later), these were used as the major independent variable in analysis of potential impacts related to patient care and disposition.
2. Data were collected for each examination concerning the time lapses in various stages of the X-ray request/report cycle. The extent of teleradiology's impact on patient care depends in large part on its impact on the timeliness of this cycle.[4]

D. THE CATEGORIES OF X-RAY EXAMINATIONS

In order to group the X-ray examinations performed during the study period in a way that would have clinical meaning to primary care providers and to radiologists, the following X-ray categories were defined and used in analysis of data related to impacts on patient care and disposition:

- Routine Physical chest exams
- Emergency exams
- (Non-Emergency) Diagnostic exams
- Exams performed For-the-record or as Follow-up procedures.

These categories were designed to group X-rays on the basis of the following characteristics:

- the likelihood that the X-ray examination is being used as the primary diagnostic tool in immediate patient care and disposition decisions;

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[4] The Bureau of Radiological Health collected a large amount of data concerning the time intervals between various stages in the request/report cycle at the remote sites in the baseline period. Some additional time interval data were collected by Arthur D. Little, Inc., in the baseline period. Arthur D. Little, Inc., was responsible for all data collection in the post-implementation period.

TABLE [illegible]

SUMMARY OF EVALUATION METHODOLOGY
FUNCTIONAL EVALUATION

TELERADIOLOGY FIELD TRIAL

Impact/Study Questions	Evaluation Measure	Measurement Technique	Data Obtained	Sample Size
(Independent Variable)	Characteristics of X-ray Volume	Self-reporting by referring providers (Data Collection Instruments X-1, Y-1)	Percentage of X-ray volume by patient age/sex and by X-ray category: • Routine Physical chest exams • Emergency exams • Diagnostic exams • For-the-record and Follow-up exams	X 418 patients Y 695 patients
(Independent Variable)	Elapsed time in the X-ray request/report cycle a. Turnaround Time	Self-reporting by referring providers and other staff and system reporting at time of each stage in the request/report cycle (Data Collection Instruments X-1, Y-1)	Mean Elapsed time in hours and minutes	X 418 patients Y 915 patients
	b. Oral reporting	Self-reporting by referring providers	Mean Elapsed time in hours and minutes	X 418 patients Y 695 patients
Patient Care and Disposition				
If teleradiology resulted in a change in the time lapse between X-ray request and report review, would this change alter patient care or alter patient disposition at the transmitter sites?	1. The role of the X-ray exam *in patient care* and disposition decisions			
	a) Does the referring provider view the X-ray films?	Self-reporting by referring providers for all X-ray patients seen during the study period (Data Collection Instruments X-1, Y-1)	Percentage of exams viewed by referring providers by X-ray category	X 418 patients Y 695 patients
	b) What effect does the referring provider's viewing of the X-ray films have on his handling of the case?	Self-reporting by referring providers for all X-ray patients seen during the study period (Data Collection Instruments X-1, Y-1)	Percentage of responses by X-ray category rated as: • No Effect or Inconclusive • Some Effect: Increased confidence in clinical impression • Some Effect: altered clinical impression, but did not alter patient treatment and/or disposition • Major Effect: altered patient treatment and/or disposition	X 281 patients Y 358 patients

Impact/Study Questions	Evaluation Measure	Measurement Technique	Data Obtained	Sample Size
	c) What effect does the radiologist's interpretation report have on the referring provider's handling of the case?	Self-reporting by referring providers for all X-ray patients seen during the study period (Data Collection Instruments X-1, Y-1)	Percentage of responses by X-ray category rated as: • No Effect: merely duplicated your own findings • Some Effect: increased your confidence in your interpretation • Some Effect: altered your opinion but did not alter course of patient treatment and/or disposition • Major Effect: altered course of patient treatment and/or disposition or caused recall of patient to reaffirm clinical impression	X 396 patients Y 676 patients
	d) What are the disposition patterns of X-ray patients?	*Disposition* tracking by referring providers for all X-ray patients seen during the study period (Data Collection Instruments X-1, Y-1)	Percentage of patients who • Waited in the clinic for X-ray interpretation • Told to restrict activities • Referred to a medical center • Admitted or returned to ward.	X 417 patients Y 630 patients
	2. The significance of prompt receipt of the radiologist's interpretation a) Significance considered at the time of X-ray request.	Self-reporting by referring providers for all X-ray patients seen during the study period (Data Collection Instruments X-1, Y-1)	Percentage of responses by X-ray category rated as: • Not Significant: would not affect patient's treatment or immediate disposition • Somewhat Significant: unlikely to affect patient's treatment or immediate disposition, but likely to increase your diagnostic confidence • Significant: likely to affect your opinions and/or decisions regarding patient care and/or disposition • Very significant: essential to your decisions regarding patient care and/or disposition.	X 424 patients Y 647 patients

Impact/Study Questions	Evaluation Measure	Measurement Technique	Data Obtained	Sample Size
	b) Significance considered at the time of report review	Self-reporting by referring providers for all X-ray patients seen during the study period (Data Collection Instruments X-1, Y-1)	Percentage of responses by X-ray category rated as: • Patient treatment or disposition would/would not have been altered	X 410 patients Y 643 patients
	3. Effects of interpretation accuracy			
• If technical limitations of the teleradiology system resulted in X-ray images being more difficult to interpret than X-ray films and, consequently, reduced the accuracy of interpretation, would such a reduction affect patient care or disposition at the transmitter sites?	Interpretation "difficulty"[a] of X-ray exams performed	Self-reporting by referring providers and X-ray technicians concerning types of exams and patient diagnoses for all X-ray patients seen during the study period (Data Collection Instruments X-1, Y-1)	Percentage of exams by X-ray category	X 418 patients Y 695 patients
Feasibility				
Would use of the teleradiology system alter the amount of transmitter site and receiver site staff time spent in X-ray processing functions?	Distribution of transmitter site X-ray department staff time spent in various activities	Individual work sampling of X-ray technicians and other relevant personnel (Data Collection Instruments X-3, Y-3)	Distribution of X-ray department staff time among various activities by facility	X 151.8 hours Y 203.5 hours
	Amount of time required for radiologist's X-ray interpretation	Self-reporting by radiologists and system reporting for a sample of X-ray patients seen during the study periods (Data Collection Instruments X-4, Y-4)	Minutes of interpretation time required per X-ray exam by facility	X 64 forms = 400 exams Y 22 forms = 900 exams

[a] Based largely on MITRE/BRH definition.

Impact/Study Questions	Evaluation Measure	Measurement Technique	Data Obtained	Sample Size
Acceptability				
Would teleradiology be acceptable to system users?	Opinions of system users	Surveys of radiologists (Data Collection Instrument Y-6)	Opinions and recommendations of system users	X -- Y 26 forms
		Surveys of primary care providers (Data Collection Instrument Y-5)	Opinions and recommendations of system users	X -- Y 28 forms
		Interviews with transmitter site system operators (Data Collection Instrument Y-7)	Opinions and recommendations of system users	X -- Y 8 forms
		Interviews with transmitter site project officers	Opinions and recommendations of system users	X -- Y 4 forms
Costs				
What would be the incremental costs of using the teleradiology system?	Incremental per X-ray exam costs of obtaining interpretation services at the transmitter sites	Operating cost data obtained from business offices at remote sites; equipment inventory and workload data obtained from X-ray department records at remote sites; equipment amortized over 7 years.[b] System cost obtained from MITRE Corp. (Data Collection Instruments X-2, Y-2)	Total costs and per X-ray exam cost of X-ray services by facility; estimated incremental cost of using three methods for obtaining radiologists' interpretations at the transmitter sites	

[b] In each case, the costs of vehicles which transport films and reports between the remote sites and their interpretation sites are not included in the calculations. These vehicles are also used for transporting patients, laboratory specimens, EKG's, etc., back and forth between remote and central sites. Therefore, the costs which could be appropriately applied to the X-ray departments were insignificant.

- the level of skill required to interpret the examination with sufficient accuracy for use in immediate patient care and disposition decisions;
- the likelihood that the examination is performed with a clear expectation that results will be normal or abnormal.

For example, chest films are considered difficult for a nonradiologist physician to interpret. However, Routine Physical chest exams seldom have an immediate effect on clinical care: their results are usually expected to be normal and the X-ray constitutes but one in a battery of diagnostic tests.

On the other hand, the results of Emergency exams -- for example, an X-ray performed to determine whether or not an arm is fractured -- are often expected to be abnormal and immediate action is taken, depending upon whether and where the X-ray indicates fracture. Although Emergency films certainly require experience to interpret consistently and accurately, nonradiologists' readings may be sufficient for determining immediate treatment.

Non-emergency Diagnostic exams may involve suspected disorders of greater complexity than do either Emergency exams or Routine Physical chest exams, and may require a greater degree of skill for adequate interpretation. Such conditions, however, are less likely to require immediate treatment than are cases of trauma.

Finally, exams that are performed For-the-record or as Follow-up procedures vary in the amount of skill required for their adequate interpretation and whether normal or abnormal results are anticipated. However, immediate patient care decisions are unlikely to rest solely on their results.

IV. RESULTS

A. THE INDEPENDENT VARIABLES

1. Characteristics of X-ray Volume

The value of prompt X-ray interpretation report turnaround depends upon the case mix of the X-ray patients being examined. As a measure of case mix, data regarding the characteristics of patients and examinations were collected.

The characteristics of the X-ray patients examined at the transmitter sites during the two study periods are presented in Table 5.[5] Although there were minor variations among the ages of the patients seen at the three military facilities, the great majority were between the ages of 14 and 45, with older patients comprising 7% and 16% of the populations at Bolling and Patuxent, respectively, and 26% of the X-ray patients at Detrick. At CVCHC, however, 66% of the patients were over 45 and 34% were over 64. As might be expected, a majority of the patients at the military facilities were male (59% to 67%); while at CVCHC, the X-ray patients were nearly equally distributed by sex.

The distribution of types of X-ray examinations performed during the two study periods, the reasons for the examinations, and whether examinations were associated with trauma are presented in Table 6 for each of the four transmitter sites.[6] At all of the sites, approximately 80% of examinations were either extremity or chest films. Also, more X-rays were considered "diagnostic," rather than being performed "for-the-record," as "follow-up" procedures or in association with routine physical examinations. The proportion of exams performed at the military sites "for-the-record" and in association with routine physical exams was nearly equal (23% and 25%, respectively),

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[5] Tables C-1 and C-2 in the Appendix present data for each of the study periods separately.

[6] Tables C-3 and C-4 in the Appendix present data for each of the study periods separately.

TABLE 5

CHARACTERISTICS OF X-RAY PATIENTS EXAMINED DURING STUDY PERIODS BY TRANSMITTER SITE[a]
TELERADIOLOGY FIELD TRIAL

Facility	Age (years) <14	14-45	46-64	65+	Sex (% Male)
Bolling					
n= 235	13%	80%	6%	1%	67%
Detrick					
n= 200	6%	65%	22%	7%	59%
Patuxent					
n= 392	11%	73%	13%	3%	68%
CVCHC					
n= 88	6%	28%	32%	34%	51%
Mean of Military Sites					
n= 827	11%	73%	13%	3%	66%

[a]Tables C-1 and C-2 in the Appendix present data for each of the study periods separately.

TABLE 6

CHARACTERISTICS OF X-RAY EXAMINATIONS PERFORMED DURING STUDY PERIODS BY TRANSMITTER SITE[a]

TELERADIOLOGY FIELD TRIAL

Facility	Type of Exam						Reason for Exam					% Trauma
	Chest	Extremity	Skull	Spine	Abdomen	TOTAL	Routine Physical Exam	For the Record	Diagnostic	Follow-Up	TOTAL	
Bolling (n= 325 exams)	42%	38%	9%	6%	5%	100%	28%	24%	45%	3%	100%	38%
Detrick (n= 333 exams	39%	40%	6%	8%	7%	100%	18%	30%	50%	2%	100%	35%
Patuxent (n= 564 exams)	45%	36%	8%	5%	6%	100%	27%	19%	48%	6%	100%	43%
CVCHC (n= 146 exams)	44%	36%	4%	6%	10%	100%	7%	12%	78%	3%	100%	31%
Mean of Military Sites (n=1222 exams)	42%	38%	8%	6%	6%	100%	25%	23%	48%	4%	100%	40%

[a]Tables C-3 and C-4 in the Appendix present data for each of the study periods separately.

while many fewer of the exams performed at CVCHC fell into these categories. Although a large proportion of examinations at each site were associated with trauma, the percentage of trauma-related X-rays varied somewhat among sites, from 31% at CVCHC to 43% at Patuxent.

The distribution of X-rays performed at the transmitter sites during the study period are presented by X-ray category in Table 7.[7] Bolling and Patuxent, with rather young patient populations, had high proportions (46% and 43%, respectively) of Emergency exams, compared with Detrick and CVCHC (each at 28%). CVCHC, the only civilian site involved in the study, had the smallest proportion of Routine Physical examinations (6%, compared with 28%, 16% and 25% at the three military sites).

The X-ray categories tend to be associated with certain ages and sexes of patients as shown in Table 8.[8] A higher proportion of X-rays performed on adult patients, aged 14-45 and 46-64, were associated with Routine Physical examinations than were X-rays of younger (under 14) and older (65+) patients. The younger age groups (under 14 and 14-45) had higher proportions of Emergency exams than did older patients (46-64 and 65+). Older patients were more likely to have non-emergency Diagnostic exams than were younger ones; and the exams of older patients were more likely to be performed For-the-record or as Follow-up procedures.

Males had a higher proportion of Routine Physical exams than did females (27% compared with 11%). Females had proportionately higher numbers of Diagnostic exams (33% compared with males at 15%). The two sexes experienced nearly equal proportions of Emergency exams and those performed For-the-record or as Follow-up procedures.

In summary, the characteristics of the patients seen and examinations performed at these X-ray departments are typical of X-ray case mix found in a primary care setting. In the military sites,

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[7] Tables C-5 and C-6 in the Appendix present data for each of the study periods separately.

[8] Tables C-7 and C-8 in the Appendix present data for each of the study periods separately.

TABLE 7

DISTRIBUTION OF X-RAY EXAMINATIONS PERFORMED DURING STUDY PERIODS BY CATEGORY AND BY TRANSMITTER SITE[a]

TELERADIOLOGY FIELD TRIAL

Facility	Category: Routine Physical Exams	Emergency Exams	Diagnostic Exams	For-the-Record and Follow-up Exams	TOTAL
Bolling n= 212	28%	46%	10%	16%	100%
Detrick n= 260	16%	28%	27%	29%	100%
Patuxent n= 518	25%	43%	16%	16%	100%
CVCHC n= 123	6%	28%	50%	16%	100%
Mean of Military Sites n= 990	23%	39%	17%	21%	100%

[a]Tables C-5 and C-6 in the Appendix present data for each of the study periods separately.

TABLE 8

DISTRIBUTION OF TOTAL X-RAY VOLUME PERFORMED DURING STUDY PERIODS BY CATEGORY AND BY AGE AND SEX OF PATIENTS[a]

TELERADIOLOGY FIELD TRIAL

	Age (years)					Sex	
Category	< 14 n=106	14-45 n=693	45-64 n=156	65+ n=79	Total n=1034	Male n=634	Female n=400
Routine Physical Exams	3%	26%	18%	5%	21%	27%	11%
Emergency Exams	62%	40%	22%	18%	37%	37%	37%
Diagnostic Exams	18%	17%	28%	57%	22%	15%	33%
For-the-Record and Follow-Up Exams	17%	17%	32%	20%	20%	21%	19%
TOTAL	100%	100%	100%	100%	100%	100%	100%

[a]Tables C-7 and C-8 in the Appendix present data for each of the study periods separately.

X-ray patients tended to be rather young -- 84% were under 46 years old -- and rather healthy -- 39% of exams were associated with trauma, 23%, with routine physical examinations.

2. Elapsed Time in the X-Ray Request/Report Cycle

a. Turnaround time

The major potential benefit of teleradiology for patient care is its ability to reduce turnaround time for X-ray interpretation reports. To measure turnaround time and its components, data were collected regarding the timing of the various stages in the X-ray request/report cycle.

Data regarding mean elapsed times in various stages of the X-ray request/report cycle are presented by facility in Table C-9 in Appendix C. Mean time lapses are presented there for stages of the X-ray film cycle both before teleradiology was installed and during the system's operation, and for the X-ray video image cycle during the post-implementation period.

Mean elapsed time varied substantially between facilities and within each facility at each stage of the cycle, during each data collection period, and using each interpretation mode. The mean total time required for the X-ray film request/report cycle ranged from 88 (+/- 33) to 108 (+/- 44) hours at the four transmitter sites before system installation, and from 120 (+/- 75) to 232 (+/- 111) hours during system operation. The mean total request/report cycle for video images varied from 99 (+/- 56) hours to 212 (+/- 104) hours at the four transmitter sites.

In each facility and using each viewing mode, exams were performed promptly after they were requested. The mean time lapse between the provider's X-ray's request and the exam's completion was 1.3 (+/- 5.6) hours overall. Patients in the transmitter sites -- all primary care facilities -- usually went directly from their provider encounter to the X-ray department and were examined there almost immediately.

The long delays of the request/report cycle occurred after the X-ray examination was completed. During the post-implementation period, mean elapsed time between exam completion and exam interpretation was 78 (+/- 96) hours overall for films and 55 (+/- 68) hours for video images; and that between exam interpretation and provider report review was 119 (+/- 86) hours for films and 110 (+/- 80) hours for video images.

Although in a nonexperimental situation, it is hypothesized that teleradiology interpretations would be available to providers more promptly than are film interpretations, during the field trial the total mean turnaround times were approximately the same length for image interpretations as they were for film interpretations. The long delays for teleradiology interpretations experienced during the field trial were largely attributable to the experimental nature of the system and its use:

- the system did not always function reliably;
- inputting of films did not always occur regularly or on a daily basis;
- radiologists were only available to perform teleradiology interpretations on a part-time basis; and
- "manual" interpretation reports were often received prior to teleradiology interpretations of the same exam, and, hence, were not always read promptly.[9]

These facts about the experimental situation suggest that the data collected for actual teleradiology interpretation turnaround time do not accurately represent what a routinely operational teleradiology system would be like. Indeed, exams can be input into the system directly after completion; inputting takes about 10 minutes per exam, and image transmission, an additional 15 to 30 minutes. Interpretation can occur at any time thereafter, and can be communicated immediately back to the transmitter site.

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[9] Overall, for 41% of exams, the referring provider reviewed the teleradiology interpretation before the film interpretation of the same exams; for another 41%, the film interpretation was reviewed first; and for 18%, the two interpretations were reviewed at the same time.

The field trial figures demonstrate, however, that installation of the teleradiology technology does not, itself, result in reduced turnaround time. Although system operation is neither extremely time-consuming nor very complex, for the system to be used effectively, protocols must be established for inputting films regularly, radiologists must be available to interpret images on a routine basis, and, as under any reporting system, if one's goal is to minimize time delays, reports must be delivered to providers promptly and read by providers upon receipt.

b. Oral Reporting

Oral reporting can substantially reduce total turnaround time if it occurs shortly after interpretation, and it was presumed at the onset of data collection that oral interpretation reporting by radiologists might occur frequently. Hence, the incidence of oral reporting of radiologists' interpretations was measured during both data collection periods.

Only 12 instances of oral communication were noted for the 418 patients in the baseline study sample and 13 instances occurred for the 695 patients in the post-implementation sample. It can be concluded that the radiologist's written interpretation report is, usually, the only radiologist's interpretation that is used in patient care at the transmitter sites.

B. PATIENT CARE AND DISPOSITION

1. The Role of the X-Ray Examination in Patient Care and Disposition Decisions

To determine how X-ray exams and interpretation reports were used in patient care at the transmitter sites, data were collected regarding whether referring providers viewed the exams that they ordered, how this viewing and the radiologist's interpretation report affected treatment decisions, and concerning the disposition patterns of X-ray patients.

a. Does the referring provider view the X-ray films?

Tabulations of survey responses indicate that providers who order X-rays often view the films themselves. This is not surprising, as radiologists' interpretations are usually not available until

several days after the X-ray exam is performed. If an exam is to be used by providers for immediate diagnosis, they have to read the films themselves. Table 9 shows the proportion of each category of X-ray that was viewed immediately after exam performance. Providers were most likely to view films for Emergency exams (77%), followed by other exams that they considered Diagnostic (69%). They viewed many For-the-record and Follow-up examinations as well (62%), but, not surprisingly, relatively few Routine Physical chest examinations (10%).

b. What effect does the referring provider's viewing of the X-ray films have on his handling of the case?

As is demonstrated in Table 10, when films were viewed by referring providers, this primarily served to increase clinical confidence. This was the case for 65% of cases and is to be expected: most X-rays are performed to confirm diagnoses suspected upon physical examination. For 15% of total cases-- primarily for trauma cases or for other Diagnostic exams -- the film viewing had a major effect on the provider's handling of the case, providing really new information. It was least likely to have had any effect for Routine Physicals.

c. What effect does the radiologist's interpretation report have on the referring provider's handling of the case?

In considering providers' responses to the question, "How did the radiologist's report affect your handling of this case?" (Table 11), it is important to remember that this report is almost always received several days after the X-ray has been performed and the patient treated and sent home. Reports received after so long a delay might not have an effect on patient care unless their findings differed substantially from those made earlier by the referring provider.

Overall, 42% of reports were considered to have had "No effect" on patient care, 43% were felt to have increased the primary care provider's clinical confidence, 7% to have altered his clinical impression, and 8% were felt either to have had a major effect on patient care or to have resulted in patient recall.

TABLE 9

PERCENTAGE OF EXAMINATIONS VIEWED BY REFERRING PROVIDERS
BY CATEGORY OF EXAMINATION[a]
TELERADIOLOGY FIELD TRIAL

Category	% Viewed[a] Period X n=449	Period Y n=693	TOTAL
Routine Physical Exams n_x= 61 n_y=178	5%	12%	10%
Emergency Exams n_x=199 n_y=243	80%	75%	77%
Diagnostic Exams n_x=123 n_y=120	72%	65%	69%
For-the-Record and Follow-Up Exams n_x=174 n_y=152	91%	50%	62%
TOTAL	69%	52%	59%

[a] A different data base was used for this analysis than for Table 12; hence, these data should be considered separately.

TABLE 10

OPINIONS OF REFERRING PROVIDERS:
THE EFFECT OF THE REFERRING PROVIDER'S VIEWING
OF THE X-RAY FILMS ON HIS HANDLING OF THE CASE
BY CATEGORY OF EXAMINATION
TELERADIOLOGY FIELD TRIAL

Category	Effect of Referring Provider's Viewing: No Effect	Some Effect: Increased Clinical Confidence	Some Effect: Altered Clinical Impression	Major Effect
Routine Physical Exams n_x = 3 n_y = 22	x 67% y 32% } 36%	0% 64% } 56%	0% 4% } 4%	33% 0% } 4%
Emergency Exams n_x = 160 n_y = 182	x 15% y 3% } 8%	60% 73% } 68%	5% 11% } 8%	20% 13% } 16%
Diagnostic Exams n_x = 89 n_y = 78	x 15% y 3% } 9%	46% 61% } 53%	18% 15% } 17%	21% 21% } 21%
For-the-Record and Follow-Up Exams n_x = 29 n_y = 76	x 14% y 9% } 10%	79% 79% } 79%	7% 11% } 10%	0% 1% } 1%
TOTAL n_x = 281 n_y = 358	x 15% y 6% } 10%	57% 72% } 65%	9% 11% } 10%	19% 11% } 15%

TABLE 11

OPINIONS OF REFERRING PROVIDERS:
THE EFFECT OF THE RADIOLOGIST'S INTERPRETATION
ON THE REFERRING PROVIDER"S HANDLING OF THE CASE
BY CATEGORY OF EXAMINATION
TELERADIOLOGY FIELD TRIAL

Category	Effect of Radiologist's Interpretation: No Effect	Some Effect: Increased Clinical Confidence	Some Effect: Altered Clinical Impression	Major Effect
Routine Physical Exams n_x = 51 n_y =173	x 62% y 52% } 54%	20% 40% } 36%	4% 4% } 4%	14% 3% } 6%
Emergency Exams n_x =171 n_y =237	x 49% y 29% } 38%	40% 57% } 49%	2% 7% } 5%	9% 7% } 8%
Diagnostic Exams n_x =114 n_y =117	x 37% y 26% } 31%	40% 58% } 49%	10% 10% } 10%	13% 6% } 10%
For-the-Record and Follow-Up Exams n_x = 60 n_y =149	x 45% y 45% } 45%	32% 34% } 33%	18% 14% } 15%	5% 7% } 7%
TOTAL n_x =396 n_y =676	x 47% y 38% } 42%	36% 48% } 43%	7% 8% } 7%	10% 6% } 8%

As might have been expected, interpretation reports concerning Routine Physical chest exams were more frequently regarded as having had "No effect" (54%) than reports concerning examinations from other categories.

For Emergency exams, interpretation reports were not often felt to have significantly affected care: only 8% were thought to have altered clinical decisions and 5% to have altered clinical impressions. These X-rays are likely to be performed for immediate use in diagnosing and treating fractures -- 77% of those in this study were viewed by providers directly after they were performed -- and subsequent interpretations were not of great value in handling of the case.

For Diagnostic exams and those performed For-the-record or for Follow-up, relatively high proportions of radiologists' reports caused providers to alter either their opinions or their decisions regarding patient care. The percentage of reports that were felt to have had such an effect were 20% and 22%, respectively. These exams may be somewhat more difficult to interpret than emergency films, and the symptoms that call for their performance do not always result in immediate treatment. Radiologists' interpretations of these examinations would, therefore, be more likely to give providers new information that is useful in patient treatment decisions. Also, the fact that providers review these films somewhat less often than they do Emergency exams (69% and 62%, respectively, versus 77% for emergencies), probably enhances the value of the radiologists' reports in the handling of these cases.

It is important to notice, however, that for each category of examination, some interpretation reports did have a major effect on care.

d. What are the disposition patterns of X-ray patients?

Table 12 displays the disposition pattern of X-ray patients examined at the transmitter sites. The data from the baseline and the post-implementation periods were pooled for presentation, as little variation existed in patterns of patient disposition during the two study periods. Data are presented regarding patient disposition at

TABLE 12

DISPOSITION PATTERN OF X-RAY PATIENTS
BY CATEGORY OF EXAMINATION[a]
TELERADIOLOGY FIELD TRIAL

Category	Disposition at Time of X-Ray Request					Disposition at Time of Provider Film Review[a] (base = patients who waited for interpretation)				TOTAL			
	Admitted (or return) to Ward	Referred to Medical Center	Restricted Activities	Normal Activities	Wait for Provider Film Review[a]	Go to Ward	Referred to Medical Center	Restricted Activities	Normal Activities	Go to Ward	Referred to Medical Center	Restricted Activities	Normal Activities
Routine Physical Exams n=175	9%	0%	1%	88%	2%	0%	0%	0%	100%	9%	0%	1%	89%
Emergency Exams n=425	2	2	2	6	88	5		51	43	8	5	42	45
Diagnostic Exams n=238	3	1	1	11	84	0	7	30	63	7	7	21	65
For-the-Record and Follow-Up Exams n=209	4	1	6	34	55	0	4	43	53	6	3	23	68
TOTAL n=1047	4	1	3	26	66	3	3	44	50	8	3	23	66

[a] A different data base was used for this analysis than for Table 9; hence, these data should be considered separately.

the time of X-ray request and at the time of film review by the referring provider.

Most (66%) of patients waited in the clinics for their providers (or, in a few cases, for a radiologist) to interpret their X-rays. Not surprisingly, this was most often the case for patients with either Emergency exams or other Diagnostic exams (88% and 84%, respectively) and least often the case for patients undergoing Routine Physical examinations (2%). Overall, 66% of X-ray patients returned to normal activities on the day of examination, 23% were told to restrict their activities and the remaining 11% were either referred elsewhere or admitted for treatment or observation. Of patients whose films were reviewed directly after exam performance, 50% were told to return to normal activities, 44% to restrict their activities, 3% to go to another medical facility for further tests or treatment and 3% were admitted to the small hospital.

2. Significance of Prompt Receipt of the Radiologist's Interpretation

Providers were asked to indicate for each exam how significant prompt receipt of a radiologist's interpretation would be to patient care. This question was asked twice -- first, at the time that he requested the X-ray, and second at the time that he received the radiologist's interpretation report. Data relating to the significance of prompt receipt of the X-ray interpretation are presented in Tables 13 and 14. In reviewing these data, it is important to keep two facts in mind. First, the referring provider usually reviews the films himself shortly after the examination has been performed and must, at that time, make a decision regarding immediate disposition of the patient. Consequently, the provider's first opinion concerning the value of a prompt interpretation most likely reflects (a) his view of the diagnostic function of the X-ray and (b) his confidence in his own ability to read the films. Second, the referring provider generally receives the radiologist's interpretation several days after the examination has been performed and initial patient disposition made. His second opinion of the relative value of prompt interpretation receipt, therefore, probably reflects the extent to which the radiologist's interpretation varies from his own reading of the films.

TABLE 13

REFERRING PROVIDERS' OPINIONS:
SIGNIFICANCE OF PROMPT RECEIPT OF A RADIOLOGIST'S INTERPRETATION TO REFERRING PROVIDER'S HANDLING OF CASE CONSIDERED AT THE TIME OF X-RAY REQUEST
BY CATEGORY OF EXAMINATION
TELERADIOLOGY FIELD TRIAL

Category		Significance of Prompt Interpretation Receipt: Not Significant		Somewhat Significant		Significant		Very Significant	
Routine Physical Exams									
n_x = 59	x	88%	59%	5%	28%	5%	12%	2%	1%
n_y = 159	y	54%		32%		14%		0	
Emergency Exams									
n_x = 182	x	22%	15%	40%	35%	27%	36%	10%	14%
n_y = 228	y	12%		32%		40%		16%	
Diagnostic Exams									
n_x = 121	x	11%	13%	13%	25%	60%	49%	16%	13%
n_y = 115	y	15%		30%		45%		10%	
For-the-Record and Follow-Up Exams									
n_x = 62	x	34%	29%	53%	59%	11%	11%	2%	1%
n_y = 145	y	28%		60%		11%		1%	
TOTAL									
n_x = 424	x	30%	27%	29%	36%	31%	29%	10%	8%
n_y = 647	y	27%		37%		28%		8%	

TABLE 14

REFERRING PROVIDERS' OPINIONS:
SIGNIFICANCE OF PROMPT RECEIPT OF A RADIOLOGIST'S INTERPRETATION
TO REFERRING PROVIDER'S HANDLING OF CASE CONSIDERED AT THE TIME OF REPORT REVIEW
BY CATEGORY OF EXAMINATION
TELERADIOLOGY FIELD TRIAL

Category	Significance of Prompt Interpretation Receipt: Not Significant		Significant	
Routine Physical Exams				
n_x = 55	x 79%	92%	21%	8%
n_y = 156	y 96%		4%	
Emergency Exams				
n_x = 176	x 90%	94%	10%	6%
n_y = 227	y 97%		3%	
Diagnostic Exams				
n_x = 114	x 87%	95%	13%	5%
n_y = 115	y 95%		5%	
For-the-Record and Follow-Up Exams				
n_x = 65	x 95%	95%	5%	5%
n_y = 145	y 95%		5%	
TOTAL				
n_x = 410	x 88%	93%	12%	7%
n_y = 64	y 96%		4%	

Overall, referring providers showed much more interest in prompt interpretation receipt when requesting examinations than when they reviewed the interpretation reports. At the time of X-ray request, providers felt that a prompt interpretation would significantly (or very significantly) affect clinical handling in 37% of cases. However, at the time of report review, providers believed quite uniformly that a more timely interpretation would not have altered care (93% of cases, overall). In other words, although primary care providers frequently wished at the time of X-ray request that a radiologist were available to interpret films promptly, seldom did the radiologist's report contain information that would have changed patient care had it been received earlier.

a. Significance Considered at the Time of the X-Ray Request

Among the various X-ray categories, at the time of X-ray request, providers indicated least often that a prompt interpretation would be significant for Routine Physical chest examinations. For 59% of such examinations, a prompt interpretation was rated as "Not significant." For For-the-record and Follow-up examinations, a prompt interpretation was frequently considered "Not significant" (in 29% of cases). These results are consistent with the premise that these types of examinations tend not to be performed for use in immediate therapeutic or diagnostic decisions.

For half of the Emergency exams, a prompt interpretation was rated at the time of X-ray request as either "Not significant" or "Unlikely to affect patient's treatment or immediate disposition." However, in the majority of these cases, providers believed that a timely radiologist's reading would serve to enhance their clinical confidence. For many trauma-related X-rays, immediate therapeutic action is apparently taken with reasonable confidence, even when a radiologist's interpretation is not available.

The confident and accurate interpretation of non-emergency Diagnostic exams generally requires a greater degree of X-ray reading skill than do trauma examinations. As might be expected, providers rated a prompt interpretation of such films as "Significant" or "Very significant" in 62% of cases.

b. Significance Considered at the Time of Report Review

Although providers felt that a number of radiologists' reports did affect the handling of their cases (see Table 11), seldom was the timeliness of report receipt considered significant. Timely receipt was considered important for 7% of examinations, overall. It is interesting to note that in the baseline period, providers were more likely to rate prompt receipt as significant than they were in the post-implementation period. It may be that before the teleradiology system was installed, when attention was focused on the system's future arrival and accompanying benefits, turnaround time was more of an issue than it was later, during relatively routine system operation.

3. Effects of Interpretation Accuracy

Interpretation "Difficulty" of X-ray Exams performed

If technical limitations of the teleradiology system resulted in X-ray images being more difficult to read than X-ray films and, consequently, reduced the accuracy of interpretation, would such a reduction affect patient care or disposition at the transmitter sites?

Data gathered in an experimental evaluation of the teleradiology system indicate that radiologists do interpret teleradiology video images at high levels of accuracy.[10] However, interpretation accuracy does vary slightly between film and video readings of the same examination. The system was shown to perform better for simpler, rather than more difficult, cases. It performed best for extremity exams (3.68 on a 4-point "accuracy score" scale [11]), followed by chest

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[10] Harrington, M. et al., op. cit.

[11] The 4-point scale has a range from 1="abnormality not noted" to 4 = "abnormality fully characterized." It is interesting to note that differences between accuracy scores for film and video readings of the same examinations increased in parallel with decreasing accuracy scores for video readings; i.e., the more difficult it was for a radiologist to read a given film, the relatively worse his video reading of that same examination would be. The differences between accuracy scores for films and video readings of the same examination were .16 (on the 4-point scale) for extremity films, .34 for chest films, .44 for skull films, .46 for abdomen films, and .57 for other skeletal films.

exams (3.44), abdomen exams (3.28), skull exams (3.08), and other skeletal exams (2.93).

As is apparent from data presented in Section 1 of this chapter, a substantial portion of the X-rays performed at the four transmitter sites involved in the teleradiology field trial is made up of cases of low complexity, and the X-ray department workloads involve high numbers of the types of examinations for which the system has been shown to perform best. At all sites, over 70% of examinations were either extremity or chest exams (see Table 6) -- for which teleradiology has been shown to have relatively high "accuracy scores." More "difficult" abdomen exams make up 6% of total examinations, skull exams 8%, and spine exams (other skeletal), 6%.

Therefore, if technical limitations in the teleradiology system did result in X-ray images being more difficult to read than X-ray films, the possible reduction in interpretation accuracy may have less impact in these primary care settings than it would in facilities with a greater number of complex cases or more "difficult" examinations.

C. FEASIBILITY OF ROUTINE USE

1. Transmitter Sites

In order to determine whether the teleradiology system could be accommodated into normal X-ray department operations at transmitter sites, the distribution of X-ray department staff activities were recorded using work-sampling techniques. Work-sampling was performed before system installation and during system operation. Because all but one of the transmitter sites did increase their staff to accommodate system use , it was not possible to measure directly the impact of system operation on the distribution of regular staff time. The work-sampling data do, nevertheless, provide estimates of the ease with which the system could be accommodated into normal department operations, and served as a replacement for alternative "manual" methods for obtaining interpretations.

Tables 15, 16 and 17 display the work sampling results. The number of minutes of staff time per exam spent in various activities varied among sites and between the study periods. However, both

TABLE 15

MEAN X-RAY DEPARTMENT STAFF TIME
SPENT IN VARIOUS WORK ACTIVITIES PER X-RAY
BY TRANSMITTER SITE
TELERADIOLOGY FIELD TRIAL

Facility		X-Rays Performed During Sampling Period	FTE Staff	Manhours Sampled	Mean Time Per X-Ray in Minutes: Performing X-Ray	Processing X-Ray	Filing X-Ray	Paper Work	Preparing X-Ray for Dispatch	Teleradiology Operation	Total Minutes of Work Activity Per X-Ray	Average # X-raysPer 8-Hr Day	Proportion of Staff Time Spent in Work-Related Activities
Bolling	X	25	1	15.7	5.1	5.7	1.9	6.6	0	-	19.3	12.7	51.2%
	Y	26	2	32	5.2	4.5	2.1	19.5	.2	7.1	38 6	6.5	44.2%
Detrick	X	33	2	24.5	5.0	5.0	1.4	9.3	0	-	20.7	10.8	51.6%
	Y	32	3	62	15.2	5.2	4.4	20.0	.8	11.1	56.7	4.1	50%
Patuxent	X	96	4	88.0	6.5	14.3	6.7	11.2	.9	-	39.6	9.0	71.5%
	Y[a]	65	5	67.2	6.1	2.3	2.0	9.6	.6	7.0	27.6	11.1	35.6%
CVCHC	X	9	1	8.5	11.6	2.8	1.1	4.4	1.1	-	21.0	8.5	36.9%
	Y	8	1	19.3	10.0	3.8	.8	9.6	6.8	11.2	42.2	3.3	41.0%

[a]Includes nontechnician teleradiology system operator at Patuxent during Period Y

TABLE 16

PERCENTAGE OF X-RAY DEPARTMENT STAFF TIME
SPENT IN VARIOUS ACTIVITIES
BY TRANSMITTER SITE
TELERADIOLOGY FIELD TRIAL

Facility	Radiologist Present	Staff Position	X-rays Performed During Sampling Period X	X-rays Performed During Sampling Period Y	Manhours Sampled X	Manhours Sampled Y	Percentage of Staff Time: Performing X-rays X	Performing X-rays Y	Processing X-rays X	Processing X-rays Y	Filing X-rays X	Filing X-rays Y	Paper Work X	Paper Work Y	X-ray for Dispatch X	X-ray for Dispatch Y	Teleradiology System Operation X	Teleradiology System Operation Y	Other Activities X	Other Activities Y
Bolling	No	Technician	25	26	15.7	35	13.4%	6.9	15.1%	5.9	5.1%	3.0	17.6%	25.8	0%	.2	-	2.4	48.8%	55.8
Detrick	No	Technician	19	32	17	46.7	7.2%	13.4	6.3%	4.1	2.9%	3.2	24.0%	14.6	0%	0	-	13.3	59.6%	51.4
	Yes	Technician	14		7.5	15.3	27.6%	12.0	31.0%	6.9	3.5%	6.0	8.6%	24.0	0%	3.3	-	3.3	29.3%	45.4
	No	Secretary	19	52	10.8	16.5	0	0	.8%	1.1	8.3%	3.0	19.5%	9.9	0%	0	-	0	71.4%	86
	Yes	Secretary	14		4.3	6.5	0	0	1.9%	0	1.9%	1.6	28.3%	26.7	0%	0	-	0	67.9%	71.7
Patuxent	No	Technician	63	65	38.8	43.0	10.6	8.4	28.6%	1.6	13.9%	3.9	24.6%	11.2	2.4%	.8	-	4.1	19.9%	70%
	Yes	Technician	33		29.2	24.0	18.8%	14.7	19.6%	9.2	3.5%	1.1	12.4%	16.2	0%	1.3	-	4.6	45.7%	52.9
CVCHC	No	Technician	9	8	8.5	19.3	20.4%	6.9	4.9%	2.6	1.9%	0	7.8%	11.3	1.9%	4.7	-	14.9	63.1%	59.6
TOTAL	No	Technician	116	131	100	144	11.1%	9.5	20.7%	3.6%	9.7%	2.9	22.1%	15.9	1.6%	.9	-	8.1	34.8%	59.1
TOTAL	Yes	Technician	47		36.7	31.5	20.7%	13.6	21.9%	8.0	3.6%	2.8	11.5%	19.2	0%	2.1	-	4.1	42.3%	50.2
MEAN							13.8%	10.2	21.0%	4.4	8.1%	2.4	19.3%	16.5	1.1%	1.1	-	7.4	36.7%	58

[a] Includes nontechnician teleradiology system operator at Patuxent during Period Y.

TABLE 17

PERCENTAGE OF TELERADIOLOGY
TRANSMITTER SYSTEM
OPERATOR'S TIME SPENT IN VARIOUS ACTIVITIES
BY TRANSMITTER SITE
TELERADIOLOGY FIELD TRIAL

Facility	Minutes Sampled	Exams Input During Sampling Period	Percentage of System Operator's Time: Lightbox/ Camera Operation	CRT Keyboard Operation	Waiting	Report Printer Activities and Logging	Non-Related Activities	Mean Minutes Per Exam Spent Inputting
Bolling	197	28	17.5%	38.1%	4.8%	15.9%	23.7%	7.1
Detrick	122	11	36.9%	33.6%	0%	8.2%	21.3%	11.1
Patuxent	63	9	42.1%	39.6%	0%	14.7%	3.6%	7.0
CVCHC	143	13	35.7%	42.0%	6.3%	6.3%	9.7%	11.2
TOTAL	525	61	36.2%	38.7%	2.3%	11.0%	11.8%	8.7

before and after system implementation, approximately one-half of X-ray department time was spent in activities unrelated to X-ray department work. Workload is extremely uneven in these small departments, and much of this time was spent "on-call" for X-ray duty during non-busy times. Performing and processing each X-ray and doing the paperwork and filing associated with X-ray exams took between 20 minutes and 40 minutes per exam; inputting teleradiology images required an additional 10 minutes per exam.

From these data, it appears that if a small X-ray department were not extremely busy, it could accommodate teleradiology system operation into the daily schedule. Image inputting could be fit in to the day's routine -- either directly after examinations are performed or during slow periods of the day. However, if workload were heavy, the 10 additional minutes per exam required for teleradiology operation might present a burden.

2. Central Site

Time study data were collected regarding the amount of radiologists' interpretation time required for viewing films and viewing video images (Table 18).

Radiologists spent a mean of 2.7 minutes per X-ray exam interpreting films and 3.40 minutes per X-ray exam interpreting video images. There are several possible explanations for this difference:

- video interpretation may actually require more time than film interpretation;
- the nature of the experimental teleradiology system -- the limited number of monitors, the number of keyboard operations it required -- might have lengthened video interpretation time;
- the radiologists' lack of expertise at reading video images might have lengthened video interpretation time;
- the two sets of data may not be equally accurate: film interpretation data were recorded by the radiologists themselves, while the video data were collected by the teleradiology system.

TABLE 18

MEAN TIME REQUIRED FOR X-RAY INTERPRETATION
BY INTERPRETATION MODE
TELERADIOLOGY FIELD TRIAL

Interpretation Mode	Minutes Per Exam		Number of Observations	Number of Exams Observed
	$\bar{x}$	σ		
Film Interpretation	2.71	1.81	66	347
Teleradiology Video Image Interpretation	3.40	1.26	22	906

D. ACCEPTABILITY TO USERS

During the post-implementation data collection period, teleradiology users were surveyed to determine their acceptance of the system.

1. Radiologist Survey

The radiologists who interpreted teleradiology images at the central site during the field trial were asked to answer a series of open-ended questions regarding their impressions of the system. Twenty-six (or 87%) of the radiologists responded. Approximately one-third (31%) were military physicians; one-half described themselves as being in academic practice, and 19%, in private practice. Most of the respondents had been involved in several teleradiology interpretation sessions (56% in four or more; 30% in two to three; and 14% in one).

Overall, the radiologists were impressed with the system. Responses to specific questions are summarized below.

a. Ease of orientation

Of the 26 respondents, only two felt that orientation to the system had been difficult or awkward. Eighteen felt that orientation had been accomplished very easily, and six, satisfactorily.

b. Ease of use

Overall, comments regarding ease of system use were quite positive. Respondents used words like "excellent," "easy," "no problem," "simplistic," "straightforward," and "moderate," to describe system operating procedures. One radiologist felt that the system was awkward to use, and eight complained that image accessioning time was too long (though two stated that this time had been substantially reduced toward the latter part of the field trial).

c. Technical quality of images received

The general tone of comments regarding the technical quality of images was "acceptable," rather than "excellent." Most felt quality was "good" or "fair"; a few said that it was "moderate" or "adequate." One commented that transmitted images of soft tissue and chest exams were not as good as those of bones.

d. Adequacy of resolution

Again, the tone of responses was "acceptable" rather than "good." Several radiologists commented that the system's resolution was limited for observing minute details and subtleties such as lung changes or slight fracture.

e. Accuracy of interpretation

Seven of the respondents felt that their interpretations were equally accurate when performed via video and via film. Sixteen responses were positive but qualified: small fractures and fine details were more likely to be missed using teleradiology, and soft-tissue images were considered difficult to visualize using the video mode. Three respondents stated that their video interpretations were generally less accurate than their film interpretations.

f. Confidence in interpretation

Most respondents expressed less confidence in their video interpretations than in those of film, particularly when subtle abnormalities were present in the exam. They expressed a higher degree of confidence for gross observations and normal studies, or when images were of particularly good quality. Two respondents mentioned that their confidence increased with their increased exposure to the video interpretation mode.

g. Positive aspects of the system

Responses to this question were quite diverse. Respondents mentioned their ability, using the system, to adjust image brightness and contrast, to avoid film handling, and to review a large number of cases quickly. They liked the fact that technicians could transmit images that were coned down on the original projection.

h. Negative aspects of the system

Again, responses were diverse. They were generally focused on the limited resolution of fine film details (five comments), the excessive waiting time for image display (eleven comments), and the inferior quality of transmitted images (four comments).

i. Suggested improvements

Not surprisingly, the respondents suggested improving those aspects of the system of which they were critical: five recommended

improvements in image resolution, seven, in the timeliness of image display and two, further technician transmission training. However, respondents also mentioned that two or three more viewing monitors would be useful, that a 1024x1024 image would be preferable to the 512x512 used in this system, and that the range possible for image contrast should be expanded. Also, human engineering refinements were suggested, involving redesign of the console and simplification of the keyboard.

j. Use in remote clinics

All but two of the respondents felt that teleradiology should be used to provide radiologists' interpretation services to remote clinics and hospitals that do not otherwise have access to radiologists' services. Only one radiologist felt that the system should definitely not be used and one felt that it should "possibly" be used. Five respondents qualified their affirmative responses: three recommending using the system for wet readings only, one, for emergency or urgent cases only, and one stressed that system users should be alerted to the system's limitations -- e.g., soft-tissue resolution, small fracture visualization, etc.

k. Use in other settings

Four respondents suggested using the system for teaching, three, for consultation within or among hospitals or large outpatient clinics, one, for night-call, and one, on ships or in field medical facilities.

l. Additional comments

"Additional" comments were generally enthusiastic: participants felt that the system was a good start - had great potential, especially in military settings. Two radiologists commented that this system would be better for serving an uncomplicated outpatient population like that involved in the field trial, rather than for providing basic interpretation services to facilities that would require radiologists to provide other services, i.e, for fluoroscopic exams or other special procedures.

2. Provider Survey

A written questionnaire regarding post-implementation X-ray services was completed by 28 (90%) of the health care providers at the transmitter sites.[12] Seventy-five percent of those responding were staff physicians, 21% were physicians' assistants and 4% were nurse practitioners. Respondents were generally pleased with the X-ray services at their facilities, and impressed with the teleradiology system's potential utility.

a. Utilization of radiologists' services

Ninety-three percent of respondents stated that they always read the radiologist's X-ray interpretation report on exams that they order (while 7% read this report "most of the time"). Most said that they used their own film interpretation, as well as the radiologist's, in making diagnostic or treatment decisions (41% depend on their own; 33% use the radiologist's combined with their own; and 26% depend on the radiologist's interpretation). All respondents stated that they did, at times, consult with radiologists (Seventy-eight percent do this to discuss X-ray films, 59% to clarify reported findings and to determine the need for further examinations, 37% to consult in advance regarding the need for X-ray and 33% to ask for information not found in the X-ray report). Thirty-seven percent felt that the non-availability of radiologists at their facility represented a major drawback to X-ray service, while 44% felt that delayed reporting was the X-ray department's primary shortcoming.

b. Opinions of X-Ray services

Providers were asked to note how often they experienced delays in receipt of X-ray reports or in finding X-ray films, and to indicate how often these incidents delayed patient management. Survey responses are summarized in Table 19. While most providers (70%)

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[12] During the baseline period, Arthur D. Little was not responsible for surveys of providers, but such surveys were performed and analyzed by the Bureau of Radiological Health and results are available in the BRH's report of findings.

TABLE 19

PROVIDERS' OPINIONS:
INCIDENCE OF X-RAY DEPARTMENT DELAYS
POST-IMPLEMENTATION (PERIOD Y)
TELERADIOLOGY FIELD TRIAL

Event	Monthly Incidence of Delays Associated With X-Ray Services at Transmitter Sites — Post-System Implementation[a]					Relative Incidence of *Delays Associated* With X-Ray Services at Transmitter Sites — Pre- vs. Post-Implementation[b]					
	None	1-4	5-9	10+	Don't Know	Much more frequently now	Slightly more frequently now	Same	Slightly less frequently now	Much less frequently now	Don't Know
Delays in receiving X-ray reports	26%	36%	15%	22%	4%	0%	0%	52%	30%	21%	0
Delays in receiving reports that resulted in delaying patient management	59%	33%	4%	4%	0	0	0	59%	18%	22%	0
Delays in finding X-ray films	63%	33%	0	0	4%	0	7%	56%	7%	11%	18%
Delays in finding X-ray films that resulted in delaying patient management	81%	15%	0	0	4	0	4%	50%	7%	22%	15%

[a] Represent primary care providers' responses to the question: "How many times *per month* do you experience the following problems associated with radiology services now that teleradiology is installed and functioning properly (since April, 1982)?"

[b] Represent primary care providers' responses to the question: "Do you feel that the following problems are experienced with different frequency now versus prior to teleradiology?"

indicated that they had experienced at least one reporting "delay" during the past month, these delays usually did not result in patient management being postponed. A much smaller proportion of providers (33%) had experienced delays in finding X-ray films, but, once again, seldom did delays affect patient care. The majority of providers felt that delays occurred with similar frequency during the field trial and prior to system installation; a number felt that there were fewer delays since teleradiology had been installed.

Fourteen percent of providers indicated that they had recently (i.e. during the field trial) had to re-order an X-ray exam because of delays in reporting, while 7% indicated that a re-examination had been required because of difficulty in finding films.

Providers were asked to rate various aspects of the X-ray services provided at their facilities. These ratings are summarized in Table 20. Overall, answers were quite positive. Providers were most concerned with the timeliness of reporting (21% indicated that timeliness was "poor"), but the majority felt that the timeliness, availability, accuracy, comprehensiveness and readability of reports were either "good" or "excellent." They felt that X-ray department staff were both able and cooperative, but noted some problems with patient scheduling and with the availability of X-ray films.

c. Teleradiology

Providers were asked several questions concerning their familiarity with and opinions of the teleradiology system. All respondents stated that they were aware of the system's existence and most (54%) felt that it had improved X-ray services; however, 10% felt that the system had aggravated or created problems in the department.

Although several providers commented that the teleradiology system had great potential, few felt that it had had much impact on X-ray services or on patient care during the field trial. Two commented that the present system had had too many technical problems to be really useable; three, that because teleradiology interpretations had not generally been received prior to film interpretations, the system had had little impact.

TABLE 20

PROVIDERS' OPINIONS:
RATINGS OF VARIOUS CHARACTERISTICS OF X-RAY SERVICES [a]
POST-IMPLEMENTATION (PERIOD Y)
TELERADIOLOGY FIELD TRIAL

Characteristic	Rating (percent)				
	Excellent	Good	Adequate	Poor	Very Poor
Timeliness of Reports	11%	54%	14%	21%	0
Availability of Reports	39%	32%	25%	4%	0
Accuracy of Reports	29%	50%	21%	0	0
Comprehensiveness of Reports	36%	54%	10%	0	0
Readability of Reports	50%	43%	7%	0	0
Availability of X-Ray Films	36%	25%	39%	0	0
Ability of Staff	61%	25%	14%	0	0
Cooperativeness of Staff	68%	14%	18%	0	0
Scheduling of Patients	46%	36%	14%	4	0

[a] Represent responses to the question:

"Please rate your facility's radiology service since Teleradiology on each of the following"

Concerning future use of teleradiology, two providers commented that rapid turnaround would be of little value in primary care clinics such as theirs, because providers rely on their own interpretations of simple cases and refer complex cases elsewhere for both diagnosis and treatment. Three commented that a 1-hour report turnaround would be very useful, one praising the PRIORITY mode, which had been added to the system during the latter half of the trial. One felt that prompt radiologists' interpretations would be most useful to emergency room providers during evenings and weekends, when other providers were unavailable to assist in film interpretation and disposition decisions. And one recommended that a telephone be available for communication with interpreting radiologists.

3. User Interviews

a. Technicians

Each of the transmitter site system operators was interviewed during the post-implementation data collection period to determine their opinions of the system. A total of eight individuals were interviewed: seven technicians who operated the transmitter systems at the sites and one specially hired transmitter system operator. The interviews focused on how well the system had functioned, ease of system use, the adequacy of system turnaround time, exams for which the system was most useful, the impact of the system on patient care, suggestions for ways of improving the system, and opinions on whether and where the system should be permanently installed. Responses are summarized below.

i. System function

Users reported that the system had functioned reasonably well during the latter half of the field trial. Early on, both the image processing system and the word processor had frequently malfunctioned. The fewest problems were experienced at Bolling, where the system was not installed until quite late in the field trial, and the most were found at CVCHC -- where the telephone lines were poor -- and Patuxent -- which had the largest workload.

ii. Ease of system use

All of the operators reported that the system was very easy for them to use, although several commented that the inputting process was too time consuming. Some also complained about the number of manual and physically awkward steps involved in inputting films and the time required for logging activities, recording patient information and operating the printer. Only one of the system operators felt that the software's many prompts and safeguards were superfluous; the others fount these reminders helpful.

iii. Turnaround time

Technicians generally felt that the system's several-day turnaround time for interpretation reports was adequate for their facilities because most of the cases that were input were not associated with emergencies. Three commented that a 1-hour turnaround time would greatly enhance the system's utility; they felt that the PRIORITY mode had not been available for long enough to be given an adequate trial.

iv. Examinations for which the system was most useful

Three technicians reported that the system was useful for all exams equally, while others specified those for which teleradiology was most or least appropriate. Several technicians felt that the system would be best for emergency exams, but one technician commented that, because emergency cases were usually sent elsewhere for treatment, timely reporting was not a high priority. Technically, the technicians felt that the system transmitted extremity films and fractures best, and chest, spine, hand and abdomen exams less clearly.

v. Impact on patient care

Technicians did not generally feel that the system had affected patient care. Two reported that for the mix of patients examined at their clinics, the system could have little impact, even if turnaround time were reduced. Others felt that the system's impact was limited by referring providers' lack of confidence in the system.

vi. Suggested Improvements

The technicians had many suggestions for system improvement, most of which were designed to shorten the inputting process, and some to increase the amount of information that was transmitted. Major recommendations were:

- quadrant inputting should be automatic
- image focusing should be automatic
- software redundancy should be reduced
- time lag between images should be reduced
- control of all inputting functions should be possible from the keyboard
- patient and case-specific information should be recallable and revisable during or after image capture
- more projection codes should be available and free form descriptions of projections should be possible
- lightbox lighting should be more consistent
- the lightbox should be larger
- the images should be markable with an R or an L and ruled
- the system's sensitivity to external problems, such as rain or telephone line inadequacies should be reduced
- staffing should be increased to accommodate system use

vii. Permanent installation

All of the system operators felt that they would like to see a refined teleradiology system permanently installed in their facilities. Several commented that it would also be useful on ships, in facilities that process large numbers of physical examinations, and in areas that do not otherwise have radiologists services available.

b. Project Officers

Each of the project officers at the transmitter sites was interviewed regarding his opinions of the system. Three were physicians and one was an administrator. On most points, the project officers' opinions correlated with those of the technicians. However, they had more comments regarding the system's potential and the clinical utility of the system. Major impressions were:

- The system is more likely to increase the clinical confidence of providers than to alter actual patient treatment.
- The system is of more value where referring providers are less capable of interpreting films themselves.
- The system would be particularly useful if it allowed 24-hour access to radiologist consultation.
- The system can serve to extend the arm of the remote primary care provider, allowing him to function as he would in the outpatient department of a hospital.

Several project officers expressed disappointment with the system, having expected a high degree of functional reliability and a very short report turn around time.

E. ESTIMATED INCREMENTAL COSTS OF USING TELERADIOLOGY

In order to determine the cost of using the teleradiology system in facilities typified by the transmitter sites and the central site involved in the field trial, data were collected regarding total X-ray department operating costs, and the costs of teleradiology system. Also, the costs of obtaining radiologists' interpretations by the standard "manual" methods used at the transmitter sites were estimated from observation of their operations. Estimated annual costs of operating the X-ray services at the transmitter sites -- less the cost of obtaining radiologists' interpretations -- are presented in Table 21. These figures were combined with X-ray workload to calculate cost per examination at each facility, as shown in Table 22. The per examination costs can be used as base figures against which to compare the costs of obtaining radiologists' interpretation services using different methods.

At each of the four transmitter sites, it would be possible to use any of three standard methods for obtaining radiologists' interpretation services: to use a courier service, to contract for a visiting radiologist on a part-time basis or to use teleradiology. In these clinics, the equipment and staff necessary to perform and process X-ray exams are essentially the same regardless of which method is used. Hence, in the analysis of teleradiology's costs, attention was

TABLE 21

ESTIMATED ANNUAL OPERATING COSTS OF X-RAY SERVICES LESS COSTS OF OBTAINING RADIOLOGISTS' INTERPRETATION BY TRANSMITTER SITE

TELERADIOLOGY FIELD TRIAL

Facility	Personnel Costs[a]		Other Costs[a]		Overhead and Maintenance[a]	Total Costs[a]
	Technicians[b]	Radiologists	Equipment	Supplies		
Bolling	$ 34,076	$ 4,794	$ 7,391	$ 12,874	$ 86,460	$ 145,595
Detrick	80,208	7,510	17,629	14,688	23,829	143,864
Patuxent	87,671	13,127	32,500	21,972	12,223	167,493
CVCHC	20,369	18,440	46,468[c]			85,277[c]

[a] Does not include costs of courier services or radiologists' travel time.

[b] Includes secretarial services at Malcolm Grow Medical Center for Bolling AFB Clinic and at Fort Detrick Army Clinic.

[c] Only total "non-personnel" cost figures were available at CVCHC.

TABLE 22

ESTIMATED COST PER UNIT OF X-RAY WORKLOAD
BY TRANSMITTER SITE
TELERADIOLOGY FIELD TRIAL

Facility	Total Costs[a]	# X-ray Patients/Year	X-ray Cost/Patient [a]	# X-ray Exams/Year	X-ray Cost/Exam[a]
Bolling	$ 145,595	3387	$ 42.99	3921[b]	$ 37.13
Detrick	143,864	4059	35.44	4668[c]	30.82
Patuxent	167,493	7118	25.53	8159[b]	20.53
CVCHC	85,277	1370	62.25	1576[c]	54.11

[a]Does not include cost of obtaining radiologists' interpretations.

[b]Data available.

[c]Estimates based on presuming 1.15 examinations per X-ray patient.

focused only on the incremental or marginal costs associated with the three alternatives; only the costs of obtaining the interpretation were included; those of performing the interpretation or other X-ray processing activities were not.

Table 23 shows estimates of the incremental costs of obtaining interpretation services at facilities similar to the study sites using each of the three methods listed above.[13] The cost of using the teleradiology system was found to be approximately $7 per X-ray exam, compared with an estimated $2.50 per exam when a part-time visiting radiologist is employed and $0.50 when a courier system is used.

The figures presented in Table 23 were based on the characteristics of the field trial transmitter sites, on the central site, and of the teleradiology system. These figures would vary in different settings. For example, operating a courier or visiting radiologist system would be much more expensive if the clinics were very remote. And the cost of using a teleradiology system would be reduced if the capital cost of the system was lower or if a larger volume of cases were input into the system; and teleradiology costs would increase if a satellite were used for image transmission or if transmitter system operators went through a formal training program.

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[13] Tables C-10 and C-11 in the Appendix present cost figures for the teleradiology system components.

TABLE 23

ESTIMATED ANNUAL MARGINAL COST OF THREE APPROACHES
TO OBTAINING RADIOLOGISTS' INTERPRETATION SERVICES AT SMALL SITES[a] PER SITE

	Estimated Annual Marginal Cost			
			Teleradiology	
Cost Element	Courier	Visiting Radiologist	Satellite Site Cost	Central Site Cost
Space	$ 0	$ 500[b]	$ 250[c]	$ 1,000[d]
Equipment	0	400[e]	15,840[f]	35,200[g]
Supplies	300[h]	0	3,000[i]	0
Services (Telephone)	500	500	5,000	0
Staff	0	,000[j]	0	10,000[k]
Transport	1,750[l]	6,600[m]	0	0
			$ 24,090	$ 46,200
Total Cost Per Site	$2,550	$ 12,000	$35,640	
Per X-Ray Incremental Cost of Obtaining Radiologist's Interpretation (20 X-rays/day)[n]	$ .51	$ 2.40	$ 7.13	

[a]Assumes that the equipment, space, supplies and staff necessary to perform and to process X-ray exams are the same under each alternative, that the radiologists' time and charges for interpretation are the same under each alternative, and that under teleradiology, regular staff radiologists at the central site would read teleradiology images as part of the daily interpretation routine, and that the cost of acquiring space for obtaining X-ray interpretation reports is amortized over 10 years.

[b]50 ft^2 workspace for radiologist at remote site ($100/$ft^2$)

[c]25 ft^2 space for teleradiology equipment at remote site ($100/$ft^2$)

[d]100 ft^2 space for teleradiology equipment at central site ($100/$ft^2$)

[e]Dictation and transcription equipment, viewboxes, desk, etc., at remote site ($2,000: 5-year life)

[f]Teleradiology equipment ($72,000: 5-year life + 10% maintenance) (figures obtained from MITRE Corporation)

[g]Teleradiology equipment ($160,000/4: 5-year life + 10% maintenance) (figures obtained from MITRE Corporation)

[h]Envelopes for transport

[i]Word-processor supplies

[j]Part-time transcriptionist at remote site (40% x $10,000/year)

[k]Part-time teleradiology system coordinator (50% x $20,000/year)

[l]10% of courier service; assumes that services are provided for other reasons as well ($7,500/year for vehicle + $10,000/year for driver)

[m]Expense and time charges for radiologist's travel (200 miles/week @ $.22/mile + 4 hours/week travel time x $20/hour)

[n]Estimated workload of a typical small X-ray department

V. DISCUSSION AND CONCLUSIONS

The nature of the field trial did not allow direct measurement of the patient care impacts, staffing impacts, or cost impacts of teleradiology use. However, the results of the trial can be used to reach some conclusions about the utility of teleradiology in routine medical practice.

First, the teleradiology system appears to be acceptable to users. A few human engineering refinements, and increased exposure to the system would probably make it totally acceptable operationally.

Second, operating the teleradiology system requires about 10 minutes per exam. In a small X-ray department whwere workload is moderate, technicians would be likely to have enough time to perform their regular duties and to operate the machine as well. If workload were heavy, however, the 10 additional minutes might present a burden to technicians.

It appears that the interpretation of teleradiology images requires slightly more time than interpreting exams in film form. This incremental time is small, however, and it is probable that if a large X-ray department could accommodate the film interpretation of a given number of X-ray exams, it could similarly accommodate the interpretation of teleradiology images of these exams.

Third, if operating procedures were redesigned to maximize the benefits of the system, teleradiology report turnaround time could be quite short: 24-hours for routine exams and 1 hour for STAT cases. Such procedures would allow small or remote clinics to have access to radiologists' services similar to that which exists in larger or less remote facilities (such as hospital outpatient departments). It is important to recognize that a teleradiology system can only provide rapid report turnaround if it is operated in a very routine and timely fashion.

Furth, the major patient-care benefits that could result from using teleradiology is a reduction in turnaround time for the radiologist's interpretation report. The patient-care value of the

system depends upon how important the promptness of the turnaround is to patient treatment and disposition decisions in a given setting. For any setting, the value of prompt interpretation depends on:

- whether many X-ray are performed for use in immediate treatment decisions or are performed routinely or "for the record";
- the relative interpretation skill of the health care providers who would otherwise be interpreting the exams. The less confident and the less skilled the providers, the more valuable is the prompt expert's interpretation.
- the treatment capabilities of the facility where the X-ray is performed. If patients who are severely ill can not be be treated adequately at a given transmitter site prompt interpretation receipt is of marginal value since such patients are immediately sent elsewhere regardless of X-ray findings. On the other hand, if X-ray results may help providers to decide whether or not to send patients elsewhere, prompt interpretation may be very important.
- the alternatives available: in extremely remote locations, teleradiology may be the only method for obtaining radiologists' services, or obtaining them in a reasonable length of time, while in less isolated settings, other alternatives may be available.

Fifth, the costs of using the teleradiology system appear to be higher than the costs of the manual alternatives for facilities typified by the field trial transmitter sites. However, the relative costs of the three alternative methods for obtaining interpretations would vary in different settings.

APPENDIX A

DATA COLLECTION INSTRUMENTS

Data Collection Instrument X-1

Time History: X-Ray Request/Report Cycle

TIME HISTORY:

X-RAY REQUESTS/REPORT CYCLE

Arthur D. Little, Inc., has been commissioned by the TRIMIS Program Office to evaluate impacts of a TELERADIOLOGY system on the radiology service provided in several clinics in the Washington, D.C. area. This system is scheduled for installation in the late Fall of 1981.

As part of the evaluation, we are interested in describing the *present* system for requesting and interpreting X-rays. We are asking staff to complete the various sections of the attached form, which document the five major stages of the X-ray request/report cycle:

to the ATTENDING PHYSICIAN:

SECTION I is to be completed by the ATTENDING PHYSICIAN when ordering an X-ray examination.

to the X-RAY TECHNICIAN:

SECTION II is to be completed by the X-RAY TECHNICIAN when performing the X-ray examination.

to the ATTENDING PHYSICIAN:

SECTION III is to be completed by the ATTENDING PHYSICIAN if and when he looks at the films *before* a radiologist interprets them.

to the RADIOLOGIST:

SECTION IV is to be completed by the RADIOLOGIST performing the X-ray interpretation.

to the RECEPTIONIST or TECHNICIAN at the originating clinic:

SECTION V is to be completed when the interpretation report is received at the originating clinic (if the X-ray has been sent elsewhere for interpretation).

to the ATTENDING PHYSICIAN:

SECTION VI is to be completed when the interpretation is reviewed by the ATTENDING PHYSICIAN.

(We understand that some questions may not apply to every clinic.)

Information will also be collected after the TELERADIOLOGY system is operational. The data will be used to identify changes in the use of X-ray examinations in patient care.

THANK YOU.

/ / / / / (1–4)

SECTION I: To be filled out by the **ATTENDING PHYSICIAN** when ordering X-rays.

1. What is the reason for this X-ray examination

Routine physical examination (1) _____ (5)

For the record: diagnostic, but not expected to affect patient's immediate disposition. Please note presenting symptoms or provisional diagnosis: (2) _____

Diagnostic: expected to influence patient's immediate disposition. Please note presenting symptoms or provisional diagnosis: (3) _____

Follow-up. (4) _____

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2. Given that the option existed of having these films interpreted by a radiologist within one hour of exam performance, would you feel that such a prompt reading would be:

Not significant. Would not affect patient's treatment or immediate disposition. (1) _____ (6)

Somewhat significant. Unlikely to affect patient's treatment or immediate disposition, but likely to increase your diagnostic confidence. (2) _____

Significant. Likely to affect your opinions and/or decisions regarding patient care and/or disposition. (3) _____

Very significant. Essential to your decisions regarding patient care and/or disposition. (4) _____

---

3. TIME of request for X-ray examination:

hour minute	month	day	year
/ / / /	/ /	/ /	/ /
(7–8) (9–10)	(11–12)	(13–14)	(15–16)
(24-hour clock, e.g., 1645)		(Date, e.g., 09/23/81)	

---

4. Immediate disposition of patient: (17)

Wait in clinic for attending physician to interpret X-rays. (1) _____

Wait in clinic for radiologist to interpret X-rays. (2) _____

Wait in clinic for other reasons. (3) _____

Discharged. Return to normal activities (4) _____

Discharged. Stay at home. (5) _____

Referred to another facility. (6) _____

Admitted for treatment or observation. (7) _____

Return to ward. (8) _____

THANK YOU.

ATTENDING PHYSICIAN or P.A. – SECTION I

SECTION II: To be filled out by the X-RAY TECHNICIAN.

5. **FACILITY**

Bolling AFB Clinic	(1)	_____	(18)
Central Virginia Community HC	(2)	_____	
Ft. Detrick Hospital	(3)	_____	
Patuxent NATC	(4)	_____	

6. Patient's Identification (20–30)

Number* / / / /-/ / /-/ / / / /-/ / /

7. Age / / / (31–33)

8. Sex:

Female	(1)	_____	(34)
Male	(2)	_____	

9. Status:

Outpatient	(1)	_____	(35)
Inpatient	(2)	_____	
Emergency	(3)	_____	

10. Exam type(s) requested (e.g., skull, abdomen, chest)

1. _____ _____ (36)
2. _____ _____ (37)
3. _____ _____ (38)
4. _____ _____ (39)
5. _____ _____ (40)

11. Is this a NEW patient?

Yes	(1)	_____	(41)
No	(2)	_____	

12. If this is **NOT** a new patient, how many pertinent old *films* are available (i.e., relatively recent films of the same area of the body)?

none	(0) _____	three	(3) _____	five to ten	(6) _____	(42)
one	(1) _____	four	(4) _____	eleven to fifteen	(7) _____	
two	(2) _____	five	(5) _____	sixteen to twenty	(8) _____	
				more than twenty	(9) _____	

*Patient number will be used only to correlate responses and will then be deleted in future analysis

THANK YOU.

SECTION III: To be filled out by the **ATTENDING PHYSICIAN** if and when looking at the films *before* a radiologist interprets them.

13. How has your viewing of these films affected your handling of this case?

No effect or inconclusive.	(1)	(43)
Some effect: increased confidence in clinical impression.	(2)	
Some effect: altered clinical impression, but did not alter patient treatment and/or disposition.	(3)	
Major effect: altered patient treatment and/or disposition.	(4)	

14. Disposition of patient:

Disposition already made.	(1)	(44)
Wait in clinic for radiologist to interpret X-rays.	(2)	
Wait in clinic for other reasons.	(3)	
Discharged. Return to normal activities	(4)	
Discharged. Stay at home.	(5)	
Referred to another facility.	(6)	
Admitted for treatment or observation.	(7)	
Return to ward.	(8)	

THANK YOU.

SECTION IV: To be filled out by the **RADIOLOGIST** interpreting the X-ray films.

15. **LOCATION OF RADIOLOGIST:** (45)

Bethesda NMC	(1)	_____
Ft. Detrick Hospital	(2)	_____
Malcolm Grow Hospital	(3)	_____
Patuxent NATC	(4)	_____
University of Virginia MC	(5)	_____
Other	(6)	_____

16. *How many* **OLD** *films did you use for comparison in this interpretation?*

none	(0)	_____	(46)
one	(1)	_____	
two	(2)	_____	
three	(3)	_____	
four	(4)	_____	
five	(5)	_____	
five to ten	(6)	_____	
eleven to fifteen	(7)	_____	
sixteen to twenty	(8)	_____	
more than twenty	(9)	_____	

THANK YOU.

SECTION V: To be filled out by the **RECEPTIONIST or TECHNICIAN** at the X-ray's **ORIGINATING CLINIC** at the time of receipt of the X-ray report (if films were sent outside for interpretation).

17. TIME interpretation report received at originating clinic

hour minute	month	day	year
/ / / /	/ /	/ /	/ /
(47–48) (49–50)	(51–52)	(53–54)	(55–56)
(24-hour clock, e.g., 1645)	(Date, e.g., 09/23/81)		

THANK YOU.

SECTION VI: To be filled out by the **ATTENDING PHYSICIAN** at the time of X-ray interpretation report receipt.

18. TIME interpretation report reviewed by attending physician:
hour minute / month / day / year
/ / / / (57–58) (59–60) / / / (61–62) / / (63–64) / / (65–66)
(24-hour clock, e.g., 1645) (Date, e.g., 09/23/81)

19. Did the radiologist communicate his interpretation to you verbally? (67)
Yes (1) _____
No (2) _____

20. If yes, at what time?
hour minute / month / day / year
/ / / / (68–69) (70–71) / / (72–73) / / (74–75) / / (76–77) (80–1)
(24-hour clock, e.g., 1645) (Date, e.g., 09/23/81)
(1–4)

21. If yes, by what method?
Oral/personal (1) _____ (5)
Telephone (2) _____

22. How did the radiologist's report (written or oral) affect your handling of this case; (6)
No effect. Merely duplicated your own findings. _____ (1) _____
Some effect. Increased your confidence in your interpretation _____ (2) _____
Some effect. Altered your opinion but did not alter course of patient treatment and/or disposition. _____ (3) _____
Major effect. Altered course of patient treatment and/or disposition. _____ (4) _____
Major effect. Caused recall of patient to reaffirm clinical impression. _____ (5) _____

23. Disposition of patient: (7)
Disposition already made. _____ (1) _____
Wait at clinic for other reasons. _____ (2) _____
Discharged. Return to normal activities _____ (3) _____
Discharged. Stay at home. _____ (4) _____
Referred to another facility. _____ (5) _____
Admitted for treatment or observation. _____ (6) _____
Return to ward. _____ (7) _____

24. If you had received the radiologist's report on the day of the X-ray exam, do you feel that patient treatment or disposition would have been altered (presuming that you did not, in fact, receive the report this promptly)? (8)
Yes (1) _____
No (2) _____

If your answer to question 24 was No, please proceed to question 26.

25. If yes, how? _____ _____ (9)
_____ _____ (10)
_____

26. If you had received the radiologist's report within one hour of exam performance, do you feel that patient treatment or disposition would have been altered (presuming that you did not, in fact, receive the report this promptly)? (11)
Yes (1) _____
No (2) _____

If no, please disregard question 27.

27. *If yes, how?*
_____ _____ (12)
_____ _____ (13)
_____

THANK YOU.

ATTENDING PHYSICIAN or P.A. – SECTION VI

Data Collection Instrument Y-1

Time History: X-Ray Request/Report Cycle

A: Film X-Ray Request/Interpretation Report

B: Video Image: Entry/Interpretation

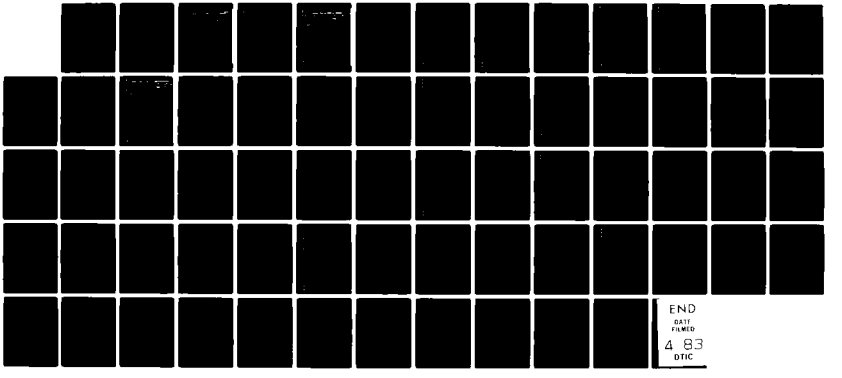
C: Video Image: Interpretation/Transcription

D: Video Image: Interpretation Report

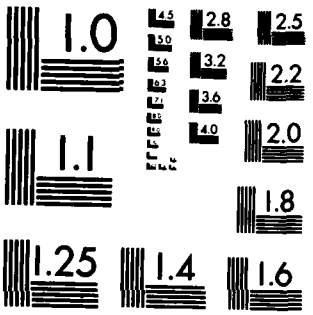
AD-A126 253 FUNCTIONAL EVALUATION OF THE WASHINGTON-AREA TELERADIOLOGY DEMONSTRATION PROJECT(U) LITTLE (ARTHUR D) INC CAMBRIDGE MA 29 DEC 82 ADL-86296

2/2

UNCLASSIFIED MDA903-81-C-0209 F/G 6/5 NL



END
DATE FILMED
4 83
DTIC



TIME HISTORY:

X-RAY REQUEST/REPORT CYCLE

Arthur D. Little, Inc., has been commissioned by the TRIMIS Program Office to evaluate impacts of the TELERADIOLOGY system on the X-ray service provided in several clinics in the Washington, D.C. area.

As part of the evaluation, we are asking staff to complete the various sections of the attached form, as it follows the X-ray request from initiation to final report receipt.

THANK YOU.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

2. What is the reason for this X-ray examination?
(16)

(1) ___ *Routine physical examination.*
(2) ___ *For the record: diagnostic, but not expected to affect patient's immediate disposition.*
(3) ___ *Diagnostic: expected to influence patient's immediate disposition.*
(4) ___ *Follow-up.*

Please note presenting symptoms or provisional diagnosis:

3. Is this X-ray exam associated with trauma?
(17)

(1) ___ Yes.
(2) ___ No.

4. Given that the option existed of having these films interpreted by a radiologist *within one hour* of exam performance, would you feel that such a prompt reading would be:
(18)

(1) ___ *Not significant.* Would not affect patient's treatment or immediate disposition.
(2) ___ *Somewhat significant.* Unlikely to affect patient's treatment or immediate disposition, but likely to increase your diagnostic confidence.
(3) ___ *Significant.* Likely to affect your opinions and/or decisions regarding patient care and/or disposition.
(4) ___ *Very significant.* Essential to your decisions regarding patient care and/or disposition.

5. What are your *immediate* instructions to the patient?
(19)

(1) ___ *Stay in clinic* for attending provider to interpret X-rays.
(2) ___ *Stay in clinic* for Teleradiology interpretation to be received.
(3) ___ *Stay in clinic* for radiologist to interpret X-rays.
(4) ___ *Stay in clinic* for reasons other than X-ray interpretation.
(5) ___ *Leave clinic.* Return to normal activities.
(6) ___ *Leave clinic.* Do not return to normal activities.
(7) ___ *Leave clinic.* Go to another medical facility.
(8) ___ *Be admitted* to ward for treatment or observation.
(9) ___ *Return to ward.*
(0) ___ *Other, specify:*

THANK YOU.

I. PROVIDER: At time of X-RAY REQUEST

SECTION II: to be filled out by TECHNICIAN at time of X-RAY REQUEST RECEIPT

6. Patient's Name _____

7. Status: (17)

(1) ___ Inpatient
(2) ___ Outpatient
(3) ___ Emergency

7a. Category of patient (check category if available)

(4) ___ Sponsor (20)
(5) ___ Child of sponsor (01-19)
(6) ___ Spouse of sponsor (30)
(7) ___ Parents of sponsor (40,45,50,55)
(8) ___ Other bonified personnel (66)
(9) ___ Civilian emergency (98)
(0) ___ Other or CVCHC

8. Exam type(s) requested (e.g., skull, abdomen, chest) (18-22)

(1) ___ 1. _____
(2) ___ 2. _____
(3) ___ 3. _____
(4) ___ 4. _____
(5) ___ 5. _____

official use only

	TIME	DATE month	day	
9. TIME X-ray *request received* in X-ray department:	⌊⌊⌊⌊	⌊⌊	⌊⌊	(23-30)
10. TIME *patient checked in* to X-ray department:	(24-hour clock, e.g., 1645)	(e.g., 0 6	0 5)	
11. TIME X-ray exam(s) *begun*:	⌊⌊⌊⌊	⌊⌊	⌊⌊	(31-38)
12. TIME X-ray exam(s) *completed, processed,* and *patient released* from X-ray department:	⌊⌊⌊⌊	⌊⌊	⌊⌊	(39-46)
	⌊⌊⌊⌊	⌊⌊	⌊⌊	(47-54)

13. Is this a NEW patient? (55)

(1) ___ Yes.
(2) ___ No.

14. If this is NOT a new patient, how many pertinent old *films* are available (i.e., relatively recent films of the same area of the body)? (56)

(0) ___ none
(1) ___ one
(2) ___ two
(3) ___ three
(4) ___ four
(5) ___ five
(6) ___ six to ten
(7) ___ eleven to fifteen
(8) ___ sixteen to twenty
(9) ___ more than twenty

	TIME	DATE month	day	
15. TIME films ready for interpretation:	⌊⌊⌊⌊	⌊⌊	⌊⌊	(57-64)
	(24-hour clock, e.g., 1645)	(e.g., 0 6	0 5)	

THANK YOU.

II. TECHNICIAN: At time of REQUEST RECEIPT

[illegible]

(1) ___ No effect on impression.

(2) ___ Minor effect: Increased confidence in clinical impression.

(3) ___ Some effect: Altered clinical impression, but did not alter patient treatment and/or disposition.

(4) ___ Major effect: altered patient treatment and/or disposition.

15. What are your instructions to the patient now?

(1) ___ *Stay in clinic* for Teleradiology interpretation to be received.

(2) ___ *Stay in clinic* for radiologist to interpret X-rays.

(3) ___ *Stay in clinic* for reasons other than X-ray interpretation.

(4) ___ *Leave clinic.* Return to normal activities.

(5) ___ *Leave clinic.* Do not return to normal activities.

(6) ___ *Leave clinic.* Go to another medical facility.

(7) ___ *Be admitted* to ward for treatment or observation.

(8) ___ *Return to ward.*

(9) ___ *No further instructions* are necessary, as patient did not stay in clinic for X-rays to be reviewed.

(0) ___ Other, specify:

THANK YOU

II. PROVIDER: At time of FILM REVIEW

SECTION IV: to be filled out by TECHNICIAN or TELERADIOLOGY SYSTEM OPERATOR at time of TELERADIOLOGY ENTRY

19. Teleradiology number: (1-10) ⌊⌊⌊⌊⌊⌊⌋⌋⌋⌋⌋⌋

20. We are interested in knowing what you have input into the Teleradiology system for this case. Please note the number of films (OLD and NEW) and the number of images (of films *OLD and NEW*):

number of OLD FILMS (11-12) ⌊⌊⌋⌋ number of IMAGES of OLD FILMS (15-16) ⌊⌊⌋⌋

number of NEW FILMS (13-14) ⌊⌊⌋⌋ number of IMAGES of NEW FILMS (17-18) ⌊⌊⌋⌋

21. Is this case being entered as a PRIORITY case? (19)

(1) ___ Yes

(2) ___ No

THANK YOU.

IV. TECHNICIAN OR TELERADIOLOGY SYSTEM OPERATOR: At time of TELERADIOLOGY ENTRY

(If film is entered into system)

SECTION V: to be filled out by RECEPTIONIST at time of FILM RECEIPT

22. TIME films received at Medical Center for interpretation:

TIME	DATE		
	month	day	(26-27)
☐☐☐☐	☐☐	☐☐	
(24-hour clock, e.g., 1645)	(e.g., 0 6	0 5)	

THANK YOU.

V. RECEPTIONIST AT MEDICAL CENTER: At time of FILM RECEIPT (MGMC and NNMC only)

SECTION VI: to be filled out by RADIOLOGIST at time of FILM INTERPRETATION

20. TIME interpretation of films begun:

TIME (24-hour clock, e.g., 1845) ____

DATE month day (m-d) (e.g., 0 6 0 5) ____

21. How many OLD films did you use for comparison in this interpretation? (m)

(0) ___ none
(1) ___ one
(2) ___ two
(3) ___ three
(4) ___ four
(5) ___ five
(6) ___ six to ten
(7) ___ eleven to fifteen
(8) ___ sixteen to twenty
(9) ___ more than twenty

22. Location of radiologist: (m)

(1) ___ Bethesda NNMC
(2) ___ Ft. Detrick
(3) ___ Malcolm Grow MC
(4) ___ Patuxent NATC
(5) ___ University of Virginia MC
(6) ___ Other

THANK YOU.

SECTION VII: to be filled out by TRANSCRIPTIONIST at time of REPORT TRANSCRIPTION (if report is transcribed)

	TIME	DATE	
		month day	
28. TIME typing of X-ray report begun:	☐☐☐☐	☐☐ ☐☐	(38-46)
	(24-hour clock, e.g., 1645)	(e.g., 0 6 0 5)	
7. TIME report ready for radiologist review	☐☐☐☐	☐☐ ☐☐	(46-53)

THANK YOU.

VII. TRANSCRIPTIONIST: At time of REPORT TRANSCRIPTION (if report is transcribed)

SECTION VIII: to be filled out by RADIOLOGIST at time of REPORT SIGNING (If report is signed)

28. TIME report signed by radiologist:

TIME	DATE		
	month	day	(54-61)
⌊⌋⌊⌋⌊⌋⌊⌋	⌊⌋⌊⌋	⌊⌋⌊⌋	
(24-hour clock, e.g., 1645)	(e.g., 0 6	0 5)	

HANK YOU.

VIII. RADIOLOGIST: At time of REPORT SIGNING (If report is signed)

SECTION III: to be filled out by PROVIDER at time of FILM INTERPRETATION RECEIPT

Time report received by referring provider:

	TIME	DATE month	day	year
	(24-hour clock, e.g. 1640)	e.g. [illegible]	[illegible]	

30. How does the radiologist's report affect your handling of this case?
(70)

(1) ___ *No effect.* Merely duplicated your own findings.
(2) ___ *Some effect.* Increased your confidence in your interpretation.
(3) ___ *Some effect.* Altered your opinion but did not alter course of patient treatment and/or disposition.
(4) ___ *Major effect.* Altered course of patient treatment and/or disposition.
(5) ___ *Major effect.* Caused recall of patient to reaffirm clinical impression.

31. Did the radiologist communicate his interpretation to you verbally?
(71)

(1) ___ Yes
(2) ___ No *(If NO, please skip to question # 38)*

32. If Yes, by what method?
(72)

(1) ___ Oral/Personal
(2) ___ Telephone

33. If Yes, at what TIME?

TIME	DATE month	day	(73-80)

(1-4) Official Use Only

34. What are your instructions to the patient now?
(5)

(1) ___ *Stay in clinic* for further tests, treatment or observation.
(2) ___ *Leave clinic.* Return to normal activities.
(3) ___ *Leave clinic.* Do not return to normal activities.
(4) ___ *Leave clinic.* Go to another medical facility.
(5) ___ *Be admitted* to ward for treatment or observation.
(6) ___ *Return to ward.*
(7) ___ *No further instructions are necessary*, as patient did not stay in clinic for radiologist's interpretation to be received.
(8) ___ *Other, specify:*

35. If you had received a radiologist's report (by Teleradiology or by film interpretation) *on the day of the X-ray exam*, do you feel that patient treatment or disposition would have been altered?
(6)

(1) ___ Yes
(2) ___ No

If you did receive the report this promptly, please note here:
(7)

36. If you had received a radiologist's report (by Teleradiology or by film interpretation) *within one hour of exam performance*, do you feel that patient treatment or disposition would have been altered?
(8)

(1) ___ Yes
(2) ___ No

If you did receive the report this promptly, please note here:
(9)

THANK YOU.

TELERADIOLOGY

/ / / / /
(1-4)

Case No. / / / / / /- / /
(5-10)

PATIENT NAME _____

AGE / / /
(11-12)

SEX / / F=1 M=2
(13)

Hx

/ / / /
(14-16)

	TIME		DATE	
TIME ENTERED:	/ / /	/ / /	/ / / / /	(17-24)
TIME SENT:	/ / /	/ / /	/ / / / /	(25-32)
TIME VIEWED:	/ / /	/ / /	/ / / / /	(33-40)

(1-4)
Official Use Only

TIME HISTORY: TELERADIOLOGY

INTERPRETATION AND TRANSCRIPTION

Arthur D. Little, Inc., has been commissioned by the TRIMIS Program Office to evaluate impacts of the TELERADIOLOGY system on the X-ray service provided in several clinics in the Washington, D.C. area.

As part of this evaluation, we are asking staff to complete the two sections of this form.

SECTION I: to be filled out by the RADIOLOGIST at the time of INTERPRETATION OF TELERADIOLOGY IMAGES

1. Teleradiology case number (5-10)

2. How many IMAGES of OLD films did you use for comparison in this interpretation?
(11)

(0) ___ none
(1) ___ one
(2) ___ two
(3) ___ three
(4) ___ four
(5) ___ five
(6) ___ six to ten
(7) ___ eleven to fifteen
(8) ___ sixteen to twenty
(9) ___ more than twenty

3. How many IMAGES of NEW films did you use in this interpretation?
(12)

(1) ___ one
(2) ___ two
(3) ___ three
(4) ___ four
(5) ___ five
(6) ___ six to ten
(7) ___ eleven to fifteen
(8) ___ sixteen to twenty
(9) ___ more than twenty

THANK YOU.

I. RADIOLOGIST when INTERPRETING TELERADIOLOGY IMAGES

SECTION II: to be completed by TRANSCRIPTIONIST at time of TRANSCRIPTION and by TELERADIOLOGY WORDPROCESSOR at time of TRANSMITTING REPORT

	TIME	DATE	
		month	day
4. TIME typing of Teleradiology report begun	⌊⌋⌊⌋⌊⌋⌊⌋ (24-hour clock, e.g., 1645)	⌊⌋⌊⌋ (e.g., 0 6	⌊⌋⌊⌋ 0 5) (13-20)
5. TIME report transmitted to originating facility	⌊⌋⌊⌋⌊⌋⌊⌋	⌊⌋⌊⌋	⌊⌋⌊⌋ (21-28)

THANK YOU.

II. TRANSCRIPTIONIST (and WORDPROCESSOR OPERATOR) when TRANSCRIBING and TRANSMITTING REPORT

(1-4)

Official Use Only

TIME HISTORY: TELERADIOLOGY

INTERPRETATION REPOI

SECTION I: to be filled out by TECHNICIAN or TELERADIOLOGY SYSTEM OPERATOR at time of RECEIPT OF TELERADIOLOGY INTERPRETATION REPORT

1. Patient Name _____

Teleradiology case number (5-10)

2. TIME Teleradiology report ready for distribution to provider

TIME	DATE		
	month	day	(11-18)
(24-hour clock, e.g., 1645)	(e.g., 0 6	0 5)	

THANK YOU.

I. TECHNICIAN or TELERADIOLOGY SYSTEM OPERATOR

[redacted]

[redacted]

[redacted]

[redacted]

(0) ___ *No effect* because received after or coincident with film interpretation.
(1) ___ *No effect* as inconclusive for other reasons.
(2) ___ *Some effect:* increased confidence in clinical impression.
(3) ___ *Some effect:* altered clinical impression, but did not alter patient treatment and/or disposition.
(4) ___ *Major effect:* altered patient treatment and/or disposition.
(5) ___ *Major effect:* caused recall of patient to reaffirm clinical impression.

What are your instructions to the patient now?
(m)

(1) ___ *Stay in clinic* for radiologist to interpret X-rays.
(2) ___ *Stay in clinic* for reasons other than X-ray interpretation. Please specify reason:

(3) ___ *Leave clinic.* Return to normal activities.
(4) ___ *Leave clinic.* Do not return to normal activities.
(5) ___ *Leave clinic.* Go to another medical facility.
(6) ___ *Be admitted* to ward for treatment or observation.
(7) ___ *Return to ward.*
(8) ___ *No further instructions are necessary,* as patient did not stay in clinic for Teleradiology interpretation to be received.
(9) ___ *Other,* specify:

THANK YOU.

[redacted]

II. PROVIDER at time of TELERADIOLOGY REPORT RECEIPT

Data Collection Instrument X-2

COST DATA COLLECTION FORM

Facility: _____ Date: / / / - / / / - / / /

Surveyor: _____

PERSONNEL -

TECHNOLOGISTS: # ☐

Pay Grade

1. _____
2. _____
3. _____
4. _____
5. _____

RADIOLOGISTS: # ☐

Pay Grade

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

SECRETARY/
TRANSCRIPTIONIST: # ☐

	Pay Grade
1.	
2.	
3.	
4.	
5.	

DRIVER: # ☐

	Pay Grade
1.	
2.	

CAPITAL EXPENSE:

EQUIPMENT:

	Type	Age	Cost
1.			
2.			
3.			
4.			
5.			

SPACE (ft^2):

	Cost
X-Ray	
Total Facility	

SUPPLIES:

FILM:

Type	Quantity	Period	Cost

PROCESSING SUPPLIES:

	Type	Quantity	Period	Cost
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

MAINTENANCE:

MACHINES:

	Contract	Period	Cost
1.			
2.			
3.			
4.			
5.			

SPACE (ft^2)

TRANSPORTATION:

	Vehicle	Purpose	Cost
Of Radiologist			
Of X-Rays			
Of Reports			

TELEPHONE COMMUNICATIONS:

Cost/min to central facility: _____

PATIENTS:

	Rank	Pay Grade
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Data Collection Instrument Y-2

COST DATA COLLECTION FORM

FACILITY: _____ DATE: / / / / / / / / / / / /
Month Day Year

SURVEYOR: _____

PERSONNEL:

TECHNOLOGISTS: # ☐

PAY GRADE

1. _____
2. _____
3. _____
4. _____
5. _____

RADIOLOGISTS: # ☐

PAY GRADE

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

TELERADIOLOGY
SYSTEM OPERATOR # ☐

PAY GRADE

1. _____
2. _____

SECRETARY/
TRANSCRIPTIONIST: # ☐

PAY GRADE

1. _____
2. _____
3. _____
4. _____
5. _____

DRIVER: # ☐

PAY GRADE

1. _____
2. _____

CAPITAL EXPENSE:

EQUIPMENT:

	TYPE	AGE	COST
1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____
4.	_____	_____	_____
5.	_____	_____	_____

SPACE (ft^2):

	COST
X-Ray	_____
Total Facility	_____

SUPPLIES:

FILM:

Type	Quantity	Period	Cost

PROCESSING SUPPLIES:

	Type	Quantity	Period	Cost
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

MAINTENANCE:

MACHINES:

	Contract	Period	Cost
1.			
2.			
3.			
4.			
5.			

SPACE (ft^2):

TRANSPORTATION:

	Vehicle	Purpose	Cost
of Radiologist			
of X-Rays			
of Reports			

TELEPHONE COMMUNICATIONS:

Cost/min to central facility: _____

PATIENTS:

	Rank	Pay Grade
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

COST OF TELERADIOLOGY SYSTEM:

Equipment _____

Operations _____

Personnel _____

Data Collection Instrument X-3

WORK ANALYSIS FOR EACH X-RAY TECHNOLOGIST AND
FOR OTHER RELEVANT PERSONNEL INDIVIDUALLY

Facility:_____ Date: / / / - / / / - / / /
Month Day Year

Individual:_____ Surveyor:_____

Time (24 hr clock)	ACTIVITY						
	Performing X-Ray Exams	Processing X-Rays	Filing X-Rays	Retrieving X-Rays	Paper Work	Preparing X-Rays for Dispatch	Non-Related Activities

Data Collection Instrument Y-3-A

WORK ANALYSIS FOR EACH X-RAY TECHNOLOGIST
SECRETARY AND TELERADIOLOGY SYSTEM OPERATOR INDIVIDUALLY
(5 minute intervals)

Facility: _____ Date: / / / - / / / - / / /
Month Day Year

Individual: _____ Surveyor: _____

ACTIVITY

Time (24 hr clock)	Performing X-Ray Exams	Processing X-Rays	Filing X-Rays	Retrieving X-Rays	Paper Work	Preparing X-Rays for Dispatch	Teleradiology System/Operation	Non-Related Activities

Data Collection Instrument Y-3-B

WORK ANALYSIS FOR EACH
TELERADIOLOGY SYSTEM OPERATOR INDIVIDUALLY
(1 minute intervals)

FACILITY: _____ DATE: / / / - / / / - / / /
Month Day Year

INDIVIDUAL: _____ SURVEYOR: _____

Time (24-hr clock)	ACTIVITY				
	Lightbox/ Camera Operation	CRT Keyboard Operation	Waiting Between Stages of Case Entry	Report printer Activities and Report Logging	Non-Related Activities

Data Collection Instrument X-4

RADIOLOGIST: X-RAY INTERPRETATION TIME STUDY

Arthur D. Little, Inc., has been commissioned by the TRIMIS Program Office to evaluate the *TELERADIOLOGY* system soon to be installed in several clinics in the Washington, D.C. area. This form constitutes one part of our evaluation. It is designed to measure the length of time needed to perform X-Ray interpretations. It has been suggested that interpretation time may differ between when using the standard mode of viewing films and when using teleradiology. Our goal is, to measure the average time needed for interpretation of an X-Ray from one of these clinics. We are requesting that you complete this form after you have read each batch of X-Rays. (We will make a similar request of radiologists who are reading teleradiographs.)

THANK YOU.

DATE: ___/___/___ ___/___/___ ___/___/___
(5-6) (7-8) (9-10)
Month Day Year

INTERPRETATION FACILITY: (11)

Bethesda NMC	(1)	_____
Ft. Detrick Hospital	(2)	_____
Malcolm Grow MC	(3)	_____
Patuxent NATC	(4)	_____
University of Virginia MC	(5)	_____
_____	(6)	_____

SATELLITE FACILITY: (12)

Bolling AFB Clinic	(1)	_____
Central Virginia CHC	(2)	_____
Ft. Detrick Hospital	(3)	_____
Patuxent NATC	(4)	_____

NUMBER OF PATIENTS: Patients _____ (13-15)

NUMBER OF EXAMS: Exams _____ (16-18)

NUMBER OF FILMS: Films _____ (19-21)

TOTAL TIME TO COMPLETE READINGS: Minutes _____ (22-24)

COMMENTS: (e.g., Is there anything that made this batch of X-rays unusual -- taking more or less time than usual?) (25-26)

_____

_____

_____

Data Collection Instrument Y-4

RADIOLOGIST: TELERADIOLOGY IMAGE INTERPRETATION TIME STUDY

DATE: / / / / / / / / /
Month Day Year

TIME OF FIRST VIEWING: / / / / /

TIME OF FINAL VIEWING: / / / / /

Total Time _____

NUMBER OF PATIENTS: _____

NUMBER OF EXAMS: _____

NUMBER OF IMAGES: _____

ORIGIN OF EXAMS:

___ Patuxent NAS Hospital

___ Bolling AFB Clinic

___ CVCHC

___ Ft. Detrick Army Clinic

/ / /
Facility No.
(1-2)

Data Collection Instrument Y-5

/ / / /
Control No.
(3-5)

PROVIDER QUESTIONNAIRE
TELERADIOLOGY STUDY

Confidentiality Statement - Please answer all items as accurately and honestly as possible. All information you supply will be held in strict confidence. Only statistical summaries will be made available for publication.

1. In what year did you graduate from professional school? / / / / /
(6-9)

2a. What is your position in relationship to the facility? (check one)
(10)

(1) ____ Physician, facility staff
(2) ____ Physician, private practice
(3) ____ Physician, academic medicine
(4) ____ Physician's Assistant
(5) ____ Nurse Practitioner
(6) ____ Other, specify _____

2b. Is this relationship: (check one)
(11)

(1) ____ Full-time
(2) ____ Part-time

3. What is your primary specialty? (e.g. Internal Medicine, Cardiology)
Please be as specific as possible:
(12)

_____

4. Approximately what percent of your total professional working time do you spend in:

/ / / /% Direct Patient Care
(13-15)

/ / / /% Administration
(16-18)

/ / / /% Research
(19-21)

/ / / /% Teaching
(22-24)

/ / / /% Other, specify _____
(25-27)

5. On the average, how many X-ray examinations do you usually request <u>during a week</u> from your facility's radiology service?

/ / / /
(28-30)

6. What percent of X-ray examinations do you request for:

/ / / /% Diagnosis
(31-33)

/ / / /% Treatment
(34-36)

/ / / /% Disposition
(37-39)

/ / / /% Follow-up
(40-42)

/ / / /% Other, specify _____
(43-45)

7. Do you read the radiologist's report on X-ray examinations you request? (check one)
(46)

(1) ____ All of the time

(2) ____ Most of the time

(3) ____ Occasionally

(4) ____ Never

8. For interpretation of X-rays do you: (check one)
(47)

(1) ____ Primarily depend on the radiologist's interpretation

(2) ____ Primarily depend on your own interpretation

(3) ____ Develop your own interpretation in consultation with the radiologist.

9. For approximately what percent of X-ray examinations you request, do you find it necessary to consult with a radiologist?

/ / / /%
(48-50)

10. For what reasons do you consult with a radiologist? (check all responses that you find appropriate)

____ (51) To consult in advance regarding the need for an X-ray examination

____ (52) To discuss X-ray films

____ (53) To clarify items in the radiology report

____ (54) To ask about information that was not included in the report

____ (55) To determine the need for further X-ray examinations

____ (56-57) Other, specify: _____

_____

_____

11. In general do you prefer radiology reports that (check one)
(58)

(1) ____ Give a detailed description of all findings

(2) ____ Give only a concise summary of summary findings

(3) ____ Other, specify: _____

(4) _____

_____

12. Do you prefer radiology reports that make recommendations for follow-up or further examinations?
(59)

(1) ____ Yes

(2) ____ No

13. What is the greatest shortcoming of your facility's radiology service now that teleradiology is installed and functioning properly (since April, 1982)
(60)

(1) ____ Non-availability of radiologists

(2) ____ Delayed X-ray reporting

(3) ____ Inability to obtain patient X-ray films

(4) ____ Other, specify

(5) ____ Don't know

14a. How many times per month do you experience the following problems associated with radiology services now that Teleradiology is installed and functioning properly (since April, 1982)

Problems		Number of Occurences				
		None	1-4	5-9	10 or more	Dont Know
Delays in reciving X-ray reports	(61)	(1)	(2)	(3)	(4)	(5)
Delays in receiving reports that resulted in delaying patient management	(62)	(1)	(2)	(3)	(4)	(5)
Delays in finding X-ray films	(63)	(1)	(2)	(3)	(4)	(5)
Delays in finding films that resulted in delaying patient management	(64)	(1)	(2)	(3)	(4)	(5)

14b. Do you feel that the following problems are experienced with different frequency now versus prior to Teleradiology?

		Much more frequently now	Slightly more frequently now	With the same frequency now	Slightly less frequency now	Much less frequency now	Dont know
Delays in receiving X-ray reports:	(65)	(1)	(2)	(3)	(4)	(5)	(6)
Delays in receiving reports that result in delaying patient management:	(66)	(1)	(2)	(3)	(4)	(5)	(6)
Delays in finding X-ray films:	(67)	(1)	(2)	(3)	(4)	(5)	(6)
Delays in finding X-ray films that result in delaying patient management:	(68)	(1)	(2)	(3)	(4)	(5)	(6)

15a. During the past three months (since Teleradiology has been installed and functioning properly), have you ever had to re-order the same X-ray examination because of a problem in the reporting service?
(69)

(1) ____ Yes

(2) ____ No

If yes, how many times?

/ / /
(70-71)

If yes, for what reason(s):

(72) _____

_____

(73) _____

_____

15b. Do you feel that since Teleradiology installation there has been a change in the frequency with which you have to re-order the same X-ray examination because of a problem in the reporting service?
(74)

(1) ____ reorder much more frequently now

(2) ____ reorder slightly more frequently now

(3) ____ reorder with the same frequency now

(4) ____ reorder slightly less frequently now

(5) ____ reorder much less frequently now

(6) ____ don't know

16a. During the past three months (since Teleradiology has been installed and functioning properly) have you ever had to re-order the same X-ray examination because of a problem in locating previous X-ray films?
(75)

(1) ____ Yes

(2) ____ No

If yes, how many times?

/ / /
(76-77)

If yes, for what reason(s):

(78) _____

_____

(79) _____

_____

/ / / / / /
(1-5)

16b. Do you feel that since Teleradiology installation there has been a change in the frequency with which you have to reorder the same X-ray examination because of a problem in locating previous X-ray films?
(6)

(1) ____ reorder much more frequently now

(2) ____ reorder somewhat more frequently now

(3) ____ reorder with the same frequency

(4) ____ reorder slightly less frequently now

(5) ____ reorder much less frequently now

(6) ____ don't know

17a. Please rate your facility's radiology service since Teleradiology on each of the following:

		Excellent	Good	Adequate	Poor	Very Poor
Scheduling of patients	(7)	(1)	(2)	(3)	(4)	(5)
Timeliness of reports	(8)	(1)	(2)	(3)	(4)	(5)
Comprehensiveness of reports	(9)	(1)	(2)	(3)	(4)	(5)
Accuracy of reports	(10)	(1)	(2)	(3)	(4)	(5)
Readability of reports	(11)	(1)	(2)	(3)	(4)	(5)
Availability of reports	(12)	(1)	(2)	(3)	(4)	(5)
Cooperativeness of staff	(13)	(1)	(2)	(3)	(4)	(5)
Ability of staff	(14)	(1)	(2)	(3)	(4)	(5)
Availability of X-ray films	(15)	(1)	(2)	(3)	(4)	(5)

17b. Please note whether you feel that the following aspects of your facility's radiology service are different now versus prior to Teleradiology.

	Much better now	Slightly better now	The same	Slightly worse now	Much worse now	Dont know
Scheduling of patients (16)	___ (1)	___ (2)	___ (3)	___ (4)	___ (5)	___ (6)
Timeliness of reports (17)	___ (1)	___ (2)	___ (3)	___ (4)	___ (5)	___ (6)
Comprehensiveness of reports (18)	___ (1)	___ (2)	___ (3)	___ (4)	___ (5)	___ (6)
Accuracy of reports (19)	___ (1)	___ (2)	___ (3)	___ (4)	___ (5)	___ (6)
Readability of reports (20)	___ (1)	___ (2)	___ (3)	___ (4)	___ (5)	___ (6)
Availability of reports (21)	___ (1)	___ (2)	___ (3)	___ (4)	___ (5)	___ (6)
Ability of staff (22)	___ (1)	___ (2)	___ (3)	___ (4)	___ (5)	___ (6)
Availability of X-ray films (23)	___ (1)	___ (2)	___ (3)	___ (4)	___ (5)	___ (6)

18. Are you aware of the existence of Teleradiology in your facility?
(34)

(1) ____ Yes, very much so

(2) ____ Yes, vaguely

(3) ____ No

19. Do you feel that Teleradiology has improved radiology services in your facility?
(35)

(1) ____ Yes, definitely

(2) ____ Yes, somewhat

(3) ____ No improvement

(4) ____ No; it has aggravated or created problems

(5) ____ No opinion

20. Comments
(36-37)

Your signature is optional

Data Collection Instrument Y-6

RADIOLOGIST'S COMMENTS ON TELERADIOLOGY SYSTEM

1. Name:

2. Business Address:

3. Telephone Number:

4. Year of Graduation from Medical School:

5. Board Certification in Diagnostic Radiology:

   No: _____

   Yes: _____ Year: _____

6. Sub-Speciality in Radiology:

7. Current Type of Practice:

   _____ Academic

   _____ Military

   _____ Private

   _____ Combination, specify

   _____ Other, specify

8. Percent of Time Spent In:

____% Direct Patient Care

____% Administration

____% Research

____% Teaching

____% Other, specify

9. How many Teleradiology image interpretation sessions have you participated in at Malcolm Grow Medical Center?

10. About how many x-ray examinations have you interpreted from the video displays?

11. Please provide your opinion of the following aspects of the Teleradiology system:

a. Ease of orientation:

b. Ease of use, particularly accessing cases and adjusting contrast and brightness:

c. Technical quality of images received:

d. Adequacy of resolution:

e. Compared with film, what is the effect of viewing video images on the accuracy of findings and impressions?

f. Compared with film, what is the effect of viewing video images on your confidence of interpretations?

12. What do you like best about the Teleradiology system?

13. What do you like least about the Teleradiology system?

14. How would you improve the Teleradiology system?

15. Do you feel that the Teleradiology system, in its present form, should be used to provide radiological interpretations to remote clinics and hospitals that do not have radiologists readily available?

16. Do you feel that the Teleradiology system should be used in other settings? If so, what kinds?

17. Additional Comments:

Signature _____ Date _____

Data Collection Instrument Y-7

INTERVIEW GUIDE
FOR INDIVIDUALS DIRECTLY INVOLVED WITH THE
TELERADIOLOGY SYSTEM

FACILITY: _____

INTERVIEWEE: _____

TITLE: _____

What is your position relative to the Teleradiology project?

How long have you been involved with the Teleradiology project?

Please describe your responsibilities in relation to the project:

Please comment on the Teleradiology system's performance:

How well has it worked?

How easy is it to use?

Does it produce interpretation reports which are adequately prompt?

In which examination situations is it most useful?

Do you feel that the Teleradiology system has improved/interfered with patient care?

What do you feel are the major strengths of the Teleradiology system?

What do you feel are the major weaknesses of the Teleradiology system?

How would you suggest that the Teleradiology system be improved?

Do you feel that the Teleradiology system should be permanently installed at your facility?

Do you feel that the Teleradiology system should be installed in other facilities? If so, what kind of facilities?

Additional Comments:

APPENDIX B

OPERATING PROCEDURES OF TRANSMITTER SITE X-RAY DEPARTMENTS

OPERATING PROCEDURES OF TRANSMITTER SITE X-RAY DEPARTMENTS

1. BOLLING

A patient is referred to the X-ray department and given an X-ray request/report form by his primary care physician or physician's assistant. He takes the form to the X-ray department and registers there with the X-ray technician. The appropriate examination is performed and the patient leaves the department.

The new films are then set aside with available historical films in the X-ray viewing room, and the primary care provider is notified that they are ready for review (except in the case of chest films associated with routine physical examinations, which the referring provider seldom examines). After the provider has had the opportunity to view the films, the patient's complete X-ray folder is placed in a cardboard box in the viewing room, with the X-ray request/report from clipped to it.

Each morning a courier from MGMC collects the folders from the cardboard box and takes them back to MGMC. The films are interpreted at some point during the next day or two by a radiologist in the radiology department at MGMC. The interpretations are dictated and the reports are typed.

After being reviewed, the completed X-ray request/report forms and the folders of films are sent via the morning courier back to the Bolling. The X-ray technician there files the film folder and places the completed X-ray request/report form in the referring primary care provider's mail box.

During the teleradiology field trial, X-ray exams were always held to be input into the system before they were sent to MGMC. Teleradiology interpretataion reports were placed in the referring providers' mail boxes upon receipt from the word processor printer.

2. DETRICK

A patient is referred to the X-ray department and given an X-ray request/report form by his physician at the Detrick clinic or inpatient ward, or by a nurse at the Litton Bionetics installation on-base. He takes the form to the X-ray department and registers there with either the receptionist/secretary or an X-ray technician. The appropriate examination is performed or scheduled and the patient leaves the department.

On Tuesdays, Wednesdays, and Fridays, (i.e., when no radiology resident is at the clinic), the new files and available historical films are brought by the X-ray technician to the referring physician's office (or, during off-hours, to the referring physician in the inpatient ward). After the physician has reviewed the new and historical films, the patient's complete X-ray folder, with X-ray request/report form, is placed on a table in the X-ray viewing room to await the radiologist's arrival.[14]

On Mondays and Thursdays each week, one of a group of radiology residents from WRAMC works at Detrick X-ray department from 0900 until 1300 or 1400. While he is there, the X-ray department is much busier than on other days: contrast studies and fluoroscopic exams are performed, as well as the more routine X-rays. All films that are taken while the resident is on-site are brought directly to him and interpreted as they are taken. During the resident's stay, he also interprets all other examinations that have been performed since his last visit. He writes or dictates the interpretation reports. If dictated, these reports are later typed by the receptionist/secretary of the department or by one of the radiology technicians. Reports are delivered to the referring providers and the X-ray folders are filed by X-ray department staff.

---

[14] In the case of examinations requested by Litton Bionetics, the patient's complete X-ray folder is placed in the viewing room directly after the examination is performed.

During the field trial, X-ray exams were input into the system at a convenient time after they were performed: this was sometimes before and sometimes after the film interpretation had been performed. During the first half of the field trial, teleradiology interpretation reports were not delivered to referring providers, but merely filed in the X-ray film folders. Later on in the trial, each batch of teleradiology interpretation reports which was received on the word processor printer were delivered in batch to the senior physician in the clinic and after his review were filed in the film folders.

3. PATUXENT

A patient is referred to the X-ray department and given an X-ray request/report form by his physician, nurse practitioner, or physician's assistant. He takes the form to the X-ray department and registers with an X-ray technician there. The appropriate examination is performed or scheduled.

During weeks when no radiology resident is at the hospital, the patient, after examination, leaves the X-ray department and takes his new films, appropriate historical films, and the X-ray request/report form to his referring provider. The provider examines the films and, later on, sends the entire folder back to the X-ray department. The film folder is placed in a box in the X-ray reading room. Three mornings each week, this box is sent by courier to NNMC in Bethesda.

At some point during the next few days, the X-rays are read by medical students and interns at NNMC under the supervision of a radiologist, and an interpretation report is written. The film folder and the completed request/report form are returned to the X-ray department at Patuxent via the daily courier.

The film folders are filed by the X-ray technician and the interpretation reports are delivered to the referring providers.

Every other week, when one of the radiology residents from NNMC works at Patuxent, films are interpreted as they are performed. Patients leaving the X-ray department after examination usually return to their referring providers with a written interpretation report, as well as their films. Contrast studies and fluoroscopic exams are also performed when the resident is on-site.

During the field trial, exams performed at Patuxent were input into the teleradiology system at a convenient time after they were performed. Inputting sometimes occurred before the films were interpreted at Patuxent or sent to Bethesda and sometimes afterwards. Teleradiology interpretation reports were delivered to referring providers upon receipt.

4. CVCHC

A patient is referred to the X-ray department and given an X-ray request/report form by his primary care physician or nurse practitioner. He takes the form to the X-ray department and registers there either with the radiology technician or with the EKG technician. The appropriate examination is performed and the patient leaves the department.

The referring provider is notified that the films are ready for review; he examines them in the department, making appropriate disposition of the patient. The patient's complete X-ray folder, with new and historical films and the X-ray request/report form is set aside.

Twice each day -- in the morning and in the afternoon -- a driver employed by CVCHC collects the batched folders and takes the X-ray, some laboratory specimens, and some clinic patients to the UVMC. The X-ray examinations are later interpreted by radiologists at UVMC, reports are dictated and typed and, after review, collected by the courier and subsequently brought back with the films to CVCHC.

Upon receipt at CVCHC, the reports are logged in at the X-ray department and distributed to the referring providers; the film folders are filed by the X-ray technician.

During the field trial, X-ray exams performed at CVCHC were always input into the teleradiology system before they were sent to UVMC. Teleradiology interpretation reports were delivered to referring providers upon receipt.

APPENDIX C

DETAILED RESULTS

TABLE C-1
CHARACTERISTICS OF X-RAY PATIENTS EXAMINED
BY TRANSMITTER SITE
PERIOD X
TELERADIOLOGY FIELD TRIAL

Facility	Age (years) <14	14-45	46-64	65+	TOTAL	Sex (% Male)
Bolling n= 90	14%	77%	9%	0%	100%	58%
Detrick n= 133	15%	63%	19%	3%	100%	55%
Patuxent n= 172	17%	70%	12%	1%	100%	66%
CVCHC n= 58	9%	18%	16%	57%	100%	49%
Mean of Military Sites n= 395	16%	69%	14%	1%	100%	60%

TABLE C-2

CHARACTERISTICS OF X-RAY PATIENTS EXAMINED
BY TRANSMITTER SITE
PERIOD Y
TELERADIOLOGY FIELD TRIAL

Facility	Age (years) <14	14-45	46-64	65+	TOTAL	Sex (% Male)
Bolling						
n= 325	13%	80%	6%	1%	100%	65%
Detrick						
n= 333	10%	65%	20%	5%	100%	57%
Patuxent						
n= 564	13%	72%	13%	2%	100%	67%
CVCHC						
n= 146	7%	24%	25%	44%	100%	50%
Mean of Military Sites						
n= 1222	12%	72%	13%	3%	100%	67%

TABLE C-3

CHARACTERISTICS OF X-RAY EXAMINATIONS PERFORMED
BY TRANSMITTER SITE
PERIOD X
TELERADIOLOGY FIELD TRIAL

Facility	Type of Exam						Reason for Exam					
	Chest	Extremity	Skull	Spine	Abdomen	TOTAL	Routine Physical Exam	For the Record	Diagnostic	Follow-Up	TOTAL	% Trauma
Bolling (n=90 exams)	32%	40%	14%	7%	7%	100%	28%	24%	45%	3%	100%	50%
Detrick (n=133 exams	46%	29%	11%	6%	8%	100%	18%	30%	50%	2%	100%	32%
Patuxent (n=172 exams)	38%	39%	9%	5%	9%	100%	27%	19%	48%	6%	100%	44%
CVCHC (n=58 exams)	42%	28%	9%	7%	14%	100%	7%	12%	78%	3%	100%	24%
Mean of Military Sites (=395 exams)	39%	36%	11%	6%	8%	100%	24%	24%	48%	4%	100%	41%

TABLE C-4

CHARACTERISTICS OF X-RAY EXAMINATIONS PERFORMED
BY TRANSMITTER SITE
PERIOD Y
TELERADIOLOGY FIELD TRIAL

Facility	Type of Exam						Reason for Exam					
	Chest	Extremity	Skull	Spine	Abdomen	TOTAL	Routine Physical Exam	For the Record	Diagnostic	Follow-Up	TOTAL	Trauma
Bolling (n=133 exams)	50%	37%	4%	5%	4%	100%	10%	34%	52%	4%	100%	38%
Detrick (n=142 exams	32%	51%	1%	11%	5%	100%	14%	26%	58%	2%	100%	25%
Patuxent (n=352 exams)	50%	34%	8%	4%	4%	100%	18%	22%	54%	6%	100%	39%
CVCHC (n=66 exams)	45%	44%	0%	5%	6%	100%	7%	2%	89%	2%	100%	32%
Mean of Military Sites (n=627 exams)	46%	38%	6%	6%	4%	100%	15%	26%	55%	4%	100%	34%

TABLE C-5

DISTRIBUTION OF X-RAY EXAMINATIONS
BY CATEGORY AND BY TRANSMITTER SITE
PERIOD X
TELERADIOLOGY FIELD TRIAL

Facility	Category: Routine Physical Exams	Emergency Exams	Diagnostic Exams	For-the-Record and Follow-up Exams	TOTAL
Bolling					
n= 80	10%	60%	12%	18%	100%
Detrick					
n= 112	14%	33%	36%	17%	100%
Patuxent					
n= 169	18%	51%	16%	15%	100%
CVCHC					
n= 57	7%	24%	66%	3%	100%
Mean of Military Sites					
n= 361	14%	48%	21%	17%	100%

TABLE C-6

DISTRIBUTION OF X-RAY EXAMINATIONS PERFORMED
BY CATEGORY AND BY TRANSMITTER SITE
PERIOD Y
TELERADIOLOGY FIELD TRIAL

Facility	Category: Routine Physical Exams	Emergency Exams	Diagnostic Exams	For-the-Record and Follow-up Exams	TOTAL
Bolling					
n= 132	39%	38%	9%	14%	100%
Detrick					
n= 148	17%	25%	20%	38%	100%
Patuxent					
n= 349	28%	39%	16%	17%	100%
CVCHC					
n= 66	5%	32%	36%	27%	100%
Mean of Military Sites					
n= 629	28%	34%	15%	23%	100%

TABLE C-7

DISTRIBUTION OF TOTAL X-RAY VOLUME
BY CATEGORY AND BY AGE AND SEX OF PATIENTS
PERIOD X
TELERADIOLOGY FIELD TRIAL

	Age (years)				Sex	
Category	<14 n=62	14-45 n=269	45-64 n=59	65+ n=39	Male n=257	Female n=172
Routine Physical Exams	3%	18%	7%	5%	16%	9%
Emergency Exams	63%	47%	36%	13%	49%	38%
Diagnostic Exams	18%	21%	36%	77%	20%	39%
For-the-Record and Follow-Up Exams	16%	14%	21%	5%	15%	14%
TOTAL	100%	100%	100%	100%	100%	100%

TABLE C-8

DISTRIBUTION OF TOTAL X-RAY VOLUME
BY CATEGORY AND BY AGE AND SEX OF PATIENTS
PERIOD Y
TELERADIOLOGY FIELD TRIAL

	Age (years)					Sex	
Category	<14 n=44	14-45 n=424	45-64 n=97	65+ n=40	Total n=605	Male n=378	Female n=227
Routine Physical Exams	2%	31%	25%	5%	26%	34%	13%
Emergency Exams	62%	36%	13%	23%	33%	31%	36%
Diagnostic Exams	18%	14%	23%	37%	18%	11%	29%
For-the-Record and Follow-Up Exams	18%	19%	39%	35%	23%	24%	22%
TOTAL	100%	100%	100%	100%	100%	100%	100%

TABLE C-9

ELAPSED TIME IN HOURS BETWEEN VARIOUS STAGES OF THE X-RAY REQUEST/REPORT CYCLE BY DATA COLLECTION PERIOD AND BY VIEWING MODE

BOLLING

TELERADIOLOGY FIELD TRIAL

Stage	Elapsed Time (hours)								
	Baseline: Film[a]			Post-Implementation: Film[b]			Post-Implementation: Video[b]		
	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.	n
Request initiated									
	1.4	14.0	137	1.52	9.51	113	1.52	9.51	113
Request received									
	1.8	19.9	137	.23	.37	67	.23	.37	67
Patient check-in									
	0.1	0.1	138	.14	.19	121	.14	.19	121
Exam begun									
	0.1	0.1	138	.15	.08	121	.15	.08	121
Exam complete									
	0.1	0.1	138	.12	.13	73	.12	.13	73
Patient released									
	NA	NA	NA	1.91	10.14	47	1.91	10.14	47
Films reviewed by provider									
	0.3	1.7	138	52.18	34.80	36	26.40	30.33	60
Films/Images ready									
	19.8	18.0	113	63.99	56.26	71[c]	6.61	6.85	234
Films/Images received									
	14.1	19.2	113				25.43	20.21	235
Interpretation begun									
	18.7	19.5	113	20.39	28.44	109	2.00	2.72	232
Typing begun									
	1.0	3.3	45	.35	2.31	108	2.65	3.41	232[c]
Report ready for review									
	9.5	22.1	47	14.16	22.51	35			
Report edited, signed									
	17.8	20.0	68	123.95	89.41	36[c]			
Report ready for dispatch									
	22.6	26.9	125				26.99	39.55	128
Report received at clinic									
	13.3	28.5	127				187.00	78.60	127
Report reviewed by provider									
TOTAL:									
Request initiated									
	108	44.1	126	232.77	111.10	124	181.24	96.20	76
Report reviewed by provider									

[a] Data collected and analyzed by the BRH, February 1981.

[b] Includes only non-zero time differences

[c] Mean time for total of time segment

NA = not measured

TABLE C-9 (cont.)

ELAPSED TIME IN HOURS BETWEEN VARIOUS STAGES OF THE X-RAY REQUEST/REPORT CYCLE
BY DATA COLLECTION PERIOD AND BY VIEWING MODE

DETRICK

TELERADIOLOGY FIELD TRIAL

Stage	Elapsed Time (hours)								
	Baseline: Film[a]			Post-Implementation: Film[b]			Post-Implementation: Video[b]		
	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.	n
Request initiated	.7	4.1	121	.63	3.84	101	.63	3.84	101
Request received	.2	0.5	121	.32	.22	36	.32	.22	36
Patient check-in	0.1	0.2	131	.18	.29	99	.18	.29	99
Exam begun	0.2	0.4	131	.14	.09	102	.14	.09	102
Exam complete	0.1	0.1	131	.05	.03	40	.05	.03	40
Patient released	NA	NA	NA	2.55	14.19	45	2.55	14.19	45
Films reviewed by provider	0.5	4.1	131	44.25	44.72	39[c]	40.10	60.66	42
Films/Images ready							3.37	2.46	202
Films/Images received	34.2	31.5	127[b]				25.19	24.74	202
Interpretation begun	15.0	12.3	76	8.14	7.85	24	2.20	1.62	193
Typing begun	0.1	0.1	76	.03	.02	25	2.49	1.03	194[c]
Report ready for review	7.4	11.5	76	88.09	72.93	55[c]			
Report edited, signed	24.7	28.8	125						
Report ready for dispatch	10.3	30.0	127				21.69	33.23	161
Report received at clinic	5.8	8.6	127				6.52	16.44	160
Report reviewed by provider									
TOTAL:									
Request initiated	91.8	62.0	117	120.74	74.97	95	99.42	61.29	92
Report reviewed by provider									

[a] Data collected and analyzed by the BRH, February 1981.

[b] Includes only non-zero time differences

[c] Mean time for total of time segment

NA = not measured

TABLE C-9 (cont.)

ELAPSED TIME IN HOURS BETWEEN VARIOUS STAGES OF THE X-RAY REQUEST/REPORT CYCLE
BY DATA COLLECTION PERIOD AND BY VIEWING MODE

PATUXENT

TELERADIOLOGY FIELD TRIAL

Stage	Elapsed Time (hours)								
	Baseline: Film[a]			Post-Implementation: Film[b]			Post-Implementation: Video[b]		
	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.	n
Request initiated	2.0	15.6	212	1.25	4.73	280	1.25	4.73	280
Request received	.1	.1	205	.16	.50	89	.16	.50	89
Patient check-in	.3	.6	223	.07	.09	215	.07	.09	215
Exam begun	.2	.2	230	.09	.08	274	.09	.08	274
Exam complete	.1	.1	223	.10	.56	116	.10	.56	116
Patient released	NA	NA	NA	23.92	55.43	98	23.92	55.43	98
Films reviewed by provider	.2	2.3	222	141.27	197.03	37[c]	98.32	156.33	82
Films/Images ready	50.7	32.7	104				6.56	12.49	404
Films/Images received	2.1	1.0	104	4.65	7.05	111	25.74	23.64	404
Interpretation begun							2.32	3.21	402
Typing begun	0.6	5.7	229[c]	124.10	86.53	290[c]	3.62	6.71	403[c]
Report ready for review							12.67	23.12	273
Report edited, signed	0.1	0.1	226						
Report ready for dispatch	36.9	27.6	222						
Report received at clinic	7.9	21.3	220				83.72	72.13	267
Report reviewed by provider									
TOTAL:									
Request initiated	91.7	57.6	203	198.55	107.25	292	212.36	104.11	228
Report reviewed by provider									

[a] Data collected and analyzed by the BRH, February 1981.

[b] Includes only non-zero time differences

[c] Mean time for total of time segment

NA = not measured

TABLE C-9 (cont.)

ELAPSED TIME IN HOURS BETWEEN VARIOUS STAGES OF THE X-RAY REQUEST/REPORT CYCLE
BY DATA COLLECTION PERIOD AND BY VIEWING MODE
CVCHC
TELERADIOLOGY FIELD TRIAL

Stage	Elapsed Time (hours)								
	Baseline: Film[a]			Post-Implementation: Film[b]			Post-Implementation: Video[b]		
	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.	n
Request initiated	.1	1.0	52	.25	.23	43	.25	.23	43
Request received	.1	.1	52	.03	.02	28	.03	.02	28
Patient check-in	.1	.1	54	.07	.07	40	.07	.07	40
Exam begun	.2	.1	54	.18	.12	43	.18	.12	43
Exam complete	.1	.1	54	.07	.05	22	.07	.05	22
Patient released	NA	NA	NA	2.20	9.38	26	2.20	9.38	26
Films reviewed by provider	1.9	10.1	54	44.00	27.37	34	5.72	14.88	42
Films/Images ready	28.2	23.8	53	9.31	9.40	33[c]	31.24	52.39	89
Films/Images received	1.4	0.7	53				21.29	21.16	89
Interpretation begun	8.2	8.0	53	16.76	12.14	35	2.36	1.61	84
Typing begun	0.1	0.1	53	.06	.03	37	7.36	11.25	84[c]
Report ready for review	9.2	11.2	52	16.32	24.52	29			
Report edited, signed	11.8	20.8	52	67.41	35.81	30[c]	24.79	38.62	44
Report ready for dispatch	19.3	21.7	53						
Report received at clinic	5.6	8.7	53				29.03	43.28	40
Report reviewed by provider									
TOTAL:									
Request initiated	87.6	32.5	51	161.53	54.53	40	99.99	55.99	45
Report reviewed by provider									

[a] Data collected and analyzed by the BRH, February 1981.

[b] Includes only non-zero time differences

[c] Mean time for total of time segment

NA = not measured

TABLE C-10

CAPITAL COSTS
TELERADIOLOGY EQUIPMENT
CENTRAL SITE[a]

Item	Mfr/Model	Qty	Rate ($)	Total Cost ($)
Modem	Paradyne T96	4	$ 3,500	$ 14,000
Error Corrector	Datatel 4020	4	910	3,640
Control Processor	Cromemco System III	1	7,027	7,027
200 Megabyte Disk	STC 2720	4	8,773	35,092
Image Processing & Display System	Comtal Vision One/20	1	78,939	78,939
Video Monitors	Conrac	3	1,590	4,770
Video Display Terminal	Zenith Z19	1	717	717
System Printer	Epson MX80	1	457	457
Equipment Rack	NA	1	619	619
Processor	MITRE PC Card	4	1,500[b]	6,000
Subtotal--Image System				$151,261
Dictation/ Transcription Machine	Lanier	2	450 479	929
XOM/XOFF Box	Black Box	1	600	600
ABCD Switch	Black Box	1	200	200
Word Processor	DEC WS78	1	5,845	5,845
Tractor Feed	DEC LA34	1	125	125
Report Printer	DEC LA34	1	1,000	1,000
Subtotal--Word Processing System				$ 8,699
TOTAL--Field Trial Central Site				$159,960

[a]Obtained from MITRE Document: "WP.82W00327: Cost for the Development and Field Trial of the Teleradiology System," May 1982.

[b]Includes some labor costs for outside contractor.

TABLE C-11

CAPITAL COSTS
TELERADIOLOGY EQUIPMENT
TRANSMITTER SITE[a]

Item	Mfr/Model	Total Cost ($)
Light Box & Copy Stand	S&S/MITRE	$ 434
Video Camera & Zoom Lens	Hamamatsu	6,152
Video Monitor--14"	Conrac	1,200
Frame Memory--512x512	Hamamatsu	48,000
Control Processor/Convertor	MITRE	1,200
200 Megabyte Disk	STC 2720	8,773
Video Display Terminal	Zenith Z19	717
Printer	Epson MX80	507
Error Corrector	Datatel 4020	910
Modem	Paradyne T96	3,500
Cabling/Equipment Rack	NA	619
TOTAL--Field Trial Satellite Site		$ 72,012

[a]Obtained from MITRE Document: "WP.82W00327: Cost for the Development and Field Trial of the Teleradiology System," May 1982.


FILME
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