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REMOTE MEDICAL DIAGNOSIS SYSTEM (RMDS) UTILIZATION STUDY. (U)

AUG 81 I STEVENS, C ZEKAN

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Technical Report 700

REMOTE MEDICAL DIAGNOSIS SYSTEM (RMDS) UTILIZATION STUDY

I Stevens
(NOSC)

C Zekan
(WESTEC Services, Inc. Contract N00123-81-D-0353)

18 August 1981

Period of Study: December 1980 - May 1981

Prepared for
Naval Medical Research and Development Command

Code 45
Bethesda, MD 20014

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This Technical Report is one in a series on the Remote Medical Diagnosis System (RMDS), performed under Program Element 64771N, Project M0933-PN (NOSC 512-CM38), and sponsored by the Naval Medical Research and Development Command. This document describes the utilization of telemedicine systems in several public health care programs and the potential utilization of the RMDS by the US Navy. It was prepared by the NOSC Bioengineering Branch (Code 5123) and WESTEC Services, Inc. (Contact N00123-81-D-0353) between December 1980 and May 1981. Principal investigators were I Stevens (NOSC, Code 5123) and C Zekan (WESTEC Services, Inc.) under the direction of WT Rasmussen, Head, Bioengineering Branch (NOSC, Code 5123).

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NOSC Technical Report 700 (TR 700)	2. GOVT ACCESSION NO. AD-A105559	3. RECIPIENT'S CATALOG NUMBER (1)
4. TITLE (and Subtitle) REMOTE MEDICAL DIAGNOSIS SYSTEM (RMDS) UTILIZATION STUDY.		5. TYPE OF REPORT & PERIOD COVERED Study December 1980-May 1981
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) I Stevens (NOSC) C Zekan (WESTEC Services, Inc.)		8. CONTRACT OR GRANT NUMBER(s) N00123-81-D-0353
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Ocean Systems Center San Diego, CA 92152		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS PE 64771N Proj M0933-PN NOSC 512-CM38
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Medical Research and Development Command Code 45 Bethesda, MD 20014		12. REPORT DATE 18 August 1981
		13. NUMBER OF PAGES 44
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (12) 44		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) (16) M0933-PN		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Medical equipment Medical information systems Medical diagnosis Telemedicine Remote Medical Diagnosis System Teleradiology		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Remote medical diagnosis systems are being successfully utilized for consultation in rural health care programs and private radiology practices. Consultation over RMDS-type systems reduces medical referrals and evacuations and assists in making triage decisions with a greater degree of confidence. RMDS-type systems can be used effectively for teleradiology consultations. The utilization of RMDS on ships and at remote shore sites has the potential for improved diagnoses. Nonphysician health care providers are more inclined to use telemedicine than physicians.		

OBJECTIVE

Document the utilization of existing RMDS-type systems. Review the utilization of earlier systems described in telemedicine literature. Analyze the effectiveness of the systems and draw conclusions as to the utilization potential of RMDS in support of shipboard medical personnel.

RESULTS

1. Remote medical diagnosis systems are being successfully utilized for consultation in rural health care programs and private radiology practices.
2. Consultation over RMDS-type systems reduces medical referrals and evacuations and assists in making triage decisions with a greater degree of confidence.
3. RMDS-type systems can be used effectively for teleradiology consultations.
4. The utilization of RMDS on ships and at remote shore sites has the potential for improved diagnoses.
5. Nonphysician health care providers are more inclined to use telemedicine than physicians.

RECOMMENDATIONS

1. As a result of the effective potential for medical consultations via the RMDS for shipboard or remote emergency cases and teleradiology, it is recommended that the US Navy pursue fleet implementation of the RMDS.
2. Coordinate these efforts with the Tri-Services Medical Information Systems (TRIMIS) Program Office.
3. Make better estimates of the utilization of the RMDS during the test and evaluation period, as follows:
 - a. Develop a formal RMDS indoctrination program.
 - b. Specifically assign organizational responsibilities for RMDS operation.
 - c. Develop a protocol for RMDS operation.
 - d. Conduct a survey of RMDS users' acceptance.

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SECTION 1

INTRODUCTION

1.1 PURPOSE

This report describes the utilization of telemedicine* systems in several public health care programs. It is intended to provide a background appreciation of the utilization potential of the Remote Medical Diagnosis System (RMDS) in the US Navy's shipboard health care program.

1.2 SCOPE

This report covers published telemedicine literature and discussions with personnel responsible for the operation of active telemedicine projects. It is primarily concerned with telemedicine systems which incorporate a slow-scan television capability. It includes descriptions of system utilization and users' attitudes. Most of the information was gathered during visits to operational systems. The observations on system usefulness, effectiveness, and acceptance are subjective; quantitative analysis is not possible because records were not made available, were incomplete, or did not exist.

1.3 BACKGROUND

The Bureau of Medicine and Surgery initiated a study in 1973 to determine the support requirements of shipboard medical personnel. The study analyzed the incidence of illness and injuries and the shipboard capability to diagnose and treat them. One of the conclusions of the study was that shipboard medical personnel did not have an adequate method of communicating with specialists ashore when emergency consultation was needed. An effort to develop this capability was initiated and eventually grew into the RMDS program.

The feasibility and testing of the RMDS concept has been successfully demonstrated in an operational setting (ref 1), and a specification has been prepared for RMDS Engineering Development Model (EDM) terminals. The EDM will be specifically designed to meet unique Navy requirements and will incorporate state-of-the-art technology. The acquisition cycle for several RMDS terminals that will be used for technical and operational suitability evaluation was initiated in March 1981, and the evaluation is planned for 1984.

*Telemedicine is the application of telecommunication technology to facilitate health care delivery (diagnosis and treatment advice) to patients who find it difficult or impossible to travel to a full-capability medical facility.

1. NOSC TR 659, Feasibility Tests of the Remote Medical Diagnosis System, January 1975 - May 1976, by WT Rasmussen, I Stevens (NOSC), and JA Kuhlman (WESTEC Services, Inc.), January 1981.

During the RMDS design review meeting of August 1980 (ref 2), it was recommended that the utilization of other RMDS-type systems (ie, telemedicine systems using slow-scan television) be studied and documented. This report was prepared in response to that recommendation.

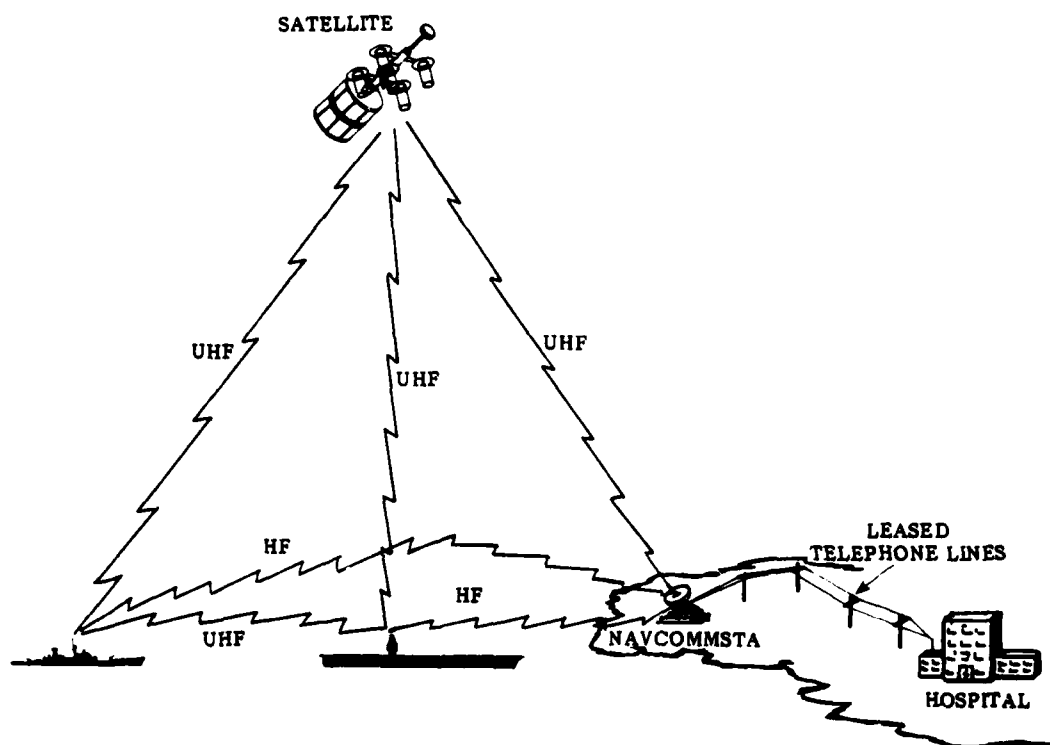


Figure 1. RMDS communication links.

2. NOSC TD 464, Remote Medical Diagnosis System (RMDS) Design Review Meeting Minutes 27-28 August 1980, prepared by WT Rasmussen and I Stevens, August 1981.

SECTION 2

REMOTE MEDICAL DIAGNOSIS SYSTEM

2.1 DESCRIPTION

The Remote Medical Diagnosis System (RMDS) is a data telecommunications system being developed by the Naval Ocean Systems Center (NOSC). The system will facilitate the exchange of medical information between naval ships and designated naval medical centers. It will have the capability for point-to-point exchange of television images, electrocardiograms (ECGs), electronic stethoscope sounds, and voice communication. The RMDS is intended to support medical personnel in ships and remote shore sites when they have a need for emergency consultation.

The system consists of RMDS terminals and existing Navy communication links. The terminals will be installed on ships and designated naval medical centers ashore and will be linked by satellite, conventional radio (uhf and hf), and telephone service. An RMDS terminal will be capable of processing the analog electrical signals from a television camera, ECG machine, and electronic stethoscope into a digital format compatible with Navy communication equipment, for transmission. The terminal will also perform the inverse function for reception. Figure 1 shows the RMDS communication connectivity. The system specification developed by NOSC provides the functional design for the RMDS terminals.

2.2 MISSION

A critical part of any health care system is the ability of the health care providers to perform accurate and complete diagnoses. Decisions on local treatment and the need for referral can be made with confidence only when the provider is aware of the implication of a symptom or sign. Medical personnel in a ship at sea or at remote shore sites perform their duties with a minimum of equipment and assistance. They must rely primarily on their experience in differential diagnosis to determine a patient's condition. The mission of the RMDS is to improve medical diagnosis on ships and at remote sites by providing the medical personnel attending a patient with a means for effective consultation with a medical specialist when the need exists.

2.3 DEVELOPMENT

After an initial baseline requirements study in FY73, a medical telecommunications system was assembled from off-the-shelf equipment to demonstrate the feasibility of the remote medical diagnosis concept (ref 1). The feasibility test involved USS JUNEAU (LPD 10), USS FORT FISHER (LSD 40) and USS ALAMO (LSD 33). It took place off the coast of southern California and during a deployment of these ships to the western Pacific. Voice and video data were transmitted between ships, by means of hf/uhf radio communications, and to NOSC or Naval Regional Medical Center (NRMC) San Diego via Naval Communication Stations (NAVCOMMSTAs) in the Philippine Islands, on Guam, and at San Diego.

System design specifications for an Advanced Development Model (ADM) incorporated the technical experience gained from the feasibility tests. The ADM

terminal design and manufacture was performed by Colorado Video, Inc. under contract to NOSC. The ADM was evaluated in the laboratory and at sea. Operational tests were conducted between USS ENTERPRISE (CVN 65) and NOSC to determine the ADM design capability and performance. Finally, tests were conducted at NOSC in which radiologists evaluated the radiographs received. A summary of these tests is contained in NOSC TN 668 (ref 3).

The results of the ADM tests were encouraging, and the need for an RMDS was affirmed by Chief of Naval Operations (CNO) endorsement of the Navy Decision Coordinating Paper for Medical/Dental Equipment Development "Mini" NDCP M-0933-PN (which includes RMDS) on 25 August 1980. NOSC proceeded to develop a functional design specification for an RMDS Engineering Development Model (EDM) terminal that would incorporate requirements predicted by system engineering to be needed in the post-1985 period. The EDM design emphasized the use of proven technology and off-the-shelf equipment to minimize development cost and risk where feasible. The procurement contract cycle was initiated in March 1981.

2.4 SHIPBOARD MEDICAL PERSONNEL STAFFING AND X-RAY CAPABILITY

Medical officers and independent duty corpsmen provide total health care aboard ship. Except on aircraft carriers, only one medical officer or one independent duty corpsman is assigned to a ship. Aircraft carriers have billets for two shipboard experienced medical officers. When aircraft squadrons are embarked, this staff is augmented by squadron flight surgeons. Thus, a deployed carrier may have as many as five experienced medical officers on board and be functionally equivalent to a large shore dispensary. Medical officers on other ships are usually serving at their first duty station prior to entering specialty training and generally are less experienced in shipboard health care. Medical officers are assigned to approximately 20 percent of the Navy's active ships.

Independent duty corpsmen are assigned to ships and stations that do not have a medical officer. They are career-oriented first class and chief petty officers who are in a second or subsequent enlistment. They have had clinical medical experience aboard ship and ashore, are graduates of the Independent Duty Corpsman course, and have been evaluated as suitable for independent duty by medical officers. However, they have had little formal training in interpreting X-rays. Table 1 shows the present distribution of medical officers, independent duty corpsmen, and X-ray capabilities by ship type.

The ships that have medical officer billets have X-ray capability. This includes an X-ray machine and, usually, an X-ray technician. The X-ray machines have a maximum rating of either 50 or 300 milliamperes (mA); in the future, the 300-mA machines will be authorized only on carriers (CVs) and amphibious assault ships

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3. NOSC TN 668, Remote Medical Diagnosis System (RMDS) Advanced Development Model (ADM) Test and Evaluation Summary Report, by WT Rasmussen and I Stevens, April 1979.

SHIP TYPE	NUMBER OF SHIPS	MEDICAL OFFICER	X-RAY EQUIPMENT	X-RAY TECHNICIAN	INDEPENDENT DUTY HOSPITAL CORPSMAN
<u>WARSHIPS</u>					
Carriers (CV, CVN)	12	X	X	X	
Cruisers (CGN)	9	X	X		
(CG)	18				X
Destroyers (DD & DDG)	82				X
Frigates (FF & FFG)	79				X
Submarines	125				X
<u>AMPHIBIOUS</u>					
LCC, LHA, & LPH	14	X	X	X	
LPD	15	X	X	X	
LSD	13				X
LKA	5		X		X
LST	20				X
<u>AUXILIARIES</u>					
AOE	4	X	X	X	
AD, AS	23	X	X	X	
AR	4	X	X	X	
AOR	7	X	X	X	
AO	8				X
AE	11				X
AFS	7	X	X		X
AVT	1	X	X	X	
OTHERS	14				X
<u>MINE WARFARE</u>					
MSO	3				X
<u>PATROL COMBATANTS</u>					
PHM	5				X

Table 1. Shipboard medical personnel
and X-ray equipment status.
(Active fleet February 1981)

(LHAs and LPDs). Shore hospitals employ machines rated at 500 to over 1000 mA. The higher rated machines require less exposure time and therefore produce a negative that is less affected by patients' movement. Radiograph processing takes approximately 90 seconds. Most ships with X-ray equipment have an X-ray technician who has had extensive training in X-ray technique and in maintaining the equipment.

The X-ray equipment aboard ship is used most frequently for annual physical examinations (chest X-rays). It is used in severe injury cases to detect nonsubtle conditions that can be diagnosed accurately by a nonspecialist. Consultation on subtle conditions with a radiologist ashore is possible via ship-shore radio telephone. However, in most cases the complexity of shading in an X-ray negative, which a radiologist must comprehend to identify a less obvious pathology, cannot be adequately conveyed verbally. For some cases, several radiographs taken from different angles are necessary to show anatomical spatial relationships and other features. Appendix A shows the number of X-ray views routinely taken to examine various areas of the body by X-ray technicians at NRM C San Diego. It is reasonable to assume that at least the same number would be required for a ship-to-shore consultation via a remote medical diagnosis system.

2.5 MEDICAL EVACUATIONS (MEDEVACs) AND THE NEED FOR CONSULTATION

During the period from April 1975 through July 1980 there were 229 helicopter MEDEVACs of 235 patients from ships operating in the Southern California fleet operating areas and from military units at El Centro and on San Clemente Island. Table 2

On-Scene Diagnosis	Ships with Medical Officers Assigned		Ships with Inde- pendent Duty Corpsmen Assigned		Totals	
	No. of Cases	Percent	No. of Cases	Percent	No. of Cases	Percent
1. Fractures, lacerations, and sprains	23	9.8	57	24	80	33.8
2. Gastrointestinal and genitourinary	30	12.8	37	15.7	67	28.5
3. Cardiovascular	8	3.4	17	7.2	25	10.6
4. Dermatologic and orbital	6	2.6	7	3.0	13	5.6
5. Neuropsychiatric	4	1.7	6	2.6	10	4.3
6. Cranial	2	.8	8	3.4	10	4.2
7. Undefined and others	3	1.4	27	11.6	30	13.0
	76	32.1	159	67.9	235	100

Table 2. Helicopter medical evacuations (MEDEVACs) from the Southern California fleet operating area, San Clemente, and El Centro (April 1975 - August 1980).

shows the MEDEVACs conducted during this period. The on-site diagnoses have been grouped into general categories and have been separated to show whether they were made by a medical officer or a corpsman. The patients were transported to NRM C San Diego. Validity of the reported diagnoses by analysis of the Emergency Treatment Report (STD Form 588), filled out at the NRM C emergency room, was not established during this study since these data were not readily available.

The decision to request a MEDEVAC is made by the commanding officer of a ship and is based on the recommendation of the medical personnel on board. A MED-EVAC normally implies an emergency condition, and the response is very rapid. The Fleet Air Coordination and Surveillance Facility (FACSFAC) at North Island NAS coordinates the air services required for MEDEVACs in the Southern California area. A review of FACSFAC records indicates that the patient arrives at NRM C San Diego in less than 2 hours and in the majority of cases within 1 hour after the MEDEVAC is requested. FACSFAC either initiates a flight or diverts a helicopter from a mission in progress to effect the MEDEVAC. In life-threatening emergencies a medical officer and corpsman board the helicopter for the flight to the patient's ship, to provide stabilization care as soon as possible.

When necessary, transfer of personnel for medical care between deployed ships in company that are beyond helicopter range from a shore base is accomplished by highline or by a helicopter that belongs to one of the ships. The objective is to move the patient to a ship that is better suited to provide the required medical care. The cost of MEDEVACs cannot be determined readily since it is difficult to segregate the cost factors, especially those which arise from diversion of a helicopter from its normal mission.

There are risks associated with MEDEVACs and other transfers at sea. There is a risk of aggravating a patient's condition as a result of rough handling and exposure to the elements. There is a risk of serious accident to units involved in the transfer. Although quantitative data on helicopter operating costs and risks associated with MEDEVACs could not be obtained, it is apparent that cost and risk are significant. The Sea-Air Rescue Model Manager at Pensacola, Florida currently is collecting and analyzing MEDEVAC data. It is anticipated that preliminary results will become known after 1 July 1981. Any reduction in cost or exposure of personnel to risk of an accident through the elimination of unnecessary MEDEVACs and other at-sea transfers benefits the Navy. When doubt exists as to the urgency of a patient's condition, the ability to consult with a specialist would assist greatly in making the decision to request a MEDEVAC.

The observation has been made that remote places such as islands off the Southern California coast and isolated stations ashore would benefit from telemedicine. Installation of X-ray and telemedicine equipment at remote locations would reduce work-hours lost in traveling to hospitals for minor problems and for routine examinations such as annual chest X-rays.

SECTION 3

TELEMEDICINE SYSTEMS

3.1 **TELEMEDICINE DEVELOPMENT**

The development of telemedicine has been divided, by several researchers (ref 4), into three stages. The first stage, during the period 1964-1969, consisted of experimentation by medical practitioners in the clinical application of telecommunications technology. The effort lacked cohesiveness and organization but demonstrated that a wide variety of clinical tasks could be accomplished successfully via television, telemetry, and voice communication systems.

The second stage, during the period 1969-1973, was characterized by government sponsorship of many of the telemedicine research and demonstration programs. Published reports helped to exchange knowledge and experience among participants in the various telemedicine programs. The development questions were expanded to include not only what could be done with telemedicine but how best to accomplish it and what organization was required for effective operation. The concepts of backup support for nonphysician providers in rural areas, comparison of various media alternatives (fixed-image TV, moving-image TV, telemetry of vital signs, etc) for diagnosis, and evaluation of the impact of telemedicine on medical practice and society also became subjects of investigation.

In the third stage, dating from 1973 onward, telemedicine has been viewed as an innovative mode of health care delivery based on the fact that its concept and utility have been demonstrated in a wide variety of applications. The main interest in telemedicine development today is in the organization and operation of systems so as to make them cost effective and economically self-supporting. The government played a central role in encouraging the development of telemedicine during the 1970s. The interest in most of the government-sponsored projects was in demonstrating how telemedicine could solve health care delivery problems rather than in evaluating how well telemedicine performed in its diagnostic role. Therefore, most of the literature is concerned with social aspects such as the impact on the health care system, acceptability, and savings in time and travel.

3.2 **TELEMEDICINE SYSTEM BANDWIDTH**

Telemedicine projects to date have examined a wide variety of media. These include black-and-white and color television, one-way and two-way television, picture phones, slow-scan television, facsimile transmission, telemetry, and telephones. Color,

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4. **Healing and the Tube: Telemedicine**, by RL Bashshur and PA Armstrong, University Program in Telecommunications Research, University of Michigan, Ann Arbor, MI, May 1975.

black-and-white, one-way and two-way live television require a wide frequency band (ie, a broadband system*) to transmit information. Picture phones, slow-scan television, facsimile, telemetry, and the ordinary telephone communications occupy less bandwidth (ie, can operate over a narrowband system) to transmit the same information, but take a longer time to do it.

Black-and-white slow-scan (narrowband) television systems did not receive the same amount of attention that broadband television systems received during the development of telemedicine. Many of the early experimenters felt that telemedicine systems used for diagnosis and medical education required the capability to transmit continuous motion and color. However, demonstration projects conducted during the last two decades have shown that the additional information conveyed by motion and color is not essential for most consultation and education uses.

There is a considerable difference in cost between the more complex broadband color systems and the black-and-white slow-scan systems. Experience has shown that the black-and-white slow-scan requires less training. The equipment reliability is significantly higher and the cost of maintenance and operation is much lower. The one feature of slow-scan television which makes it practical for use by private radiology group practices is that the public telephone system can serve as its transmission medium. The convenience of being able to install a slow-scan terminal wherever there is a telephone outlet permits operating a telemedicine system without the need for costly and complex communication equipment.

A single frame of video contains a huge amount of information. Standard television transmits 30 frames of video per second to create the illusion of motion, in the same manner as a motion picture. The frequency bandwidth required to accommodate the information of a frame in 1/30 s is very large and is termed broadband. Broadband transmission is feasible by radio or over a coaxial cable but is impossible to implement over wire lines such as telephone lines.

Slow-scan television uses a video camera as in standard television, to capture the view of interest of a stationary object. The video frame is rapidly (1/30 s) stored in a video frame storage device. The video is then read out of the storage device at a slow rate, such that the information frequency is effectively reduced. The signal is passed through a modulator and transmitted over telephone lines. At the receiving end, a demodulator extracts the slowly varying information signal and passes it to a frame storage device which in turn passes it to a video monitor. Slow-scan systems that store information signals in analog form, such as the equipment manufactured by Colorado Video, Inc., take about 79 s to develop a frame of video on the monitor. Once the full frame is displayed, it is refreshed repeatedly from the storage device at a rate of 30 times per second. A storage device with additional capacity is required if more than one frame is to be stored. A zoom lens on the video camera can be used to effectively increase the resolution of the transmitted image by transmitting a smaller field of view.

*A broadband system is one that is capable of carrying real-time video information of quality comparable to standard broadcast television. The means for broadband transmission are radio and coaxial cable. Narrowband systems are limited to information frequencies between 300 and 3000 Hz. Narrowband transmissions can be accomplished over radio or wire lines such as telephone lines. The information capacity of a broadband channel is approximately 2000 times that of a narrowband channel per unit time.

The transmission of slow-scan television over telephone lines is degraded by electrical noise and poor telephone line paths. A better image is sometimes obtained by redialing to obtain another circuit. Best performance is obtained over dedicated telephone lines. The RMDS will utilize the slow-scan concept but will digitize the information signal. This will reduce the effect of electrical noise and permit the use of advanced information-compression and information-storage technology.

The transmission of medical telemetry (ECG and stethoscope sounds) does not require a wide bandwidth. Transmission of ECG signals over telephone lines for interpretation by cardiologists is a relatively common practice. Transmission of ECG as an image via slow-scan TV is an obvious method of performing the same function by telemedicine systems that do not have a telemetry capability. However, this is an inefficient use of the media since the ECG trace takes up only a small portion of the image frame. Electronic stethoscopes are instruments that amplify auscultatory (body organ) sounds. Some telemedicine systems utilize tape recorders to store the received stethoscope sounds.

3.3 TELEDIAGNOSIS ISSUES

Medical diagnosis can be divided broadly into general diagnosis and medical specialty diagnosis. The former is primarily the province of the general practitioner. It includes the general physical examination, the investigation of specific patient complaints, and the identification of problems not recognized by the patient. Medical specialty diagnosis occurs as a result of a consultation initiated by the primary-care medical practitioner or as a result of a referral by the primary-care practitioner. The feasibility of telediagnosis for general and medical specialty purposes has been a telemedicine issue. The telediagnostic aids include the X-ray, the ECG, the stethoscope, and the medical practitioner attending the patient. The medical practitioner performs the transactions requested by the remote specialist and verbalizes the results that cannot be transmitted by television or medical telemetry. The capability of the diagnostic aids to provide diagnostic quality information to the remote specialist is a related issue.

a) Feasibility of General Diagnosis

There have been few systematic studies conducted on the feasibility of general diagnosis via telecommunications. The most impressive was conducted by Dr. KT Bird (ref 5) by means of a real-time interactive television link between Massachusetts General Hospital (MGH) and a remote station at Logan Airport in Boston. The telemedicine link also included an ECG, a stethoscope, and voice transmission capability. The first 1000 patients at the remote station were "seen" by a physician at MGH over the video link. They were also examined by an "in-person physician" at the

-
5. Telediagnosis: A New Community Health Resource Observation on the Feasibility of Telediagnosis Based on 1000 Patient Transactions, Massachusetts General Hospital, Boston, Massachusetts, 1970, by KT Bird, RL Murphy, et al; cited in An Introduction to Telemedicine, by B Park, The Alternate Media Center at the School of the Arts, New York University, NY, June 1974, p 154.

Logan Airport station before or after the video examination. A nonphysician medical assistant performed palpation or other techniques requested by the "video" physician. Comparison of the diagnoses in the first 200 cases showed that only 1 percent of the diagnoses were not satisfactory. Of the subsequent 800 consultations, the telemedicine physician ranked only 2 percent as not satisfactory or not feasible for the then-current (1974) state of telemedicine.

A comparison of diagnostic accuracy for a wide range of medical problems by means of several different media was conducted by Conrath (ref 6). Diagnosis via color and B&W television with a "hands free" telephone to a remote physician was compared with the performance of an on-site physician. The studies showed no significant difference between media and in-person diagnostic accuracy when the specific complaint of the patient was examined. The on-site physician, however, was observed to be superior to the other media in finding problems unrelated to the initial complaint when an examination was made. Situations in which a patient is found unconscious and unable to verbalize a complaint would be considered in this category. There were no references to investigations of the use of slow-scan television to compare diagnostic accuracy of a remote physician compared to that of an on-site physician for general diagnosis.

b) Accuracy of Specialty Diagnosis

The accuracy of telemedicine diagnosis in the specialty fields of dermatology and radiology has been studied in several projects. The issues of color versus black-and-white for viewing lesions in dermatology and of the accuracy of diagnosis based on interpretation of a televised X-ray image are discussed frequently in the literature. The following sections relate some representative conclusions with respect to these issues.

• Dermatology

A study to assess the capability of television to transmit pictures of dermatologic lesions was performed over links from the Massachusetts General Hospital to Logan Airport. It is summarized by Park (ref 7):

Comparisons of diagnosis made by black and white television viewing of slides of dermatologic lesions to those made by direct viewing of the same color slides reveal that in 85 to 89 percent of the cases the dermatologists were as accurate by television

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6. A Preliminary Evaluation of Alternative Telecommunication Systems for the Delivery of Primary Health Care to Remote Areas, by DW Conrath, E Dunn, et al, IEEE Transactions on Communications, October 1975.
 7. An Introduction to Telemedicine, by B Park, The Alternate Media Center at the School of the Arts, New York University, NY, June 1974, p 156, 141.

as on direct examination. Color television improved accuracy only slightly, but was more acceptable to dermatologists as less time was required to reach a diagnosis. This study demonstrates that dermatologists can diagnose color slides transmitted by black and white television more accurately than non-dermatologists viewing direct projections of the same color slides.

Another study performed by the New Hampshire - Vermont Interactive Medical Television Network (Interact) (ref 8) used both color and black-and-white television for a dermatologic experiment. The dermatologist was highly satisfied with the system and felt that lesions were discernible and that color television enhanced the session. However, it was pointed out that color only made diagnosis easier and faster, but not necessarily more accurate than black-and-white.

- Radiology

Park (ref 7) describes the University of Nebraska Slow Scan Radiology Project, which attempted to evaluate the accuracy of radiographic interpretations between family physicians and radiologists when standard film images were examined compared to that of the radiologists' diagnostic evaluation of electronically transmitted images.

Three cases that occurred in the first 2 weeks of the project's operation are described. In case 1, the University of Nebraska Medical Center (UNMC) radiologist in consultation with a physician at Broken Bow, Nebraska, was able to determine that the densities in the transmitted X-ray after an oral cholecystogram procedure indicated a carcinoma of the pancreas rather than a probable stone in the common duct as diagnosed by the primary-care physician. The patient was spared an exploratory surgical procedure for the stone and instead was transferred to a larger hospital in Kearney, Nebraska, where the carcinoma was resected.

In case 2, the original X-ray interpretation by a physician for a fracture was negative. Because of the wider density range of the image in its transmitted form, the UNMC radiologist was able to detect a "fracture of the left hip with good anatomic position" as well as "a fracture of the ramus and ischium which were not visible on the original X-ray until they had been noted on the TV transmitted image."

In case 3, an automobile accident patient who had sustained severe trauma to the rib cage and a fracture of the left humerus developed respiratory distress. The fracture was obvious to the physician "but a subsequent X-ray was interpreted as pleural effusion and/or bleeding into the left hemithorax. The UNMC radiologist determined that there was a mediastinal shift to the left and that the cause of the

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8. Final Report, The Provision of Speech Therapy and Dermatology Consultations via Closed Circuit Television, by DJ Siebert, et al, Dartmouth Medical School, Hanover, Dartmouth University, 1974.

opacity was not pleural fluid or blood but collapse of a lung due to a mucous plug in the bronchus." The patient was spared a needle tap of the chest. Aspiration of the trachea cleared the plug and restored the lung to its normal function.

c) Diagnostic Aids

The use of diagnostic aids such as X-rays, electrocardiograms, and stethoscopes is basic in the practice of conventional medicine. To perform tele-diagnosis, the information from these aids or their functional equivalents is transmitted over some medium to the remote physician. The telemedicine systems described in the literature were designed to transmit one or more of these functions.

• X-ray

The standard X-ray is a complex two-dimensional image which, used in conjunction with other X-rays, permits interpretation of a three-dimensional situation. Differential density of the chemical deposition on the film is the basis for X-ray analysis. Interpretation can be a subtle process, but radiologists who have used telemedicine systems are virtually unanimous in saying that it can be accomplished satisfactorily via television.

A series of studies made at Massachusetts General Hospital are summarized by Park (ref 7). The studies compared diagnoses made by a panel of physicians "with particular interest in chest disease" who viewed chest X-rays on television with the judgments made by the hospital radiologist who viewed the films directly. The hospital radiologist subsequently viewed the video presentation of the films. His in-person and video judgments were compared. Agreement was very high on all comparisons. It was also noted that the panel of physicians had a tendency to overclassify the seriousness of cases but were able to detect incidence of minimal disease.

The studies concluded that the manner of reading a televised X-ray will have to be different from that used for reading the film directly. "The radiologist will start with an overall camera view of the roentgenogram, which is well adapted to searching for gross abnormalities. Having oriented himself, he will then use a zoom lens to scan systematically. It is important for the zoom lens to be under the remote control of the radiologist, and for him to be able to direct the camera at any portion of the roentgenogram. It is almost certain that a radiologist experienced in tele-radiology can review a roentgenogram in this deliberate fashion without any sacrifice in resolution or in ability to interpret the shades of gray accurately . . ."

An investigation was performed by Rasmussen, Crepeau, and Gerber (ref 9) to define the resolution requirements for the transmission of radiographs. It concluded that when the transmission is supplemented by patient history and

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9. Resolution Requirements for Diagnosis of Transmitted Radiographs, by RL Crepeau, FH Gerber, and WT Rasmussen, Proceedings of the San Diego Biomedical Symposium 17, 1978, p 357-373.

symptom information, a resolution of 0.5 line pair per mm at the film is adequate. This resolution is equivalent to approximately 300 television lines per picture height at 50 percent contrast. The use of a zoom lens to improve resolution of the transmitted image by decreasing the field of view is a common practice in slow-scan transmission.

- **Auscultation**

Auscultation is the process of ascertaining the sound functions of the heart, lung, and bowel. The condition of these organs is then deduced by the listening physician. An acoustic stethoscope is normally used for this purpose. Telemedicine systems which provide for auscultation use an electronic stethoscope. Problems associated with background noise pickup and the unfamiliar sound of the electronic stethoscope output have produced some negative reports.

To be effective, the diagnosing physician must have a good television view of the placement of the stethoscope and must be able to communicate with the attending health care provider. Either the physician must learn to interpret the sounds delivered by the electronic stethoscope (sound frequencies up to 1 kHz) or the instrument's output must be degraded to the range of the acoustical stethoscope the physician is accustomed to using.

Foote (ref 10) cites an unsuccessful attempt, reported by Hastings and Dick, to transmit cardiopulmonary sounds. "They found it was technically impossible to maintain a satisfactory background noise level using a telephone line link, and that the telephone line link could not be made to transmit sounds in the frequency range of 50 to 150 cycles per second, and these are the frequencies at which initial murmurs and extra heart sounds are heard."* Foote (ref 10) also cites difficulties reported by Wempner in the Lakeview Clinic Project. The difficulties they encountered centered around sounds that were foreign to the physician's ear so that diagnostic activity was impeded. They were not able to determine whether they were caused by outside interference or were due to heart and lung conditions.

- **Patient Viewing**

During the RMDS concept feasibility evaluation (ref 1), an incident occurred which demonstrated the utilization of slow-scan television for consultation and instruction in an emergency procedure. USS ALAMO (LSD 33) and USS JUNEAU (LPD 10) were in company. A sailor on the ALAMO sustained a severe crushing injury to the middle finger of his left hand. The independent duty corpsman, who was the senior medical representative on the ALAMO, initiated consultation with the physician on the JUNEAU via a ship-to-ship communication link. Images of the injured finger were transmitted to the JUNEAU. On the basis of the received images, the physician was able to determine that amputation of the finger at the third joint was

10. Telemedicine in Alaska, the ATS-6 Satellite Biomedical Demonstration, by D Foote, E Parker, and H Hudson, Institute for Communication Research, Stanford University, February 1976, p 41.

*By using other modulation techniques (eg, FM) for analog transmission, the low frequencies can be transmitted over a telephone line successfully.

necessary. The physician then instructed the corpsman in the technique for performing the amputation. The physician stated in his report that the RMDS was beneficial to the patient's welfare. He further stated that a dynamic live video presentation might have been more useful during the instruction of the corpsman, but that the slow-scan system was adequate for the procedure.

3.4 TELEMEDICINE UTILIZATION

a) Reported Capabilities

Telemedicine systems have performed a wide variety of medical tasks in several types of environments during the last decade. They have been used as aids to diagnosis, treatment, education, and administration in health care systems for urban populations (ref 11), Indian reservations (ref 12), penal institutions (ref 13), remote rural areas (ref 14, ref 11) and by university medical groups (ref 11). Project reports have been encouraging and generally conclude that the systems have the potential for solving many health care delivery problems. The aggregate of the report comments is that telemedicine provides an effective substitute for the conventional physician-patient meeting when circumstances of time and distance or the social economic situation makes it difficult for either party to travel to a meeting point. Obvious limitations to transmission of certain diagnostic information (ie, tactile and olfactory) are overcome by trained medical persons attending the patient, who perform the requested palpation or other technique and verbalize the results for transmission.

b) Telemedicine Utilization at Naval Medical Treatment Facilities (MTFs) Ashore

The remote medical diagnosis terminals used during the 1975 feasibility testing (ref 1) were subsequently relocated to the Medical Treatment Facilities (MTFs) on San Nicolas Island (SNI), San Clemente Island (SCI), and the National Parachute Test Range (NPTR) at El Centro, California. The Naval Hospital at Port Hueneme served as the remote diagnostic center for SNI, and NRMHC San Diego performed the same function for SCI and NPTR. The use of the terminals was not prescribed but was left up to the medical personnel at each site; they were not required to use the terminals just because they were there.

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11. Technical Report MTR 6787, Benefits and Problems of Seven Exploratory Telemedicine Projects, by JJ O'Neill, JT Nocerino, and P Walcoff, The Mitre Corporation, February 1975.
 12. Telemedicine in a Rural Health Delivery System, by JW Justice and PG Decker, Advances in Biomedical Engineering, vol 7, Academic Press Inc., 1979.
 13. Final Report: An Evaluation of the Impact of Communications Technology and Improved Medical Protocol on Health Care Delivery in Penal Institutions, University of Miami Medical School, Miami FL, NSF Grant GI-39471, December 1976.
 14. Technical Report MTR 7581, Telehealth Handbook: A Guide to Telecommunications Technology for Rural Health Care, by AH Bennett, WH Rappaport, and FL Skinner, The Mitre Corporation, February 1978.

The terminal on SNI was used to transmit 37 ECGs and 18 patient images between March 1977 and November 1979. Since the MTF does not have radiology equipment, images of patients' injuries (ie, lacerations, swelling, etc) were transmitted for consultation. Available data show that as a result of ECG consultations, at least three potential evacuations of personnel with cardiac conditions were averted, one cardiac case was determined to require immediate evacuation, and two other cardiac cases were determined to require only routine evacuation on the next available flight. The system was also used to transmit seven annual physical ECGs. This reduced the time of personnel away from their duty stations and eliminated the need for transportation to the mainland for "the over 40-year age" annual physical checkups.

The terminal at SCI was used for only one actual cardiac case prior to its deactivation in 1978. During its 2-year availability, equipment failure accounted for some of its idleness. Of more significance, however, was the philosophy and attitude of the independent duty corpsmen stationed at SCI. They were confident of their ability to treat routine cases and relied on the readily available helicopter MEDEVAC services to rapidly transport serious injuries to NRMCC San Diego.

After the initial test of equipment in April 1976, NPTR El Centro did not utilize the terminal. NPTR is staffed by a medical officer and several corpsmen. Their nonuse of the system is explained by the fact that they can handle routine cases without consultation and can send serious-injury and life-threatening emergency cases to a civilian hospital in El Centro, which is less than 10 minutes away. The terminal at NPTR did not have an ECG telemetry capability. The medical staff commented that this capability would have been used had it been available.

The results of this project show that the use of remote medical diagnosis units at MTFs can be beneficial but that the extent of their utilization is determined by existing conditions. Utilization for nonemergency functions such as annual physical ECGs and chest X-rays is advantageous. Its utilization when MEDEVAC services are not readily available is of great value. However, when there is a full-medical-capability hospital nearby and MEDEVAC services are readily available, the onsite medical personnel probably will transport a seriously injured patient to the hospital rather than use a remote diagnosis system for consultation.

SECTION 4

ACTIVE SLOW-SCAN TELEHEALTH/TELEMEDICINE SYSTEMS

4.1 SIOUX LOOKOUT ZONE TELEMEDICINE PROJECT

a) Setting

The Sioux Lookout Zone Health Care System provides preventive and curative health care to approximately 10 000 people distributed over an area of 250 000 square miles in northwestern Ontario, Canada. About 80 percent of this population lives in 27 remote communities, none of which is large enough to support a full-time physician. The hub of the health care system is the zone hospital in Sioux Lookout. The hospital is staffed with four family physicians. Seven of the remote communities have nursing stations staffed by trained nurse practitioners equivalent to registered nurses (RNs). The other 20 communities have health aid stations which are staffed by indigenous health aides who have had at least first-aid training. Prior to the initiation of the University of Waterloo/Toronto telemedicine project in 1977 the only means of communication within the health care zone was by telephone and/or high frequency (hf) radio. The telemedicine project installed eight slow-scan television equipments — five in remote communities, one at the zone hospital, and two at major teaching hospitals in Toronto (Sunnybrook Medical Center and the Hospital for Sick Children) to form a telemedicine network. Toronto is about 1000 miles from Sioux Lookout and the nursing stations, and health aid stations are between 200 and 500 miles from the zone hospital. Most of the sites have telephone service. Physician access to and patient evacuation from the communities is completely dependent on air transportation and weather conditions. Closer hospitals at Winnipeg, Thunder Bay, and Dryden provide medical support to the Sioux Lookout Zone. These hospitals are not equipped with telemedicine units, however.

b) System Installation

The basic slow-scan television installation consists of analog transmitting equipment (Colorado Video Model 262B Video Compressor), receiving equipment (Colorado Video Model 275B Video Expander), two television monitors, a closed-circuit TV camera, and an image frame storage. The three hospitals each have two additional monitors and an audio tape recorder. The system uses dial-up telephone service to contact other sites. The transmission of a still image requires 79 seconds.

c) Utilization

The utilization of slow-scan television in the telemedicine project was discussed with Dr. E Dunn, who has been associated with the project since its inception, and Dr. H Shulman, a radiologist at the Sunnybrook Medical Center. The system usage has been in the following principal areas:

• Medical consultation	35%
• Continuing medical education	35%
• Social/therapeutic contact	25%
• Miscellaneous	5%

Most of the medical consultations (approximately 90 percent) have involved the interpretation of transmitted X-ray images, but there have been consultations involving ECGs, plastic surgery (burns), dermatology, physiotherapy, microscope slides, and dentistry.

The use of the systems for the continuing medical education of physicians at the zone hospital, medical personnel in the remote communities, and patients has developed since 1978. Weekly X-ray rounds are conducted by a senior radiologist in Toronto, who discusses films selected by physicians at the zone hospital. As many as 18 X-rays have been transmitted and discussed during the hour-long round. The rounds have also been used to discuss other subjects, such as cardiology, dermatology, and plastic surgery. Other programs from Toronto on general medicine and immunology are now being presented. These X-rays and general medical rounds have been accepted for hour-for-hour study credits by the College of Family Physicians of Canada. Once a month a radiologist visits the zone hospital and takes that opportunity to conduct X-ray rounds for the three television-equipped nursing stations on X-ray films chosen for specific educational objectives and on other films selected by the nurses. The system has been used effectively to teach nurses and other professionals about postural drainage and appropriate dressing technique for severe burns.

Patient education and convalescent follow-up have been performed in cases requiring physiotherapy. For example, a patient who required physiotherapy wished to return to her home, 150 miles distant from the hospital. The physiotherapist, using slow-scan television, was able to instruct the patient's family and the community nurse on the movements and exercises the patient would be required to perform during recuperation. The instructions were recorded at the nursing station so that either the family or the nurse could review the session without requiring a retransmission. Follow-up sessions were conducted which showed the range of motion of the injured leg, so that its recovery could be followed and the physiotherapy could be modified. As a result, the patient was able to return home early and the family was able to conduct the treatment satisfactorily.

Social/therapeutic contacts have proven to benefit the Indians directly. One of the problems affecting health care in this area is the depression exhibited by Indians at the zone hospital who are separated from their families for a prolonged period. The telemedicine system has been used to lessen this feeling of isolation by providing weekly television sessions with their families. It permits them to converse and view pictures. It has also been used for miscellaneous administrative requirements such as transmission of medical records, prescriptions, etc.

d) System Operation

The system is being utilized over 40 times per month. The X-ray consultations for which it has been used most successfully are those which do not involve subtle problems. Subtleties are likely to be masked by telephone line noise or poor-quality X-rays. The nurse practitioners who take X-rays at the remote locations are trained in X-ray techniques but are generally not as proficient as hospital X-ray technicians in obtaining good quality X-rays. Some of the types of illnesses and injuries for which the system has been used successfully are as follows:

- dislocation of bones after a fracture or impact injury
- collapsed lung
- pulmonary edema
- lumbar collapse
- severe pneumonia
- tuberculosis
- bowel obstructions and perforations
- skull fractures
- wounds and lacerations

Conditions for which the system has not been very successful include hairline fractures and small pneumo-thorax. On the average, three X-ray views are required for consultation. The time required for a consultation varies from about 7 minutes for a physician-to-specialist consultation to about 20 minutes for a nurse-to-physician consultation.

e) Users' Attitudes

The attitudes of the health care providers were surveyed by Dr. Dunn for a report currently in preparation. The preliminary results show that (1) the nurses at the nursing stations are favorable to the use of slow-scan television, (2) the radiologists at Toronto accept it with some reservations, and (3) the physicians at the zone hospital are less than enthusiastic. The nurses' most frequently expressed observation concerned the benefit to the patients and their families as a result of the social therapeutic use of the system during hospitalization. The continuing medical education provided over the system was also regarded as very beneficial. The nurses felt that the system would not markedly reduce the number of medical evacuations but that it would permit them to make evacuation decisions with more confidence.

The physicians at the zone hospital expressed the feeling that the system would not prevent unnecessary evacuations. Their reasons were that the need for an evacuation was usually apparent and that only hindsight could tell whether the evacuation was unnecessary. When the situation is in doubt, the wisest course of action is to request evacuation. The physicians agreed that a teleconsultation would be of benefit in determining to which hospital a patient should be evacuated, since the level of support and specialty service provided by Winnipeg, Dryden, and Thunder Bay differed. The physicians felt that the system was a good educational tool but that it was not practical from a cost standpoint.

The difference in attitude between the physicians and the nurses on the need for the system was significant. Dr. Dunn and his colleagues conjecture that because of the physicians' more extensive training, physicians do not feel the same need for medical backup and support that the nurses do. Another factor that may account for the difference in attitude is that the nurses initiate the slow-scan interaction with the zone hospital when appropriate and convenient for themselves, whereas the physicians have to respond when called. This inconvenience to the physicians has tended to generate a negative reaction. The role reversal of the physician's having to respond to the nurse rather than vice versa is considered to be at the heart of this reaction.

The radiologists' initial enthusiastic attitude towards the system and its utilization is somewhat diminished because its use is too time consuming. It was explained that radiologists each normally spend about 75 percent of the working day interpreting 100-150 X-rays. When called upon to leave their normal work area to view an X-ray image being transmitted over the system, their productivity drops. Furthermore, they may require several different views or retransmissions of poor images to perform adequate diagnoses, with consequent increase of time away from their normal "production line" type of activity.

The radiologists stated that the system provides an X-ray image that can be used for diagnosis, provided the system limitations are understood. Fine detail cannot be seen, and it is necessary to take the time to carry on an interactive dialogue and procedure with the physician or nurse attending the patient. For example, questions like "Where is the pain?", "Can you zoom the camera in on such an area?" and "How did the accident occur?" must be asked by the radiologist for the interpretation of an X-ray of below-average image quality. Radiologists felt that the major reason for the poor quality of received X-ray images was that the actual X-ray film was of poor quality to begin with. This observation was made on the basis of reviews of X-rays received from the nursing stations and hospital after the television diagnosis had been made. The principal negative attitude expressed by the radiologists was that when they were called to interpret an X-ray, they became captive to the system for an excessive period. They felt that the system provided an undisputed benefit in "true emergency" consultations but that its use for routine cases was not cost effective.

4.2 DOOR COUNTY MEDICAL CENTER TELEHEALTH SYSTEM PROJECT

a) Setting

The Door County Medical Center Telehealth System* consists of three sites, which are equipped with slow-scan television equipment and interconnected by commercial telephone lines. The Door County Medical Center is located in Sturgeon Bay, Wisconsin, and is staffed with physicians operating in group practice. The other two sites — Nor Dor Clinic at Sister Bay and the Washington Island Clinic — are staffed by two nurse practitioners and one full-time physician.

The clinics serve a population of about 5600 people that grows to over 1 000 000 during the summer months. Access to Washington Island, which is about 10 miles off the northern tip of Door County peninsula, is by airplane or a daily ferry. Travel time between Sturgeon Bay and Sister Bay (32 miles) is 45 minutes. During heavy snows in the winter months the roads become impassable for days at a time. The local population served by the clinic has an above average proportion of the elderly who are generally reluctant to travel to Sturgeon Bay for minor or routine medical care.

*The term "telehealth" is used in documents prepared by MITRE Corporation. It implies a broader range of health-related activities, including patient and provider education and administration, as well as patient care.

b) System Installation

The system utilizes the same telephone line connection for voice and television functions. An exclusion key on the telephone base is actuated to cut out the telephone handset when the image is being transmitted or received. When the key is released, the handset may be used for conversation. The analog receivers, transmitters, and transceivers used in the system are manufactured by Colorado Video Inc. Since they are not type-approved by the FCC for connection to public telephone lines, a protective data coupler or data access arrangement (DAA) is inserted between the equipment and the telephone line. The system was installed in June 1979 with funds provided by the federal government. The project funding expired in May 1981. The Medical Center administration decided to continue operating the system after May 1981 with private funds.

c) Utilization

The utilization of the system was discussed with Mr. John Turk, administrator of the Door County Medical Center. He estimated that system operating time in the last 2 years had been divided between medical consultation (75 percent) and other health care related services (25 percent). The latter category included training, administration, and miscellaneous uses. Because the clinics are relatively close to the Medical Center/Hospital complex, emergency cases are generally transported to the complex without telemedicine consultation. If there is time before the transportation becomes available, however, the nurse practitioners will use the system to alert a physician at the Medical Center of the incoming patient's condition. In the event that weather precludes transportation of an emergency case, the nurse practitioner will attempt to stabilize the patient and then initiate any needed medical consultation. The administrator estimated that life-threatening emergencies such as heart attacks accounted for 5 percent of consultations. Twenty percent of the consultations were for fracture care and fracture-care follow-up. Seventy-five percent of the consultations were for lacerations, dermatological problems, postsurgery follow-up, and throat, chest, and gastrointestinal problems.

Prior to the installation of the system, an estimate was made of the effect that the telehealth system would have on the number of referrals to the medical center. During a sample 3-month period the clinics referred 42 cases to the medical center and other hospitals. Analysis of these cases, based on admission records, concluded that 32 cases would not have been referred if teleconsultation had taken place. The validity of this conclusion was borne out by actual determination of the referral rate after the system was installed. For example during an 11-day period in August 1979, 4 of 8 potential referrals were avoided after consultation by means of the slow-scan television system. During a 25-day period in September 1979, 11 of 13 potential referrals were avoided as a result of teleconsultation. The data extracted from records for September 1979 are shown in table 3. It illustrates the frequency of use and the type of cases for which the system has been employed.

Copies of data only for the months of August and September 1979 were available. The data for October 1979 through March 1981 have been submitted to the METREK Division of the MITRE corporation. The METREK Division is performing an analysis of this 2-year period of the Door County Medical Center Telehealth project. In each of the cases of table 3, the consultation was initiated because of uncertainty of

<u>Date</u>	<u>Reason for Teleconsultation</u>	<u>Referral Action</u>
9/5	Possible spleen rupture	Avoided
9/6	Possible damage to cervical spine	Avoided
9/8	Cough and questionable chest X-ray	Avoided
9/11	Severe abdominal pain	Avoided
9/12	Possible broken fibula	Avoided
9/14	Severe lacerations of fingers	Referred
9/14	Chest pains - possible heart attack	Referred
9/19	Chest pains	Avoided
9/25	Pulmonary tumor (cytology study)	Avoided
9/26	Possible fracture of humerus	Avoided
9/30	Questionable shadow on chest X-ray	Avoided
9/30	Leg laceration	Avoided
9/30	Questionable area on X-ray of spine	Avoided

Table 3. Door County Medical Center Telehealth System usage for September 1979.

diagnosis and to prepare the Medical Center staff for the possible arrival of the patient. The consulted physician was able to clear up the uncertainty, evaluate the urgency of the case, and advise the nurse practitioner on treatment. The comments of the nurse practitioners with regard to the teleconsults are entered on each teleconsultation record sheet. A review of the available record sheets showed that the nurse practitioners evaluated the consultations as "moderately helpful" to "essential," with about 90 percent of the consultations evaluated as "very helpful."

d) System Operation

The system is being utilized 10 to 20 times per month. The consultations are initiated by the nurse practitioners when they deem it appropriate. On the average, two X-ray views are required for consultation. The teleconsults, including waiting time for a physician, are usually completed in 10 to 15 minutes. Since only one telephone service line is used, the television image and voice cannot be transmitted simultaneously. However, the 78 seconds that voice communication is interrupted for image transmission is not considered to detract from the consultation. The provision of a parallel telephone capability would not contribute significantly to the cost of the system operations but is not considered essential. For throat images, the Sister Bay and Washington Island clinics utilize a fiber-optic illuminator and the zoom feature of the camera. Provision for heart-lung sound transmission is being implemented now.

e) Users' Attitudes

The attitude of the medical center administrator was very positive. The telehealth system has enabled the administrator to provide a better quality of health care to the inhabitants of the northern Door County peninsula and Washington Island and to utilize physicians and nurse practitioners more efficiently. A significantly larger number of routine cases and follow-ups are now being handled by nurse practitioners at the clinics. This practice has resulted in saved work-hours and reduced costs.

Because of the isolation, lack of backup, and lack of patient confidence, the rate of turnover of nurse practitioners employed in rural areas is usually high. The Medical Center administrator feels that the system has helped to reduce the nurse practitioner turnover and has saved the inhabitants of Door County the time and expense associated with traveling to the Medical Center for routine cases. Primary-care medical personnel in the clinics are more confident since they have medical specialists' backup through use of the system. Patients' morale is also positively affected. Through the system, medical experts' advice is obtained for their treatment. Physicians at the medical center also have a very positive attitude towards the utilization of the system and its advantages. The administrator stated that nurse practitioner recruiting has been helped by the fact that a telehealth system is installed and used.

4.3 PAPAGO/SAN XAVIER INDIAN RESERVATIONS TELEMEDICINE (SLOW-SCAN TV) SYSTEM

a) Setting

The Papago and San Xavier Indian Reservations are located in the Sonora Desert, west of Tucson, Arizona. The terrain in that area is characterized by alternate flat expanses and clusters of mountains. The reservations occupy approximately 4500 square miles and include 75 villages. Access to most of the villages is over unpaved roads that are difficult to traverse normally and that become hazardous during heavy rains. Sells, Arizona, the administrative center of the Papago Reservation, is connected by a two-lane paved road to some of the villages, the administrative center of San Xavier Reservation, and the highway into Tucson. The population of about 10 000 is scattered among the 75 villages. The characteristics of the population are as follows: median age - 21; median educational grade level - 7.2; principal employment - agriculture and unskilled labor; one-third unemployed; average annual household income - \$3 900. Health care is provided by the Indian Health Service of the Department of Health Education and Welfare. Prior to 1975 the health care system consisted of a 50-bed hospital at Sells, Arizona, staffed by 10 general practitioners, a physician-directed health center near the city of Tucson (San Xavier), a Community Health Medic (CHM)-directed health center 36 miles northwest of Sells, and a health station 45 miles west of Sells that was manned by a CHM once a week. Other clinic services were given in homes, schools, and community buildings. Medical specialty services were available at the Phoenix Indian Medical Center and at nongovernment hospitals in Tucson. Communication facilities included data terminals, telephone service, and vhf two-way radio. The data terminals connected the hospital and health centers with a computerized Health Information Service (HIS). The HIS maintained a record of all health services rendered to reservation inhabitants.

b) System Installation

The telemedicine system was installed by the National Aeronautics and Space Administration (NASA), between 1975 and 1977, to demonstrate the application of space technology communications to support health care. The project was labelled "Space Technology Applied to Rural Papago Advance Health Care" (STARPAHC). To the existing facilities NASA added: (1) a mobile clinic, (2) two-way television (broadband) between Sells, a health center, and the mobile clinic, (3) a minicomputer in Sells, and (4) slow-scan television with digital transmission between

Sells and Phoenix. The slow-scan system terminals were manufactured by Nippon Electronic Company (NEC). Presently the slow-scan system consists of a two-way link between Sells and the medical center at San Xavier reservation and a receiving terminal in Tucson. The terminal in Tucson is located in the offices of the Southern Arizona Radiology and Diagnostic Imaging Associates. The association consists of four radiologists in a group practice. The association also maintains another telemedicine system that provides radiology consultation to private hospitals in Bisbee, Douglas, and Tucson. This second system utilizes Colorado Video Inc. equipment and analog transmission.

c) Utilization

During the initial 2 years of the STARPAHC demonstration project, the slow-scan television terminals were located at Sells and the Phoenix Indian Medical Center (PIMC). The hospital staff used the system sporadically for consultations with specialists at PIMC. However, almost all patients with emergency health problems were sent to referral hospitals in Tucson, which was not part of the system, because Tucson was only 60 miles away whereas Phoenix was 145 miles. The system was also used to study simulated clinical situations of three types: radiology, skin tones and orbital (eye) pictures, and microscopy. In early 1980, the Southern Arizona Radiology and Diagnostic Imaging Associates were retained with DHEW funds, to provide radiology consultations to the hospital at Sells and the health center at San Xavier, and the slow-scan TV system was relocated from PIMC to their office in Tucson.

d) System Operation

Slow-scan television operation was evaluated to be good during the STARPAHC project but its rate of usage was low. For example, during 205 days selected for evaluation of the video portion of the systems (both broadband and slow-scan) the slow-scan system was operated for actual cases only nine times. Analysis of these nine cases showed that all consultations were initiated because there was a genuine need for the consultation and not just because the equipment was available. The using physicians reported that seven of the consultations were of value, one was of no value, and one could not be categorized because the patient never returned to the hospital. All nine cases were X-rays of bones.

The broadband system, which used microwave transmission to link the mobile clinic, health center, and Sells hospital, was used 124 times during the 205 days. Analysis of these consultations showed that 103 consultations (83 percent) were made because of genuine need for consultation. The users included the nonphysician CHMs, who initiated the consultation, and the physicians at Sells. They agreed that 77 percent of the consultations were of value, 7 percent were of no value, and 13 percent were not categorized, since the patients could not be located after consultation. Three percent of the consultations were evaluated to have a harmful potential. Since actual usage of the slow-scan system was minimal during the project, there was time to simulate clinical situations under controlled circumstances. Chest and bone X-ray images were satisfactorily transmitted. Hairline fractures, 1 mm wide, were readily observed by the radiologists. Abdomen X-rays, however, proved to be extremely difficult to interpret correctly via slow-scan television. Skin tone and orbital picture experiments were largely unsatisfactory. Microscopy of blood smears and mixed flora produced images which the microbiologist at PIMC felt comfortable to read. Video image interpretation of the blood smears was 89 percent accurate, and that of the mixed flora was only 58 percent accurate when compared with the original smears.

Because of equipment failures, lack of maintenance parts, and lack of repair personnel, the link between Sells, San Xavier reservation, and the private radiologists in Tucson has been inoperable most of the time since 1980. In contrast, the previous 4 years of operation at PIMC had been relatively troublefree. When the system was moved to Tucson, it became essentially nonfunctional. In direct contrast to the poor reliability of the Indian Health Service slow-scan system is the successful operation of the Southern Arizona Radiology and Diagnostic Imaging Associates system. Dr. Weiss, of that association, stated that approximately four consultations per week are conducted via the Colorado Video equipment. His service is provided 24 hours per day, 7 days per week. Each of the radiologists has a terminal at home for after-working-hour emergencies. The office telephone system automatically transfers after-hours calls to the home of the radiologist on night duty.

e) Users' Attitudes

The attitudes of Indian Health Service physicians varied with respect to reliance on interpretation of video images for diagnosis. Some staff physician specialists at PIMC much preferred that patients be flown in person to the Medical Center rather than consulted about over television. No time was available from their full schedules for the radiologists to receive adequate training and experience with the new system. The referral center (Phoenix) also experienced considerable staff turnover during the time the system was evaluated. The major negative effects reported by physicians were the time lost in responding to a consultation, having to leave patients in the exam room while responding to a special teleconsultation, and time lost due to equipment malfunctions. Physician turnover problems were also experienced at Sells. Indian Health Service physicians at Sells are general practitioners most of whom, during the STARPAHC period, had just completed internship. Most of the physicians that were at Sells during system installation departed before the project was completed. The new physicians were faced with use of a system that was new to them and in which they had little confidence. As a result they did not utilize it to any great extent. It was noted that those physicians who attempted to use the system but experienced difficulty because of system malfunction or breakdown could not be induced to use it a second time. It was very evident that to build confidence and reliance on telemedicine, organization and training in system use are essential.

4.4 RADIOLOGY IMAGING ASSOCIATION, ENGLEWOOD, COLORADO

a) Setting

The Radiology Imaging Association is a radiology group practice located in Englewood, Colorado, a suburb of Denver. The association provides radiology services to 14 small and 2 large hospitals. The Swedish Medical Center in Englewood is one of the larger hospitals serviced by the association. It has a large paraplegic and quadriplegic center. The other small hospitals are located in outlying communities that require several hours to reach by automobile. The smaller hospitals are staffed by general practitioners who rely on medical centers in Denver for specialty services. The community hospitals do not have enough radiology work to support a full-time radiologist. The physicians at the hospital interpret X-rays of routine cases and depend on radiologist support from Denver. In the past this has been provided by part-time radiologists who made periodic visits to the community hospitals and by use of the mail system.

b) System Installation

The association has installed 10 slow-scan television terminals through private funding. One of the terminals is at the Swedish Medical Center, one is at the association's Englewood office, and the others are in outlying community hospitals. The outlying terminals, connected to the Swedish Medical Center and the association's office with dedicated telephone lines, use analog transmission. The terminals are manufactured by Colorado Video, Inc.

c) Utilization

The utilization of the system was discussed with Dr. WE Jobe, of the Radiology Imaging Association, who has been personally responsible for installing the system and developing the organization for its use. He stated that the system has been of value in resolving uncertainties in X-ray interpretations for general practitioners in the outlying hospitals. These practitioners interpret X-ray films per their usual routine but use the system to verify the urgency of a case (ie, the need to do exploratory surgery, evacuate the patient, etc). In cases where there is uncertainty as to diagnosis and therefore appropriate treatment, the physicians could utilize the system to obtain expert opinion as protection against possible malpractice suits. Dr. Jobe related several instances in which radiologists in Englewood have been able to help physicians make better decisions through telemedicine consultation. In some of these cases evacuations have been averted, and in others the consultations have assisted the physicians in determining the most appropriate medical center for evacuation treatment. The system has been used successfully for transmitting X-ray images of the chest, extremities, spine, abdomen, and skull.

d) System Operation

The system is being utilized at a rate of 3 to 4 times per day. A telephone switching service relays calls to the "duty" radiologist's residence after working hours. The radiologist then proceeds to the Swedish Medical Center or the association office to consult on the interpretation of the transmitted X-ray image. The average telemedicine consultation requires 15 to 20 minutes and involves a minimum of three views. The originals of all X-ray films transmitted for consultation are reviewed by the consulting radiologist within a day or two of the consultation. These films are transported to the association office by the most expeditious means available. Rarely have any significant differences in interpretation been discovered.

e) Users' Attitudes

All the general practitioners in the outlying communities have used the telemedicine system for radiology consultation at one time or another. Dr. Jobe has observed, however, that some of them — especially the older physicians — seem to be reluctant to use the system as much as they could. He attributes the reluctance to their feeling that a consultation exposes some lack of competence, as has been stated by other radiologists interviewed during the course of the study. To allay this attitude, he has made a practice of periodically visiting all the hospitals that have terminals installed, for the purpose of maintaining a personal relationship with all the physicians. He feels that because of their recent exposure to the "give and take" atmosphere in teaching hospitals, the younger physicians are more willing to accept innovative

medical practice techniques and are not as sensitive to the unpleasant "big brother" situation that sometimes develops during a consultation.

The telemedicine system has benefitted the group practice as well as the outlying communities. It has permitted the Radiology Imaging Association to extend service to communities which have a relatively light requirement for radiology, without reducing group productivity. It has also provided the communities with a rapid consultation capability, at a level of expertise which they did not have before the link was established. Previous to the telemedicine link, individual radiologists made periodic visits to the community hospitals. The time expended in travel and the underutilization of the radiologists at the hospitals were wasteful. The communities now have 24-hour access to the collective experience of a group rather than to just one radiologist.

Dr. Jobe expressed the opinion that the successful use of telemedicine can be achieved only by exposing physicians to its application through educational programs. Any attempted use of the system that is thwarted by equipment breakdown or improper operation, producing an unsatisfactory result, will likely dissuade the physician from attempting to use the system again. He recommends that a short training period on the operation of the system be given to each potential user and that the instructor have an electronic and video background.

4.5 RHODE ISLAND HOSPITAL/BLOCK ISLAND TELEMEDICINE SYSTEM

a) Setting

Block Island is situated about 10 miles off the mainland coast of Rhode Island. Its population of 450 permanent residents increases to 10 000 during the summer vacation months. During the winter months there are eight scheduled commuter flights and a daily ferry to the mainland. Dr. Cornbrooks is the island's one general practitioner.

b) System Installation

The telemedicine system consists of a Colorado Video Inc. slow-scan terminal (analog transmission) and a telephone, which use separate private lines. The equipment was installed as part of the Rhode Island Rural Health Demonstration Project, which was conducted from 1976 to 1979. The video equipment is on loan to Block Island, and the town council is deliberating its purchase for the Block Island clinic.

c) Utilization

The system was installed to provide medically underserved Block Island with a capability to consult specialists on the mainland. The system is used to send X-ray and electrocardiogram images, for consultation, to the Rhode Island Hospital at Providence, Rhode Island, about 45 miles away. It has not been used during the first 4 months of 1981 because there has not been a need for consultation. The system has been used primarily for chest X-ray and electrocardiogram image transmission.

d) System Operation

The exchange of video information has been performed successfully without operational or equipment problems. The greatest benefit has been realized from the transmission of ECG images. Although there has been little need for consultation on X-ray interpretation, there has been a need to interpret ECG images. Block Island transmits ECG images over the television system to cardiologists at the Providence Hospital. In several instances anomalies have been detected by the cardiologists that were not recognized by direct viewing of the ECG strip.

e) Users' Attitudes

Dr. Cornbrooks has a positive opinion of the system. It has been reliable in operation and has helped resolve uncertainties in diagnosing cardiac conditions. Probably the system would be utilized more frequently by a nonphysician practitioner.

SECTION 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

1. Consultation over RMDS-type systems reduces medical referrals and evacuations and assists in triage decisions.
2. Radiologists who are familiar with the limitations and capabilities of RMDS-type systems can interpret televised radiographs with the confidence required to make recommendations for major decisions such as the need for surgery, medical evacuation, etc.
3. The utilization of RMDS on ships and at remote shore sites has the potential for improved diagnoses.
4. Teleconsultations on radiographs or patient images are usually completed in approximately 15 minutes and seldom take more than 30 minutes.
5. Consultation over RMDS-type systems provides advance information to an emergency room staff prior to the arrival of an incoming patient.
6. The principal utilization of RMDS-type systems has been for radiology consultation.
7. Nonphysician medical personnel accept RMDS-type systems for consultation more readily than do physicians.
8. The effective utilization of RMDS-type systems can be improved by properly indoctrinating and motivating all personnel involved with the systems.
9. Successful operation of a telemedicine system requires establishment of organizational responsibility for system management, operation, and maintenance.

In summary, RMDS-type systems reduce medical referrals and evacuations and can be used effectively for radiology consultations as well as general medical emergencies. Test and evaluation of the RMDS EDM terminals will provide a further understanding of the utilization potential of RMDS in the US Navy health care program.

5.2 RECOMMENDATIONS

1. The US Navy should pursue eventual fleet implementation of the Remote Medical Diagnosis System aboard ships and at remote medical facilities.

2. As a result of the clear potential and interest for teleradiology via RMDS-type systems throughout all military medical facilities, closely coordinate development and implementation of the RMDS EDMs with the Tri-Service Medical Information Systems (TRIMIS) Program Office.
3. Develop a formal RMDS indoctrination program for all personnel involved in the RMDS EDM test and evaluation. As a minimum, this program should cover RMDS mission, capability, and limitations, as well as equipment operating techniques.
4. Assign specific organizational responsibility for the management, operation, and maintenance of the RMDS EDM terminal.
5. Develop a protocol for RMDS terminal operation with the objectives of standardizing equipment operation for the various types of cases and reducing consultation time.
6. Perform a survey of users' acceptance of RMDS as a consultation medium, as part of the test and evaluation of the RMDS EDM terminals.

SECTION 6

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**APPENDIX A: LIST OF ROUTINE VIEWS
OF RADIOLOGIC EXAMINATIONS**

(Extracted from Naval Regional
Medical Center San Diego Memo
14-FWG:cwh dated 2 January 1981)

NAVAL REGIONAL MEDICAL CENTER
SAN DIEGO, CALIFORNIA

14-FHG:cwh
2 January 1981

MEMORANDUM

FROM: Chairman, Radiology Department
TO: ALL REGIONAL RADIOLOGIC FACILITIES
SUBJ: List of Routine Views of Radiologic Examinations

1. The following are routine views to be used in the Region:

<u>EXAMINATION</u>	<u>VIEWS</u>	<u>FILM</u>	<u># VIEWS</u>	<u># FILMS</u>	<u># EXPO- SURES</u>
<u>CHEST</u>					
Routine	Posteroanterior (PA) Left Lateral	14x17 14x17	2	2	2
Cardiac Series	PA, RAO, LAO (60°), & Upright & Lateral with barium	14x17	5	5	5
Ribs	Anteroposterior (AP), Oblique & PA Chest (when possible)	14x17	3	3	3
Sternum	RAO and Lateral	10x12	2	2	2
<u>UPPER EXTREMITIES</u> - Use Detail Cassette techniques for all forearm, wrist, and hand views when requested by radiologist.					
Fingers	PA Hand with two views of affected finger	1-10x12 1-8x10	3	2	3
Hand	PA, Oblique & Lateral	1-10x12 1-8x10	3	2	3
Wrist (routine)	PA, Oblique & Lateral	10x12	3	1	3
(navicular)	PA, Oblique, Lateral, & Ulnar View	10x12	4	1	4
Forearm	AP and Lateral	11x14	2	1	2

EXAMINATION	VIEWS	FILM	# VIEWS	# FILMS	# EXPO- SURES
Elbow (non-trauma)	AP & 90°-flexed Lateral	8x10	2	1	2
(trauma)	AP, 90°-flexed Lateral and right & left Obliques	10x12	4	1	4
Humerus	AP and Lateral	11x14	2	2	2
Shoulder	AP internal/ external rotation	8x10	2	2	2
AC Joint	AP with/without 20 lb weights	8x10	2	2	2
Clavicle	AP & 20° cephalad	11x14	2	1	2
Scapula	AP and lateral	10x12	2	2	2
LOWER EXTREMITIES - Use Detail Cassette techniques for all feet and toe studies when requested by radiologist.					
Toes	AP foot and three views of affected toe	1-10x12 1-8x10	3	2	3
Foot	AP, Oblique & Lateral	1-10x12 1-8x10	3	2	3
Heel	Tangential and Lateral	8x10	2	2	2
Ankle	AP, Oblique, and Lateral	1-10x12 1-8x10	3	2	3
Tibia/Fibula	AP and Lateral	14x17	2	2	2
Knee	AP and Lateral (patellar series include sunset and tunnel views; trauma cases in- clude both Obliques and PA)	8x10	4	4	4
Femur	AP and Lateral	14x17	2	2	2
Pelvis	AP	14x17	1	1	1

<u>EXAMINATION</u>	<u>VIEWS</u>	<u>FILM</u>	<u># VIEWS</u>	<u># FILMS</u>	<u># EXPO- SURES</u>
Hips	AP and frogleg (feet rotated inward), views of pelvis	14x17	2	2	2
<u>SPINE VIEWS</u>					
Cervical Spine	AP, Obliques, Lateral and Odontoid. Tomography when needed	8x10	5	5	5
Thoracic Spine	AP and Lateral	14x17	2	2	2
Lumbar Spine	AP, Obliques, Lateral and L5-S1 spot film	4-11x17 1-8x10	5	5	5
Sacrum and Coccyx	AP (20° cephalad and 15° caudad tube tilt) and Lateral view	10x12	2	2	2
Sacroiliac Joints	Both Obliques and AP with 20° cephalad tube tilt	14x17	2	2	2
<u>ABDOMINAL VIEWS</u>					
Acute Abdominal Series	PA chest; upright abdomen and KUB supine	14x17	3	3	3
KUB	Kidneys-ureters-bladder (evaluation of suspected renal calculi), AP supine with low kV technique	14x17	1	1	1
Fetogram	AP supine (evaluation of multiple pregnancy) or LPO (evaluation of definite femoral epiphyses)	14x17	1	1	1
Pelvimetry	AP and Lateral with Colcher-Sussman caliper (upright Lateral with caliper when requested)	14x17	2	2	2

<u>EXAMINATION</u>	<u>VIEWS</u>	<u>FILM</u>	<u># VIEWS</u>	<u># FILMS</u>	<u># EXPO- SURES</u>
<u>SKULL VIEWS</u>					
Skull Series	PA, Townes' and both Laterals	10x12	4	4	4
Facial Series	Upright Waters' view, Lateral of injured side, Submentovertex or modified sub- mentovertex (PA skull with modified 17° caudal tube tilt) and AP skull	10x12	5	5	5
Mandible	PA, Obliques and accentuated Townes' view, SMV or modified SMV view	8x10	5	5	5
Zygomatic Arch	SMV modified and Townes' view accentua- ted and Waters' view	8x10	3	3	3
Orbits	PA skull, Waters' view, Lateral and Tangential (Stenver's)	8x10	4	4	4
Nasal Bones	Waters' view and soft tissue Laterals	8x10	3	2	3
Optic Foramina	Both PAO. Check with radiologist	8x10	2	2	2
Foreign Body	PA with eyes up, straight, and down, Waters' view and Lateral. Check with radiologist	10x12	2	2	2
Temporomandi- bular Joints	Open and closed mouth bilateral Law's pro- jection (Lateral with 20° caudal tube tilt). Townes' view centered to TMJs.	8x10	5	5	5

<u>EXAMINATION</u>	<u>VIEWS</u>	<u>FILM</u>	<u># VIEWS</u>	<u># FILMS</u>	<u># EXPO- SURES</u>
Sinus Series	Caldwell PA skull; open mouth Waters' view; Lateral of affected side (in- clude SMV or modified SMV). All films taken in upright position.	8x10	4	4	4
Mastoid Series	Law's, Stenver's, Mayer's, Owens', and Townes' and a straight PA (trans- orbital) view.	8x10	6	6	6

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