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Space Technology in Remote Health Care

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INTRODUCTION

Crews and passengers on future long-duration Earth orbital and interplanetary missions must be provided quality health services—to combat illnesses and accidental injuries, and for routine preventive care. People on Earth-orbital missions can be returned relatively easily to Earth, but those on interplanetary missions cannot. Accordingly, crews on long-duration missions will likely include at least one specially trained person, perhaps a physician's assistant, hospital corpsman, nurse, or physician who will be responsible for providing onboard health services. Specifically, we must determine the most effective way to administer health care to a remotely located population.

Many similarities exist between administering quality health care in a spacecraft and administering the same care to a remote population on Earth. In remote areas on Earth, health care is often administered under less than optimal conditions (e.g., limited clinical equipment, lack of adequate surgical and therapeutic facilities, coupled with the limited ability to consult with specialists). An electrocardiogram (ECG) from a crewmember in a spacecraft can be communicated to the ground in a nearly identical way as from a patient in a remote location on Earth. A high-resolution television presentation of an X-ray picture of a fracture from a space traveller might be transmitted and evaluated the same way as an X-ray obtained and transmitted from a patient on Earth.

We must determine the probability of illnesses and injuries in space and provide procedures, equipment, instruments, and pharmaceuticals to diagnose and treat them there. We must define the medical and surgical skill required of the onboard health-care provider. We must also determine the extent of guidance that can be given in handling serious medical emergencies by two-way voice communication and vehicle-to-ground television links. For example, an onboard physician might be guided step-by-step through emergency surgery by a fully qualified surgeon via a TV-voice link when ground contact is possible.

Significantly, the communication and data processing systems required on long-duration space missions may also be similar to those required for providing remote health-care services on the ground. Thus, operating a "test bed" health care system in selected remote locations on Earth

can provide a reasonable simulation for gathering information that could be applied to designing a flight system. This approach has "spin- off" potential, in that space technology employed in the basic design of a flight system may eventually improve the quality of health care delivery on Earth.

Citizens of remote areas on Earth face an ever-increasing shortage of quality health care. This problem results from national shortages of trained physicians, remote areas being unable to attract new physicians, and geographic dispersal of populations and medical capabilities, among other reasons. A system that allows physicians to administer quality health care to patients in remote areas, without being physically present, may provide a satisfactory solution.

As a result of these considerations, the National Aeronautics and Space Administration (NASA), with the cooperation of the Department of Health, Education and Welfare (HEW), is pursuing a program for providing health services to a remote location on Earth as a necessary step to developing and verifying this capability on a spacecraft. The content of this demonstration program is described below.

THE STARPAHC PROGRAM

The overall goal of this program is to assemble a ground-based remote area health care delivery system and operate it for 2 years in a remote location. The specific objectives are:

- To provide data for developing health care for future space crews through:
 - Further development of the physician-paramedic link
 - Clinical evaluation of advanced bioinstrumentation
 - Development of computer support for "remote" health care
 - Integration of video viewing and display devices
 - Definition of skills, training and procedural requirements
 - Evaluation of existing techniques for space application
 - Identification of areas requiring technology advancements
 - Refinement of protocols and techniques
- To improve the delivery of health care to remote areas on Earth through:
 - Improved communication methods
 - Mobile health clinic
 - Advanced health care equipment
 - Computer aids
 - Assistance to allied health professionals and health education programs

On April 17, 1973, HEW Secretary Caspar Weinberger announced that the Papago Indian Reservation in Arizona would be the site for operational testing of a system to "improve medical care in space and remote Earth locations." Accordingly, the program now is identified with the

name STARPAHC, which is an acronym for Space Technology Applied to Rural Papago Advanced Health Care.

The Site: The Papago Indian Reservation, Arizona. The Papago site was selected by HEW and NASA for several reasons, including the community's willingness to support the cost of the system after the test period was completed, and its willingness to accept primary care from physician's assistants. Arizona is one of 28 states that allow physician's assistants to provide primary care. The beneficiaries of this program would be the 8-10 thousand permanent residents of 75 villages in the Papago reservation, and also the 2-4 thousand who live outside the reservation's boundaries but return there for health care. The tribe governs itself through a tribal council and has complete police jurisdiction on the reservation. The average family size is 4.8 persons, and the median age is 21 years.

The Papago reservation covers approximately 11,180 square kilometers (4,300 square miles) east of Tucson and south of Phoenix with the Mexican border on its southern boundary. The reservation is in the Sonora Desert—a rough, dry terrain with intermittent mountain clusters. Utilities, where available, are of fair to poor quality. Power outages of 6 hours or more are frequent in July and August, even in Sells and Santa Rosa, the "big cities." Water is supplied to villages by wells. Highways are asphalt-surfaced, but other roads are graveled, unpaved and bumpy, and can be hazardous immediately after rainstorms. The main industry is raising cattle; the average annual income is approximately \$900 per family.

The HEW's Indian Health Service (IHS) administers health care on the reservation through a hospital at Sells and a part-time clinic at Santa Rosa. A large, well-equipped Indian Health Hospital in Phoenix has many specialists on the staff. In the STARPAHC system, Sells and Santa Rosa were selected as key elements for the Support Control Center (SCC) and the Local Health Services Center (LHSC), respectively. Also, the Phoenix hospital is the primary referral center (PRC). A Mobile Health Unit (MHU) is used to deliver health-care services to remote villages. The MHU is a well-equipped mobile facility staffed by physician's assistants. These system elements are described in more detail below.

SYSTEM CONFIGURATION

The STARPAHC system synthesizes a series of basic facilities, service elements and supporting functions into an operating system. The system consists primarily of:

1. The Health Services Support Control Center (HSSCC or SCC) is located in a wing of the Sells Hospital and is analogous to NASA's Mission Control Center. It is staffed by physicians and a system operator.

2. A Local Health Service Center (LHSC) is the Santa Rosa Clinic. It is staffed by a physician's assistant and functions as a fixed remote clinic.
3. The Mobile Health Unit (MHU) is a clinically equipped van-type vehicle staffed with a physician's assistant and a laboratory technician. It functions as a remote mobile clinic, visiting villages on a preselected route and schedule.
4. The Phoenix Referral Center (PRC) is a dedicated room in the Indian Health Hospital in Phoenix for access to specialists, through audio and slow-scan television links with SCC, LHSC, and MHU.
5. The Tucson Computer Center (TCC) provides STARPAHC data system access to the IHS Health Information System data base.
6. The Quijotoa Relay Station (QRS) is used for microwave and VHF transmission of television, voice and data between major system elements.
7. The Telecare Unit (sometimes called PAM) is a suitcase-size, portable, ambulance-carried selection of medical equipment for emergencies and house calls to bedridden patients.

System Operation. The basic operational features of the STARPAHC system are:

- Medically trained Community Health Medics (CHMs), commonly known as "physician's assistants," are at the fixed (LHSC) and mobile (MHU) clinics. These CHMs administer health care to patients under the direct supervision of the physicians who are miles away at the Sells Hospital (HSSCC). The CHMs are linked to the physician through radio and TV hookups, allowing the physician to view the patient, the affected body area, X-rays, microscope slides, etc. Simultaneously, descriptions and responses to the physician's questions (by the CHM and patient) can take place via the radio link. This in effect extends the high-quality diagnostic and treatment capability of the physician over large distances and several clinics while he or she is at a hospital (the HSSCC).
- An automatic data processing network supports the activities of the physician, CHM, laboratory technician and other system personnel by enabling them to request important information from the computer using keyboarded terminals. The requested information is displayed on a TV-type screen almost instantaneously and can include patient histories, instruction for care, diagnostic aids, etc. After the patient's visit, information is entered into the data system via the same terminals so that all patient information is current.
- When the physician at the HSSCC wants to consult with a specialist in the Phoenix Indian Health Hospital through the HSSCC, views of X-rays, wounds, lesions, patients, etc., can be transmitted from either clinic to the specialist's station using

the slow-scan TV. A direct telephone line is also available for discussion with the specialist.

- This combination of capabilities enables patients at the remote clinics to be diagnosed by the physician miles away at the hospital, and to be treated immediately by the CHM in the clinic under the physician's direction. The entire activity is accomplished quickly, without the need for traveling considerable distances.

The Mobile Health Unit (MHU). The MHU is a mobile clinic that visits villages on a scheduled basis. Staffed by CHMs and laboratory technicians, the MHU gives the physician a flexible "outreach" capability. Its use and features are summarized below.

A patient enters the reception area and is interviewed by a CHM to determine complaint, symptoms, duration, etc. The CHM calls up a patient history or other pertinent information as needed using the data terminal keyboards. Patients are examined in the examining room, where the physician is in radio contact with the CHM and can view the patient via TV (CHM uses the color TV camera above the examining table). If the physician decides that a view of a body orifice (e.g., the throat) is necessary, then the CHM uses the patient-viewing microscope (PVM), under voice direction of the physician, while checking the TV monitor. The PVM uses fiber optics to illuminate the viewing area and to return the image to a TV camera, from which it is transmitted to the physician at the HSSCC. Should the physician wish to review slides, such as blood smear or culture, the trinocular microscope assembly includes a TV camera to transmit the view through the microscope. The laboratory area is equipped to conduct biochemical analyses usually required for clinical examinations (blood work, urinalysis, etc.). When X-rays are required, they are taken and developed in the X-ray room. This room also contains equipment enabling the technician to transmit the X-ray to the physician at the HSSCC via TV.

Santa Rosa Health Center (LHSC). The Local Health Services Center (LHSC) is an existing clinic, the capabilities of which are enhanced by the equipment and staff needed to meet its functions in the STARPAHC system. The LHSC is staffed with CHMs, laboratory technicians, and a secretary/receptionist. Like the MHU, its function provides the physician at the HSSCC with "outreach" capability to deliver quality health care to patients through STARPAHC. It has considerably more usable area for clinical examination, patient treatment and laboratory facilities than does the MHU. Its operational procedures for patient, CHM, or physician activity are generally the same as those described for the MHU.

Sells Hospital (HSSCC). The HSSCC is the base for the STARPAHC operations. The Indian Hospital at Sells, Arizona, contains a portion of one wing as the STARPAHC system HSSCC. Here the physician directs the CHMs, laboratory technicians, communicates with patients and calls up data to assist in patient examination and treatment. The physician can also consult with specialists at the Phoenix Indian Health Hospital (PRC) and direct functions of the

system operator, such as recording the TV image, sending slow-scan X-rays to the PRC, or "patching in" other needed capabilities.

As the operational base, supporting engineering functions such as scheduling, logistics, maintenance, reporting, etc., are managed and controlled from the HSSCC. The HSSCC also houses the system data processing equipment and maintenance functions.

Physician's Console (HSSCC). The physician's console in the HSSCC is the focal point of the system. As the system's control center, it provides physicians with the required displays and controls. These controls and displays have been selected carefully for maximum flexibility as well as maximum ease of use. Privacy on voice and TV circuits can also be controlled. Most important is the capability to control the TV cameras at the MHU and LHSC directly from the physicians console/for optimal visualization of the patient.

Phoenix Referral Center (PRC). The referral center at the Indian Health Hospital in Phoenix (the PRC) is staffed with and has access to medical specialists. In the STARPAHC system, these specialists can be called upon to consult with the HSSCC physicians when unique or complex medical advice is in order. To enhance the consultation, the system allows transmission of X-rays or pictures of the patient, lesions, etc., via slow-scan TV using existing telephone lines. These same telephone lines also allow voice communication and data transmission between the HSSCC and the PRC. The slow-scan capability provides X-rays or picture transmission in 45 to 90 seconds. It inherently records the transmission, which enables almost unlimited playback for extensive study at different times and for various durations.

PROGRAM PARTICIPANTS

- The Papago Indian Tribe and its Executive Health Council
- The HEW Health Resources Administration
- The Indian Health Service Center for Research and Development
- The NASA Office of Manned Space Flight
- The Lyndon B. Johnson Space Center, Life Sciences Directorate, Bioengineering Systems Division
- The Lockheed Missiles and Space Company, Inc. (contractor to NASA)

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