BIBLIOGRAPHIC DATA SHEET

PN-AAJ-901

TWO-WAY RADIO FOR RURAL HEALTH CARE; AN OVERVIEW

PERSONAL AUTHORS - GOLDSCHMIDT, DOUGLAS
HUDSON, H.E.
LYNN, WILMA

CORPORATE AUTHORS - ACAD. FOR EDUCATION DEVELOPMENT

1980, 63P.

ARC NUMBER -
CONTRACT NUMBER - AID/TA-C-1473
PROJECT NUMBERS - 9311109
SUBJECT CLASS - ND000C000000

DESCRIPTORS - HEALTH ASPECTS
HEALTH DELIVERY
RADIO
COMMUNICATION SYSTEMS
COMMUNICATIONS TECHNOLOGY
RURAL AREAS
RURAL HEALTH

Academy for
Educational
Development

AED
International Division

TWO-WAY RADIO FOR RURAL HEALTH CARE: AN OVERVIEW

Douglas Goldschmidt
Heather E. Hudson
Wilma Lynn

May 1980

This report was prepared for the U.S. Agency for International Development, Office of Education, Development Support Bureau, by the Academy for Educational Development under contract no. AID/ta-C-1473.

1414 22nd Street, N.W.
Washington, D.C. 20037
(202) 862-1900
Cable ACADED WSH 89660

931-1109
PN-AAJ-901

A.I.D. STUDIES IN DEVELOPMENT COMMUNICATIONS

TWO-WAY RADIO FOR RURAL HEALTH CARE: AN OVERVIEW

MAY 1980

OFFICE OF EDUCATION
DEVELOPMENT SUPPORT BUREAU
AGENCY FOR INTERNATIONAL DEVELOPMENT

TABLE OF CONTENTS

		page
I.	Introduction	
	A. Difficulties in Rural Health Care Delivery	1
	B. Two-way Communication Technologies	2
	C. Components of a Two-Way Radio System	5
II.	Functions of Two-Way Communication	
	A. Medical Consultation and Referrals	7
	B. Administration	8
	C. Coordination of Transportation	9
	D. Continuing Education	11
	E. "Bush Telephone" Uses	12
	F. Disaster Relief	12
	G. Data on Functions of Two-Way Systems	14
III.	Cost Considerations	
	A. Installation and Maintenance Options	16
	B. Radio System Costs	18
IV.	Problems and Sources of Failure in Two-Way Radio Projects	
	A. Technical Problems	24
	B. Organizational Problems and Sources of Failure	28
V.	North American Projects in Two-Way Communications for Health Care	
	A. Project Summaries	31
VI.	Conclusions	34
	Appendix A	
	Radio System Costs Per Site	36
	VHF FM Solar Installation (PLENTY: Bangladesh)	37
	Citizens' Band (CB) Installation: Nicaragua	38
	Appendix B	
	Summary of Two-Way Communication Technologies	39
	Appendix C	
	Summaries of Two-Way Communication Projects for Health Services Delivery	

TWO-WAY RADIO FOR RURAL HEALTH CARE: AN OVERVIEW

I. INTRODUCTION

A. DIFFICULTIES IN RURAL HEALTH CARE DELIVERY

The growing emphasis on the needs of the rural poor in the developing world has focused attention on creating innovative means of extending health care to rural areas. It has been evident for some time that it is difficult and expensive to extend physician-based health care into rural areas. Not only are there shortages of physicians available and willing to serve in such areas, but the use of physicians in such contexts is often a poor allocation of resources. Rural areas usually lack the supporting medical infrastructure which physicians rely on--laboratories, diagnostic equipment, hospitals, and the like. Further, the provision of such an infrastructure would be prohibitively expensive. However, without an alternative to physician-based care, rural populations are left without any medical care.

The innovations of the Chinese "barefoot doctor" system, and of similar efforts to train cadres of rural health workers in other countries, have modified the approach to rural health care. Rather than relying on physicians, health planners for populations are turning to paraprofessionals, at varying levels of training. These paraprofessionals, consisting of nurses, health aides midwives, and medics, provide "front line" rural primary and preventive health care.

However, the very isolation of rural areas creates difficulties for provision of even these relatively simple medical services. The isolation makes administration of health programs difficult. Ordering drugs and supplies can take several weeks or months--usually far too long to wait, particularly during epidemics. The transmission of data for laboratory tests, and the results, may take so long at times that test results are of interest only to the statisticians. Emergency referrals to hospitals may wait for days in many areas for transportation to be arranged. In treating complicated cases, health workers

must rely on their own limited training and skills, or risk an often difficult and expensive evacuation.

Aside from the various urgencies of health care, routine administrative and medical procedures may be significantly delayed, or prevented, in the absence of reliable communications. Further, for many of the medical personnel, the isolation of the rural communities can contribute to loneliness, which in turn induces higher levels of staff turnover, and, most importantly, stagnation of skills. Without regular interchanges of information on medical procedures, the field staff can quickly fall behind in developing new skills, or even in maintaining current knowledge.

In such an environment, the possibilities of two-way telecommunications have become attractive. A two-way communications system offers the possibility of regular administrative and medical consultations, as well as a practical medium for other official and non-official communications.

B. TWO-WAY COMMUNICATION TECHNOLOGIES

Several technologies may be used for two-way communication. All permit two-way voice communication between two sites; some can be used for conferencing among several sites. They vary in cost, range (distance), quality of signal, and reliability.

Telephone communications are generally the highest quality two-way communications available. Assuming that service is maintained at a commercial level, telephone networks should provide 24-hour reliable communications of high audio quality. Unfortunately, telephone networks are extremely expensive to construct and are only beginning to be extended into rural areas. Further, many of the telephone networks of LDCs are of marginal quality, and of sub-marginal quality in the rural areas.

Telephone signals may be transmitted in a variety of ways. The most common in developing regions is over open wires. Such systems, however, are vulnerable to corrosion, breaks in the line, downed poles, removal of the wire for ornaments or buildings, etc. Telephone signals may also be transmitted via microwave, with signals relayed from one repeater tower to the next. These systems have much greater capacity than open wire systems. However, they too are vulnerable, as a breakdown or power outage of any one repeater knocks out that entire section of the system. Repeaters are often located in remote regions such as mountain tops.

Another means of transmitting telephone signals is by satellite. Satellites have the advantage of being insensitive to distance--a satellite earth station can provide communication from any point to any other point without the need for wires or relays in between. In addition, the station can be installed in or near the community for accessible maintenance. A satellite system offers the important added advantage of being easy to configure for conference communication. All sites can simply be assigned the same frequency, similar to two-way radio systems. In comparison, conferencing with terrestrial telephone systems requires complex linking of the nodes, and is prone to signal degradation.

The cost of telephone systems, whether terrestrial or satellite-based, is difficult to generalize. Their relatively high cost at this time means that the telephone systems are generally not procured and operated by the health ministry, but leased or paid for on a usage basis from the telecommunications utility.

In areas where commercial telephone service has not been provided, a variety of two-way radio systems is used. High frequency radio is perhaps the most common. High frequency (HF) communication works by bouncing radio waves off the ionosphere. HF communications can cover great distances of hundreds or

thousands of miles but with varying reliability. However, in regions where distances exceed line of sight between locations (usually 50 miles or less), HF offers the most practical means of communications.

Very high frequency (VHF) radio can be used where distances between communities are less than fifty miles or where a hill or mountain can be used for a repeater that allows the signal's line of sight to cover a much greater area. The reliability of VHF communication is generally good within its limited range.

Citizens' band (CB) radios offer very inexpensive communication but over short distances of about 5 to 20 miles. CB radios are small and portable, but are generally not ruggedly designed for rural field settings.

Two-way radio systems most nearly fit into the category of appropriate technology for rural health care. In the absence of other telecommunications systems, two-way radio systems, in a number of different forms to be discussed below, can provide varying degrees of reliability at a low capital cost. These systems, given present technology, are easy to maintain (although not always maintained in practice), easy to use by field personnel, and can provide years of service pending the eventual installation of regular telecommunications services.

This report is concerned primarily with experiences with two-way radio systems. While other two-way media will be discussed, the focus here will be on two-way radio systems, as these are currently the most likely technology to be used in future rural health programs. This should not imply, however, an uncritical endorsement of two-way radio systems. Such systems are almost invariably inferior to a properly functioning commercial telephone system in terms of reliability and, in the long run, cost (both capital

and operational). Also, the proliferation of two-way radio systems can lead to unnecessary frequency congestion and can actually impede the development of regular telecommunications services. However, in the absence of telecommunications services, two-way radio remains the most effective means of extending communications at the lowest cost.

C. COMPONENTS OF A TWO-WAY RADIO SYSTEM

The basic components on any two-way radio system (regardless of frequency or power) are:

a transceiver:	transmitter/receiver with crystals that oscillate at the given frequency (one crystal per channel) a microphone, generally "push to talk" activating the transmitter only when a button is depressed;
an antenna	for radiation and reception of signals, either: dipole -- generally suspended between two poles or trees, or whip -- a vertical antenna that may be pulled out of the radio or mounted outside (like a car radio antenna) or yaggi -- a vertical antenna like a VHF TV antenna mounted outside;
a power supply:	either AC--operating off mains power (house current) by plugging in the set, or DC operating off a storage battery such as an automobile battery which may be recharged by connecting a battery charger to the

mains power, or a small generator (usually diesel), or one or more solar collector panel(s) generally mounted on the roof.

II. FUNCTIONS OF TWO-WAY COMMUNICATION

A. MEDICAL CONSULTATION AND REFERRALS

It is generally assumed that the most critical use of two-way communications for rural health is connecting the rural health practitioners with physicians and nurses in regional or national hospitals. Such contacts are for consulting about a patient's condition for both diagnostic and prescriptive advice, determining whether a patient should be referred to a hospital for treatment, and following up on the condition of a patient either at the hospital or the field location.

The need and importance of this type of communications depends heavily on the medical protocols of the particular project. In Alaska, the Public Health Service holds regular "doctor calls" for the rural health aides--the doctor contacts each health aide daily to provide consultation and handle administrative matters. These aides have minimal training (some less than three months) and apparently require skilled outside interventions.

In Guyana, the medex* are generally expected not to consult with the physicians by radio except in the case of emergencies requiring referrals to hospitals, or in very difficult diagnoses. They have developed an extensive handbook of medical protocols which indicates what steps they should take in various situations, including emergencies. The MEDEX field staff are not encouraged to call MEDEX headquarters for consultation except in cases falling outside of the protocols. These medex have more than one year of training and are expected to be self-sufficient.

* Health workers trained by the MEDEX project in Guyana

The use of two-way radio systems for medical consultations necessarily reflects decisions made about the overall structure of the health system. Given the impossibility of posting physicians, or even nurses, throughout most developing countries, decisions must be made about the levels of medical care to be provided to various demographic areas. Such decisions necessarily include decisions about the types of personnel to be placed in field locations and the levels of support such staff will require in terms of medical advice. The existence of a two-way radio system allows varying degrees of consultation between the field and professionals depending on the reliability of the radio system and the availability of professional staff. As discussed elsewhere in this paper, improvements in radio reliability generally increase communication costs. A radio network which operates for 24 hours a day is more expensive in terms of number of frequencies and monitoring time required than a simple HF system which can operate only during parts of the day. So, the necessity for medical consultations during the evening must be evaluated in planning the radio system.

Further, utilizing professional staff as radio consultants requires that the staff be available for such consultations. Professional time requirements will vary with the number of radio sites and with the dependence of the field staff on professional backup.

B. ADMINISTRATION

Two-way communications play a critical role in the administration of health programs. This is particularly the case in ordering drugs and medical supplies. In remote locations, epidemics or less serious outbreaks of disease may require immediate shipments of antibiotics, vaccines, and

the like. However, given the rural isolation, with infrequent transportation and thus slow mail service, it may takes days, or weeks, for news of these needs to reach headquarters. Further, as AID consultants observed in Guyana, the drug order may be received and headquarters may believe that it has been shipped, while in fact the drugs remain in some warehouse, ignored by the shipping agent. The radio system can then be used to monitor the drug shipments.

Similarly, the radios can be essential for ordering and shipping routine supplies such as food, furniture, fuel, and spare parts. As with medical supplies, these items are often needed quickly, which may not be possible to arrange without rapid communications. Also, the existence of the two-way system allows headquarters to determine precisely what is needed if an order is vague or if the requested supplies are not immediately available.

The radio can also be used for routine administration, such as arranging for vacation replacements for field workers, arranging for messages to be relayed to various people at headquarters or in the field, and the like. While many of these functions do not have the same time value as ordering of drugs and supplies, the existence of the radio may not only speed these processes along, but may also significantly improve field morale.

C. COORDINATION OF TRANSPORTATION

One of the greatest difficulties in rural medical care is arranging transportation for critically ill patients from the field to a regional or national medical center. Rural areas often lack regular or frequent transportation. As a result, during emergencies special transportation must be arranged. One of the more innovative responses to this problem has been

AMREF's* Flying Doctor Service in East Africa. This service ties field professionals to each other, to hospitals, and to AMREF headquarters via a two-way radio system. The radios may be used to alert the doctors who can either fly to the site of the emergency or arrange for one of AMREF's airplanes to evacuate the patient. Generally, they try to move patients to clinics and regional hospitals where specialists can be flown in. The close ties within AMREF between communications and transportation allow for a flexible and rapid response to various types of medical needs.

Other rural health systems use radios to arrange emergency evacuations. One of the most extensive two-way communications systems, the Public Health Service's satellite communications network in Alaska, has been used heavily for arranging air evacuations in the absence of any road transportation in the Arctic. While evacuations are costly, they can be effective in saving lives if combined with a communications system which can maximize the speed of evacuation. Such unions of transportation and communications are particularly effective when, as in Alaska, East Africa, Guyana, and other locations, both the medical and transportation systems have communciations systems which allow messages to be conveyed rapidly from one to the other. For example, AMREF planes have one of the terrestrial network's frequencies. In Lesotho, the Flying Doctor Service wanted the radio system designed to include a network frequency in its plane.

In addition, the evaluation of the Alaska satellite network showed that some evacuations could be prevented if expert advice were available by radio.

* African Medical & Relief Foundation, Nairobi, Kenya

D. CONTINUING EDUCATION

The isolation of rural health workers makes continuing their training or even providing refresher courses very difficult. Although there have been efforts to enable field workers to return for refresher or training courses regularly (generally once a year), it is difficult to provide in such courses the range of problems a worker might encounter during the year.

The level of education courses can vary tremendously according to the time devoted to preparing materials and to studying in the field. The simplest types of training occur through field workers discussing their problem during consultations in a conference-call situation. This type of training is used extensively in Alaska, based on experiences during the ATS-1 satellite demonstration. Under this procedure, health workers in a particular area are on alert at the daily doctor call during which each aide describes cases and the doctor provides diagnostic and prescriptive assistance. Listening in allows each aide to hear varying descriptions of illnesses, learn ways of describing symptoms, and become aware of diagnoses and treatments possible for various symptoms.

A more directed approach has been adopted in Guyana. Once a week a general conference is held during which the physician presents a case which had been referred to Georgetown during the preceding week. The physician presents certain symptoms and quizzes the medex on them, the types of diseases associated with the symptoms, approaches to diagnosis, and the like. This session acts as a major review of particular illnesses and treatments and has been highly recommended by both physicians and field workers.

An even more sophisticated system utilizes formal continuing education programs based on interaction between the headquarters and the medex. Such a program has been developed by Judy Roberts, as an outgrowth of the HERMES (CTS)

satellite program in Canada. This form of education presents new ways of assessing medical problems through a series of presentations, questions, and followups over a period of time. While such a training program would appear to have significant promise for long-range planning, it also has some major difficulties, primarily in terms of the time required. Such a program requires a major effort by a physician, or some other medical expert, in developing the curriculum. Also, the health workers must have time to participate in the program during the hours the radio system is operational

The limitations of HF radio systems in terms of reliability and signal quality make this kind of intensive training difficult.

E. "BUSH TELEPHONE" USES

It is probable that the health system's radio network will be used for more than simple health communications. In the absence of a telephone system, rural radio networks are used for a broad range of communications. Most commonly, messages are relayed either to the headquarters or to another field post for passage to the recipient. The intensity with which the health system is used for this purpose generally depends on the health requirements of the system and the goodwill of the professionals. However, there may be increasing pressure to use the system for non-health uses in the absence of other public telecommunications systems or otherwise available radio systems.

The first non-health users of the system will generally be the field practitioners, such as extension workers or teachers, who will use the radio to send personal messages and simply to communicate with other field workers. These are important functions as they help ease the isolation and loneliness of rural living.

Other users may include social service agencies which lack their own communications facilities. For example, in Guyana the Inter-American Development Bank (IDB) uses the MEDEX system extensively for ordering

building materials for construction of new health facilities in the rural areas where the medex are located. Messages from the IDB are relayed to MEDEX headquarters in Georgetown, where they are telephoned to the IDB staff.

Still other users might include businesses, private individuals, church groups, and other government agencies. The number of applications of the system depends directly on the operating protocols established by the health system. Given the generally acknowledged repressed demand for communications services in rural areas, planners should expect that there will be great pressure for using the health system for all sorts of general communications functions.

F. DISASTER RELIEF

Two-way communications systems are also earning an impressive reputation as a fast and inexpensive as well as highly mobile way of dealing with emergencies such as epidemics and natural disasters. In Guatemala during the 1976 earthquake which devasted many areas, PLENTY, a voluntary organization was able to set up a two-way radio system which was one of the first emergency communications systems to operate during the disaster. The system linked relief teams, ambulances, and local health workers with hospitals, clinics, and fire-emergency units in the hard-hit lake country of Guatemala. In most villages, the radios were the only link with the outside world.

The ATS-1 satellite network in the Pacific has been used to coordinate emergency medical services and logistics during outbreaks of cholera and dengue fever in the South Pacific islands.

In the southern U.S., hospitals communicate with oil rigs in the Gulf of Mexico and with a helicopter "ambulance" during medical emergencies via the ATS-3 satellite.

G. DATA ON FUNCTIONS OF TWO-WAY SYSTEMS

The volume and purpose of radio traffic will vary from system to system depending on the training of the health workers, their isolation, and the types of assistance available to them by radio.

The following table compares the purposes of messages in three medical communication networks. Categories have been approximated, as there were slight variations in coding among projects.

	AMREF[1]	Nicaragua[2]	Alaska ATS-1[3]
	N=4415 (one year)	N=594 (six months)	N=3653 (one year)
Medical Advice	25.2 %	28.3 %	72 %
Administration	33.4	21.2	27
Transportation	13.4	20.9	
Personal	-	29.6	-
Miscellaneous	28.0	-	1
	100.0 %	100.0 %	100 %

Medical advice, although a major category in each system, varied in specifics from project to project. For AMREF, the highest categories of medical advice were miscellaneous including lab reports, followed by surgical, general medical, obstetrics/gynecology, and pediatrics. It should be noted that the AMREF network links primarily field hospitals rather than paraprofessional clinics. In Alaska, the most frequent diagnoses under medical advice were

[1] AMREF Reports, African Medical & Relief Foundation, Nairobi, Kenya, 1979.

[2] Radio-Communication Project Interim Report, CENDER Health Division: Partners of the Americas, Wisconsin-Nicaragua Partners, April 25, 1979.

[3] Kreimer, Osvaldo: "Health Care & Satellite Radio Communication in Village Alaska," Institute for Communication Research, Stanford University & Lister Hill National Center for Biomedical Communication, July 1974.

respiratory diseases, ill-defined symptoms, skin difficulties, ear difficulties, ear problems, and accidents. Two-thirds were considered by doctors in the middle category of "evaluation of a minor symptomatic problem with some risk of complication". Only .5 percent were considered by the doctor to be very severe or complex. It should be noted that the Alaska system is heavily weighted toward medical advice because of the daily doctor call when health aides are expected to consult with doctors.

Even systems that are not specifically designed for health communications are likely to be used for medical and emergency messages. Hudson et al (1979) found in comparing data from four rural public communications systems that emergency and health messages accounted for about 5 percent of the traffic.

Purpose of call	Percentage of Calls			
	Latin American Country	Melanesian Country	India	Canada (remote Indian village)
Emergency, health	6 %	5 %	5 %	5.1 %
Business, agriculture, public services	36	20	72.5	40.6
Maintain contact with relatives or friends	58	75	22.5	34.8
Other	-	-	-	19.5
	100 %	100 %	100 %	100.0 %

III. COST CONSIDERATIONS

A. INSTALLATION AND MAINTENANCE OPTIONS

1. Ownership and Operational Responsibility by a Communications Agency

The most common approach to the operation and maintenance of communication equipment in the industrialized countries is to have a communication organization--a telecommunications ministry or a private carrier--take full responsibility for providing the communication facilities. The user has no responsibility for the hardware, and may pay for its capital costs, maintenance, and depreciation through the tariffs for use or lease of the facilities. In most telecommunications networks, there is some degree of subsidy for rural telecommunications facilities by the telecommunications carriers as a means to avoid having to charge prices equal to the large costs of providing rural service. Thus, the user usually will pay less than the full costs of the facilities.

Unfortunately, this option is often unavailable in rural areas of developing nations due either to the complete lack of telecommunications facilities, or to the operational problems or traffic congestion common to such systems.

2. Ownership by the User Organization; Installation and Maintenance Contracted Out

In some cases the facilities may be owned by the user(s) who themselves have neither the personnel nor the resources to install and maintain the equipment. One option is to contract with a technical organization--either a carrier (government or private) or a technical firm--to do the maintenance. An example of this approach is the MEDEX two-way radio system in Guyana which is owned by the Ministry of Health. As the Ministry of Health had no communications expertise, it was decided to contract with the Guyana Telecommunications Corporation (GTC)

in the Ministry of Telecommunications for installation and maintenance.

This approach is not limited to small dedicated radio networks. The state of Alaska purchased an initial 100 satellite earth stations (later increased to 125) to provide rural telecommunications to bush Alaska. The stations were installed and operated by RCA Alascom the statewide long-lines telephone carrier. The state felt it was the only way to get reliable communication to the bush without delays of many years.

The use of contractors may ensure technical competence, but cost and operations may vary. The tendency is for technical services to be provided at the going "professional" quality and rates, whether or not they are appropriate. In Guyana, the installations considerably exceeded budget estimates because GTC insisted on using commercial telephone poles rather than locally available poles. Another potential drawback is lack of control over technical activities. In particular, contractors may not give highest priority to a contract job. Thus, a radio system needed for health services may languish because it has a low maintenance priority.

3. Ownership, Installation and Operation by User

Some users have chosen--or have been required by circumstances--to own and operate their own communication systems. Given that social service agencies are not in the business of providing communications facilities, this is usually a choice based on necessity. For example, in planning radio systems for health communication, one of the authors found in two African countries that the Ministry of Telecommunications simply had neither the personnel nor the commitment to be charged with the maintenance of the health communication system. Indeed, the health personnel in one country who had had two-way radios maintained by the Ministry of Communications unanimously voted to set up their own maintenance facilities for an expanded

network because of the long delays and low priority given their equipment by the Ministry of Telecommunications.

The most successful dedicated social health communications networks known to the authors are maintained by in-house technicians--the African Medical and Relief Foundation (AMREF) system of more than 75 radios in Kenya and Tanzania. In northern Canada a native organization, the Wa-Wa-Ta Native Communications Society operates and maintains its own network of about 40 fixed and portable HF radios, CB radios used at hunting and trapping camps, and low powered FM community radio stations.

B. RADIO SYSTEM COSTS

Definitive cost data on two-way communications systems are difficult to provide given differences in project requirements (e.g., channel capacity reliabiltiy, power), terrain, atmospheric conditions, import duties, shipping costs, and the like. It is, however, possible to provide at least some illustrative data to give an idea of the relative costs of different technologies.

The costs of two-way communications systems consist of two components: capital costs, which include the capitalized cost of the equipment and equipment installation (.e., the initial cost plus interest expenses), spare parts and power supplies; and operational costs, which consist of maintenance, power requirements, operational personnel (e.g., operators), and equipment depreciation.

Unfortunately, many plans and reports contain useful information only on the capital costs which generally are a small fraction of the overall costs of a two-way communications project. This report cannot provide estimates of operating costs (or installation costs) because of national

differences in the costs of labor, transportation, fuel, and a number of other factors. Rather, it lists the variables that will affect operating costs in section III.2., below.

1. Capital Costs

a. High frequency radio systems

The following are typical purchase costs of a high frequency two-way field radio site (based on data from Guyana):

Radio with four channel capability (crystals included)	$895
Spare kit	$135
Power supply 220 volt PS-3 (Stohner)	$195
Antenna (excluding poles)	$100
(see detailed breakdown in Appendix A)	$1325

Factors which influence capital costs are the following:

1) Radios

Power required, ruggedness (e.g. degree of corrosion resistance) and origin of equipment. Generally radios for long distances and for base stations will be more powerful and more expensive. Non-U.S. equipment, particularly from Europe or Canada, is likely to be about 50 percent more expensive than U.S. equipment.

2) Power supply

Where mains power exists, no power supply or possibly a simple voltage regulator may be required. Alternatively, the mains power will be used to recharge a battery that will power the radio. Solar cells are likely to be about twice as expensive as diesel generators at present, but should require a little or no operating expense. The costs of such cells are decreasing as solar technology advances. Local batterie may be less expensive than modern U.S. sealed batteries. However, the

sealed batteries appear to both hold charges longer and endure longer.

3) Antennas

Antenna materials can be bought and assembled into kits. Alternatively, prepackaged antenna kits can be purchased at higher initial cost. It is assumed that local poles or trees can be used to anchor the antenna. If poles have to be purchased, or steel masts used where poles do not exist, the antenna installation may cost a few hundred dollars.

b. VHF radio system

VHF radios are somewhat less expensive and can be used with a yaggi (TV type) antenna rather than an antenna strung between poles. There is no significant difference between VHF and HF-SSB in power supply costs. These costs are only for a system operating within a 50-mile radius. For longer distances, repeaters will be necessary. Generally, such elaborate systems are associated with telecommunications carriers due to the more difficult problems of installation and maintenance.

Typical VHF installation:

Radio	$500
Antenna	50
Power supply	350
	$900

c. CB radios

Citizens' band radios are very inexpensive ($100 to $300) and may be used with a built-in whip antenna. Power supply may be throw-away batteries (ongoing operational cost) or rechargeable nickel cadmium batteries requiring a power source for the battery charger.

d. Public telecommunications systems

It is difficult to provide illustrative costs for such systems as the cost for any particular point is dependent on the pre-existing telecommunications network, the types of transmission technologies used (which may depend on a number of variables, including terrain and atmospheric conditions), and the types of switching systems installed. As a rough guide, the Inter-American Development Bank estimates a cost of $20,000 per installed public call station (single public telephone per community), based on its experience with a rural telecommunication project in Colombia.

e. Satellite systems

As with other facility costs, the costs to a particular health project of a satellite system will vary according to the type of satellite and ground facilities used. While the ground stations used in the ATS-1 satellite demonstrations cost less than $5000 and the stations used in the SITE ATS-6 project in India were considerably less expensive, these stations depended on the existence of very powerful and expensive experimental satellites provided free of charge by the U.S. government. The installed cost of the small (five-meter) earth stations used in Alaskan rural areas for operation with commercially available satellites averaged about $100,000 for stations with both commercial telephone capacity and a dedicated health communications network. Users in some cases may be able to attain significant cost savings for social service delivery by convincing satellite carriers to increase the power gain, or change the directional beam ("footprint") of a satellite. Such changes can lead to decreases in the cost of the ground segments which are the major cost for users, while increasing the cost of the space segment.

In general, except for experimental applications like ATS-1, the users do not pay the capital cost directly. Instead, as in terrestrial telecommunication systems, they pay a rate for each call or for leasing one or more dedicated circuits (as is done by the Public Health Service in Alaska).

It should be noted that the cost of providing satellite telecommunication service is independent of distance--any point can communicate with any other point directly through the satellite. Thus the cost of communication should be the same whether the terrestrial distance is 50 or 500 miles. However, telecommunication carriers have traditionally based their rate structures on mileage costs and generally apply a similar structure when satellite service is added. The only exception known to the authors is the tariff for the audio conference network leased by the Public Health Service in Alaska. This tariff is based on percentage of use of each station by the health network rather than on mileage between sites.

2. Operating Costs

Operating costs may vary according to:

- Whether maintenance is done by the health agency using special staff, a telecommunications agency, or expatriates.
- The life of the equipment--generally estimated at five years, although solid state radios protected from salt and dust should last considerably longer.
- The power supply: whether the radio is run off an existing power supply, a diesel generator, or solar cells.
- Field maintenance: whether an annual field visit is scheduled or equipment is simply repaired when broken.

- Accessibility of sites for shipping equipment and maintenance visits.
- Operating staff: whether radio operators are hired and paid for that job alone (e.g., at a base station) or operate the radio as part of their clerical or clinic duties.

Given these factors, it is very hard to generalize about operational costs.

In Guyana, the telecommunications ministry initially estimated that maintenance would cost $150 per site per year, but they have since revised the estimates upward.

In Sudan and Lesotho, the cost of shipping and installation was estimated at 80 percent of the capital cost of equipment.

Generally the least expensive system will:

- Be installed and repaired by local technicians (generally in the telecommunication ministry).*
- Include 20 percent spares at the outset.
- Be powered by solar arrays or off main power where it exists.

Although preventive maintenance through annual site visits adds considerably to operating expenses, it is highly recommended to ensure the longest possible life an best possible operation of these systems.

---

* However, it may be cheaper to have an outside consultant supervise installations of a small network.

IV. PROBLEMS AND SOURCES OF FAILURE OF TWO-WAY RADIO PROJECTS

A. TECHNICAL PROBLEMS

While it is often difficult to establish the reasons for failure of two-way radio systems, there are several prominent areas where system failure can easily occur. It should be noted that health organizations are rarely prepared to undertake the long-run maintenance of radio systems. Unless the radio system is very large, and the health organization well funded, it is difficult to justify employing a technical staff for the system's maintenance. As a result, maintenance, planning, and equipment replacement must often be left to others--consultants, equipment manufacturers' representatives, or telecommunications ministries.

Regardless of the source of operational maintenance, its existence must be established and regular. As with any technology, long-term neglect can lead to catastrophic failure of the equipment with the requirement of a more costly replacement rather than the less expensive continuing maintenance. Available evidence indicates that major causes of system breakdown or failure are likely to be:

- Poor system design
- Insufficient training of users or inadequate operational procedures
- Lack of maintenance protocols
- Lack of spare parts or foreign exchange to purchase spare parts
- Power supply problems

Faulty system design occurs most often when attempts are made to minimize initial capital costs. Such savings may be achieved by purchasing older or used equipment or by purchasing simpler equipment, such as Citizens' Band radios, in the belief that they will provide the necessary service.

An example of the first can be seen in a project in South America where the project director initially requested that army surplus radio equipment be used. Such equipment, using vacuum tube technology, would have meant considerable initial capital savings, but would also have meant continuing operational problems compounded by the difficulty of obtaining spare parts and by the costs of the larger power consumption of vacuum tube transceivers compared to transistorized equipment. Fortunately, the project engineer in this case convinced the funding agency that purchase of modern, solid state equipment was a considerably more cost-effective investment.

In another project in Nicaragua, Citizens' Band radios were purchased for a two-way health project. While the initial testing of this equipment led to positive results, the equipment is currently unusable over the distances required due to sun-spot activity, and will probably always provide questionable service. As we noted previously, Citizens' Band radio, while inexpensive and a useful tool for local communications, is inadequate for any communications past 25 to 30 miles. In this case, the more costly investment in HF-SSB systems probably would have proven more cost effective over the life of the project.

Operational procedures are also a source of radio problems. Such problems range from operators being careless with handling the microphones or placing objects over the heat exhaust of the transceiver, to lax security and placement of transceivers in poor locations such as areas exposed to moisture or heat, dust or salinity. For example, in Guyana, the main station of the MEDEX

radio system was directly exposed to humid salt air blowing in off the ocean. Without remedy, this radio would be corroded beyond repair in less than two years.

Lack of training of operators can result in early damage to equipment if radios are allowed to burn out or corrode, batteries are not charged properly, battery cables to battery terminals are reversed, or gasoline is not properly mixed with oil for generators. Even if original operators are trained, the radios may soon be used by other untrained operators.

Maintenance protocols are a major consideration in the success of two-way radio systems. While solid-state radios should operate for long periods of time without the need for maintenance by a technician, some periodic preventive maintenance is advisable.

Lack of routine maintenance may severely shorten the life of the system. For example, in Lesotho, it was found that many of the antenna installations needed repair as antennas had broken, radios were not grounded, and poles were leaning dangerously. In the Pacific it was found that moisture in long grass around the guy wires for the poles rusted the couplings holding the guy wires. The guys broke, the poles fell over, and the antennas came down. Cutting grass can extend the life of a radio system!

In the absence of such maintenance procedures, systems can totally disintegrate. For example, the Ethiopian Malaria Eradication Program's radio system apparently failed for lack of spare radio parts. In Liberia, radios were repaired sporadically and because of lack of proper management procedures, they were diverted from government repair shops to other projects.

One reasonable approach to this problem, which has been used by AID in Guyana, is to contract with the local telecommunications authorities for installation and maintenance. In many projects, there is real reluctance to

use the telecommunications authorities often because of their operational record, a traditional lack of cooperation among ministries, and the cost. However, the telecommunications authority usually is best suited to maintain the radios becuase of its own supply of skilled technicians, and foten, the location of its repair shops near health headquarters. In Guyana, although the relationship has been slow in getting established, AID's consultants believe that the only way to ensure the long-range operations of the two-way radios is to contract with the telecommunications ministry.

The Inter-American Development Bank has gone further and will not fund dedicated two-way radio projects when there is a possibility of having the telecommunications ministry install the facilities. Among the reasons cited for this are maintenance requirements--IDB is concerned that equipment cannot be effectively maintained on a haphazard basis as occurs when a user ministry attempts to provide communications service.

Lack of spare parts can seriously threaten any technology including two-way radio. Some systems are procured with funds just sufficient to acquire the original equipment. When spares are required, they may be difficult to obtain, and/or the government may have insufficient foreign exchange to buy them. This factor contributed to the demise of a network in Nigeria. In the beginning, the project was entirely funded from foreign donations which also made it possible to purchase two small aircraft for the flying component of the service. This component had to be discontinued later owing to technical and financial difficulties, after which the service functioned only as a two-way system. After a few years, the scheme was handed over to the Government and was continued through public financing.

During the first two years after the hand-over, the system worked relatively well but gradually the transceivers aged and became outdated and their maintenance

became a problem. By March 1974 only the base station and a few other transceivers were in working condition, although they were not in operation.

Power supplies are a persistent technical problem. In locations with existing power source (for example a town power supply or generator for a hospital) surges in voltage can damage the radio. Voltage regulators can be included to prevent damage. However, where voltage is much below specified output, it may not be possible to use local power to run the radio or recharge its batteries.

Self-contained power units for two-way radios usually consist of small diesel generators used to recharge automobile storage batteires. The generators muse be cleaned and maintained properly. Another problem is the cost and transportation of diesel fuel. The logistics of transporting diesel oil to remote locations can often be horrendous. For example, in mountainous areas of Lesotho, interior Guyana, and the Arctic, fuel must be flown in. The cost of the fuel when it can be obtained is usually the highest single cost of operating the radio system.

In contrast, solar panels should eliminate the need for generators and fuel, although at present their capital cost is higher. Field tests do not indicate any major problems with solar panels, but none have been in operation long enough for definitive evaluation.

B. Organizational Problems and Source of Failure

A second set of causes of system failure or abandonment relates to the perceived utility of the system. To be valued and used by the rural health worker, the radio must provide communication not only to peers but to referral points such as regional hospitals and to administrative centers for ordering of drugs and supplies. The evaluators of the Liberian Lofa County Rural Health project communication system noted that the failure to operationalize the communication network between the levels of care as outlined in the project proposal had several serious repercussions.

> Referrals; particularly for emergency cases, cannot be effected and lives are consequently often needlessly lost, in light of the absence of a rapid, dependable means to notify the appropriate higher level of care of the need for technical advice, supplies and/or an ambulance to transport a critically ill patient to hospital.
>
> Physician Assistants (PA's) remain professionally isolated both from colleagues and, importantly the physician upon whom they are dependent for backup. Such isolation has an obvious detrimental effect on PA motivation and dedication to service. (Lashman, 1979)

Lack of support and continuity for field facilities encourages patients to bypass lower levels of care in favor of overcrowded county hospitals where all illnesses can be treated and referral is not necessary.

In Lesotho, health planners and nurse practitioners pointed out that it was extremely important for each clinic to be able to communicate with its regional hospital. (The variety of privately owned systems each with separate frequencies now makes this difficult). In Guyana, the medex who can now communicate with headquarters in Georgetown, and with each other, pointed out that communication with regional hospitals for referrals and supervision would make the system more valuable for them. In addition, in coastal regions where distances to hospitals are relatively short and transportation easily available, there appeared to be less use of the communication system than in rural areas.

V. NORTH AMERICAN PROJECTS IN TWO-WAY COMMUNICATIONS FOR HEALTH CARE

In North America, several projects have applied two-way communication to delivery of health services in both rural and urban areas. Projects summarized here will include only voice and other narrowband applications--i.e., information that could be transmitted over a telephone channel. Wideband applications such as motion video teleconferencing are excluded. It must be noted that the applications noted here are largely dependent on high quality narrowband connections; such connections often do not exist in rural developing country settings.

In the more remote areas, applications have been similar to those in developing countries. In both northern Canada and Alaska, the health service have used two-way HF radio and, more recently, satellite communication to link remote health clinics and nursing stations to regional hospitals. Alaska first demonstrated satellite applications on ATS-1, as described earlier in this paper. Commercial satellite systems are now used in both Alaska and Canada, with the health service being only one user of a public system that provides public telephone service as well. In Alaska, the Public Health Service has leased a specially designed audio conferencing system enabling villages served by regional hospitals to share the same channel for conferencing and learning purposes. The system can also be configured so that special courses or messages can be sent to target groups (e.g., hospitals, field nurses, aides, etc.) simply by alerting them to select a certain channel.

Other health care organizations have tried adding more information to the voice channel. Two types of information that have been successfully tested include patient data such as EKGs and heart sounds, and pictures--x-rays or pictures of wounds, joints, lesions, etc. The latter are transmitted by

slow-scan video, a technology that transmits still television pictures over a telephone line.

A. PROJECT SUMMARIES

1. Mobile Communications

In the U.S. telecommunications has also been extended to mobile units. In Alabama a UHF radio telephone system links ambulances and five medic units. The system allows for simultaneous voice communication and EKG transmission to hospitals.

The ATS-3 satellite has been used for emergency medical communication from drilling platforms in the Gulf of Mexico.

The Southern Regional Medical Consortium of hospitals in Mississippi and Louisiana uses ATS-3 to relay voice communications and data from oil rigs without line-of-sight communications. A helicopter "ambulance" can also communicate with the hospital and the rigs.

2. Slow Scan Video

Slow scan video has been used in several projects to transmit patient information. In northern California telephone plus slow scan video extend the primary helath care coverage of the nurse practitioner and physician by providing 24 hour per day communication to a major primary care clinic.

In northern Ontario, slow scan units have been placed in a nursing station, health aide clinic, regional hospital, and a major referral hospital in Toronto. In the second year of the project, transmission increased five-fold. Sixty-seven percent of transmissions involved X-rays, 25 percent were "social therapeutic", mainly allowing communication between villages and relatives i hospital, and 7 percent involved EKGs.

In Nebraska, slow scan video is used to provide on-demand assessments of x-rays transmitted from one hospital to another. X-ray evaluations are given by telephone.

3. Facsimile

Some North American projects (e.g., in Alabama and northern Ontario) also have facsimile equipment to transmit documents such as patient records and medical literature over a voice channel. Generally, the facsimile is used in conjunction with audio teleconferencing or slow scan video.

4. Educational Applications

North American projects have also attempted to provide continuing education using narrowband technology. It should be noted that the high quality of North American telephone systems makes educational applications possible that would be extremely difficult or impossible over most two-way radio systems.

In Alabama, the Medical Information Service via Telephone (MIST) provides a telephone extension service to physicians who can call a central number for consultations. In several U.S. locations, a system called Tel-Med provides a tape library on common health problems and questions. The public may access the system by dialing the number and requesting information on a certain topic. In Labrador, Canada, an audio teleconferencing system is used for continuing education of health professionals and for consultations and transmission of medical data.

5. Computer Services

North American health organizations have also combined computers and telecommunications for patient record-keeping. The Public Health Service in several locations, including Arizona and Alaska, uses a computer-based record keeping system (Patient Care Information System--PCIS). Information on

patients is written by providers on standardized forms from which data are entered in a computerized file. The file is available at any location in the health system either through a computer terminal linked to the central computer or on a regularly updated microfiche. In addition to providing reliable information particularly useful for transient native populations, the system can also be used for preventive health care activities. For example, the computer can provide lists of all women who should have PAP smears, all children requiring vaccinations, all residents with heart problems, etc., for visits by public health nurses or itinerant physicians. In Alabama, terminals linked to a computer by telephone provide on-line statewide billing for physicians to reduce costs of submitting claims and preparing billing data.

VI. CONCLUSIONS

This paper has presented an overview of the applications of two-way communciation in rural health care delivery, and the various communications technologies that can be used. The main focus has been on two-way radio systems as an appropriate technology for dedicated health communication networks in developing countries.

The main functions of two-way communications in the projects reviewed are medical consultation and referrals, administration, coordination of transportation, and continuing education. Where radio networks are shared with other users in rural communities, a variety of applications for other development sectors may share the system.

The cost of two-way communication systems is modest, varying from several hundred to a few thousand dollars, depending on the distance to be covered, the terrain, and the availability of a power source. Operating costs also depend on a number of factors including proper training of users, regular maintenance, the cost of fuel, and the organizational structure responsible for maintenance.

In addition to reviewing several two-way radio projects from developing countries, we have included examples for North America using narrowband technologies for transmission of visual information, heart sounds, EKGs, and patient record data.

Several lessons can be drawn from the projects outlined in the paper and others summarized in Appendix B.

- The communication service must meet the perceived needs of the user to be accepted. If the user cannot reach the appropriate consultant or if the medical system provides no incentive to reduce referrals, consultation system will not be readily accepted.

- The equipment must be simple to use and reliable. Experiments using sophisticated equipment or equipment prone to malfunctions have largely failed despite the apparent benefits of the service provided.
- System budgets must include adequate allocations for operations, maintenance and spare parts.
- Training for operators in proper use of the radios and in preventive maintenance may extend the life of the system.
- Regular operating schedules and procedures may increase the effectiveness of the system.
- Addition of data, hard copy, and slow scan services can only be successfully carried out over relatively high quality audio circuits.
- Educational programming requires good audio quality to succeed in an audio system.
- Educational applications require a much greater investment in personnel time to prepare programs and courses than do consultative and administrative applications.

APPENDIX A

Radio System Costs Per Site

APPENDIX A

RADIO SYSTEM COSTS PER SITE

1. H.F. Diesel Powered Installation: Guyana.

Equipment and costs per station

No.	Description	Model	Unit Cost
1	Basic radio-telephone complete with microphone, USB, 12 Volt DC negative ground operation. Four channel capability	SSB-40A	850
1	Factory-installed channels, including crystal and crystal modules. Channel 2-5300 KHz, Channel 3-6920 KHz.	142020	60
1	Spares kit for SSB-40A	240057-01A Ac-121	120
	Spare microphone	5910-015	30
Transceiver Total:			1,060
1	12 Volt lead-acid battery		65
1	500 watt, 4 cycle gasoline powered generator with a D.C. output		350 (estimate
1	Sets battery clips and connecting cable		5
Power supply total			420
1	1x300 feet #14 wire or equivalent		30
1	1x75 feet of RG-59 coaxial cable with a PL-259 on each end		15
1	BN-86 HyGain BALUM 1:1		16
1	50 feet 1/8 inch nylon rope		3
1	Tape, insulating RTV, 2 end insulators		6
Antenna Total			70
		Station total	$1,550

2. VHF FM Solar Installation (PLENTY: Bangladesh)

Kit includes:

1	25-35 MHz low band AM or single sideband VHF FM	$ 350
1	Solar panel 18 volt, 600 milliamp	300
1	Battery, 14 volt rechargeable sealed	70
1	All-weather-proof, impact resistant, carrying case with lock	300
1	Antenna kit with collapsable antenna Cigarette lighter charge plug Charge circuit Circuit breaker External antenna connection External antenna mount AC 120 charge circuit Hardware, wiring and clamps	150
	Labor and miscellaneous	600
	Station Total	$1,770

Kit comes with instructions. Price includes total labor charges

3. Citizens' Band (CB) Installation: Nicaragua

1	Two-way radio transceiver:	$ 80.00
1	500 ft. reel of coaxial cable RG 8/V, superflex coaxial cable with high resistant weather cover at .17¢ per ft.	85.00
1	3 element vertical beam directional 8db gain antenna	43.00
1	Starfire V, 5 db gain antenna	45.00
1	3/8" copper clad ground rods	1.10
1	12 volt sealed, 40 AH battery	35.00
1	1" steel pipe, 20 ft long	8.50
1	Set of miscellaneous hardware (bolts, nuts tools, etc.) Estimated	300.00
1	Automatic battery charger	30.00
1	Ground anchor	2.50
	Station Total	$630.10

Power source not included

APPENDIX B

SUMMARY OF TWO-WAY COMMUNICATION TECHNOLOGIES

APPENDIX B

SUMMARY OF TWO-WAY COMMUNICATION TECHNOLOGIES

Equipment	Range	Cost	Advantages	Disadvantages
CB (Citizens' Band) radio	5 to 20 miles	$300 to $600	• inexpensive • portable • equipment simple to install	• short range • not rugged
VHF Radio	20 to 50 miles	$500 to $1000	• relatively inexpensive • reliable over short distances	• short range: need line of sight path between stations
HF Radio	50 to 500 miles or more	$1500 to $3000	• long range • relatively inexpensive	• variable reliability • propogation changes with atmospheric conditions • equipment specification must consider required hours of operation
Terrestrial Telephone	Unlimited	Varies with distance	• cost shared by many subscribers • access to all telephone subscribers	• vulnerable to outages • cost depends on distance • difficult to teleconference
Satellite Radio/Telephone	Unlimited	$20,000 to $150,000 for earth stations	• distance insensitive • may be shared with other users • teleconferencing possible	• dependent on efficient satellite design • high initial capital cost

APPENDIX C

SUMMARIES OF TWO-WAY COMMUNICATION PROJECTS FOR HEALTH SERVICE DELIVERY

LOCATION	PROJECT TITLE	FUNDING ORGANIZATIONS	YEARS OPERATED	FUNCTION	STATIONS	TECHNICAL DATA	COST	OUTCOME/COMMENTS
	Alaska Health Experiment Continued			To test the feasibility of the link and evaluate the cost vs. benefits.				evaluation report suggests that most of the goals of cutting down transport time by patients and doctors for consultation, greater communication between all levels of health care providers were met.
Alaska	Alaska Medical Satellite Network Project	Indian Health Service, Lester Hill National Ctr. for Biomedical Communication, HEW, NASA	1971 to 1978	To improve public health service in the Tanana region in interior Alaska where severe atmospheric problems resulted in poor communications and restricted transmission.	17	ATS-1,	$1.7 million	Evaluation report found that the number of patients treated with a doctor's advice during the first year on ATS-1 more than tripled. However, the ATS-1 system did not show itself to be cost-effective in reducing hospital admissions during the study period.
Appalachian	Veterans Admin. ATS-6 Health Care Experiment in Appalachia	Appalichian Regional Commission/ NASA	1974 to 1979	Part of the overall App. Educational Satellite program which began in 1972. To test ways in which communication satellites can be employed on a cost-effective basis for biomedical purposes, on diagnosis, therapy, and continuing education.	10	ATS-6 Computer		Evaluation report showed strong support for the program by hospital users. Throughout the broadcast period the number of participants in the programs remained stable. The major impact was the creation of a gestalt which facilitated increased information seeking, improved morale, and created an environment which encouraged innovation.
Appalachian	VA/CTS Experiments	Veterans Administration/ NASA	1977 to 1979	to further examine the value of satellite communication for mediating the requirement for a free flow of information thoroughout the health care system. Experiments were undertaken in teleconferencing, education and management	12	CTS, telephone, audio-scrambler, remote transmitter, audio transmitter		Evaluation found that participants showed the greatest interest in demonstrations related to allied health, nursing and physician continuing education.

LOCATION	PROJECT TITLE	FOUNDING ORGANIZATIONS	YEARS OPERATED	FUNCTION	STATIONS	TECHNICAL DATA	COST	OUTCOME/COMMENTS
Alabama	Emergency Medical Services	Alabama Regional Medical Association		To establish a cost-effective telecomm system in rural Alabama for support of advanced life-support systems	4	UHF radio/ telephone		These bases provide virtually county-wide access by ambulance and five medic units. System also allows for simultaneous voice transmission and EKG to hospitals.
Alabama	On-Line Medicaid Billing System	University of Alabama	1971 to 1973	To provide on-line state-wide billing system for physicians services to reduce costs		Standard Touch-tone telephones equipped with card-dialers; Answer-back equipment, computer		The system provides for point-of-service terminals on-line to a central computer to reduce the costs of submitting claims from physicians' offices and preparing data for the carrier.
Alabama	Medical Info Service via Telephone (MIST)	University of Alabama Medical School, Alabama Regional Medical Assoc.	1969 to Present	To provide a telephone extension service which would assist physicians in their day-to-day care of patients; to bring resources at U. of Alabama Medical Ctr. to physicians and other health professionals state-wide.		(WATS) telephone unit, Centrex tie-line	Costs per site/year $619,480 (P.C.I.)	MIST and a complimentary system DAIL (Dial Access Tape Library) is widely used by physicians calling a central number for consultations. Consultations range from emergencies, rare cases, to medical "chats." Nurses use DAIL for teaching conferences.
Alabama	Tuskegee Telemedicine System	Tuskegee Institute	1973 to Present	To establish a telecomm system to provide health care services to a three-county area in southeastern Alabama.	17	Telephone, Facsimile, Telewriter, Computer		The system is used for primary health care. 17 community sites are serviced by 2 mobile vans with facilities to transmit EKG tracings via telephone to the main clinic to be read by computer.
Alaska	Alaska Health Experiment	Indian Health Service	Sept. 1974 to May 1975	To establish an audio/ data/video communications link between primary health care providers and physicians in Anchorage, Alaska for consultation and administrative	4	ATS-6 VHF units Ground terminals Computer		Several aspects of the planned experiments were not effectively implemented, e.g., the computer-based patient info storage and retrieval system failed to operate due to equipment problems. However, the

LOCATION	PROJECT TITLE	FOUNDING ORGANIZATIONS	YEARS OPERATED	FUNCTION	# OF STATIONS	TECHNICAL DATA	COST	OUTCOME/COMMENTS
Bangladesh, 3 Thanas	Population Planning	World Bank	At feasibility stage	Connect hospitals with health workers	60	Solar powered kits	$150,000	Will use kit developed by PLENTY which will not require technical personnel; will use solar power
Cook Islands		Ministry of Health	1979 to Present	To establish a two-way communication network to serve health, education, and general public service sectors.	15	SSB transceivers	$ 1,000 per station	Sense of isolation felt by islanders
East Africa - Kenya, Tanzania	Flying Doctor Service	African Medical Research Foundation, Netherlands Organization for International Development Corp. (NOIDC) Netherlands Gov't.	1970 to Present	Communications for medical supervision, administration, referrals among doctors, nurses and medical assistants.	86 out-stations	14F-556, mobile and aircraft units, power packs		Improved health care education and supervision of non-physicians. New Dirtions: AMREF will establish two new radio communications systems this year - one in the southern Sudan and another in S. Tanzania
Egypt	Emergency Medical Services	USAID Ministry of Health	FY 1976 Feasibility Study Undertaken	Test the use of mobile radio and BS for emergency medical services	135 mobile, 2 control ctrs., 5 hospitals	Portable radios	$ 2,340	Consultant's report to AID noted that "due to the lack of a radio frequency spectrum assignment plan there are presently no specific radio channel assignments for use by Ministry of Health for a project as EMS."
Ethiopia	Malaria Education Program	Ministry of Health	Early 1960s	To transmit administrative messages daily from central ministry to field offices, and from regional offices to local offices.				Lack of local supplies forced imports from donor country; maintenance difficulties.

LOCATION	PROJECT TITLE	FOUNDING ORGANIZATIONS	YEARS OPERATED	FUNCTION	# OF STATIONS	TECHNICAL DATA	COST	OUTCOME/COMMENTS
Guatemala	Health Services Delivery Communications	USAID Ministry of Health	1971 to 1978	Determine feasibility of using a low-cost 2-way radio to link rural community health posts and hospitals for continuing education, emergency referral, and administration; also for health related community development projects like latrines.	2 regions, Quiche & Quirigua, 16 Health Posts	SSB 175 mghz transistorized Larco 566-330	2.5 million	Improved interpersonal relations among health workers, increased demand for material and supervisory services, greater use for administration than referrals. Second phase expansion failed due to gov't opposition to having many radios in local hands.
Guatemala	Rural Relief Systems	USAID Ministry of Health	1976 to 1978	Connect 2 villages with ambulance teams, local health workers, hospital clinics, and fire emergency units after 1976 earthquake -- later developed into general health system.	26 stations linking 12 villages	5 watt CB with modular design solar panels	$35,000	Decreased medical transportation by allowing remote consultation; very broad range of support. Network used for monitoring training, supervision, referral, and infrastructure linkages. *PLEASE phased out on request of Guatemalan gov't - felt project should be in local hands.
Guyana	Two-way Radio in Support of Medex	USAID	1980	Pilot project to provide administrative, referral, and educational communications between field Medex and Georgetown headquarters.	12	Stoner 558, 150, 2 with solar panels	$55,000	Most extensive radio use by Medex in isolated interior villages; coastal Medex find radio marginally useful; major benefits in drug ordering, arranging transportation for patients and administration. Full, project evaluation to be completed in August 1980.

LOCATION	PROJECT TITLE	FOUNDING ORGANIZATIONS	YEARS OPERATED	FUNCTION	# OF STATIONS	TECHNICAL DATA	COST	OUTCOME/COMMENTS
India	EC-AIIMS Experimental Pilot Study	All Indian Institute of Medical Sciences, Ministry of Health and Family Welfare	1977 to Present	Connect primary health center at Ballabhgarh with other public health centers for consultations and emergencies.	315 watt VHF transceivers plus 400 MW walkie-talkie, 11 stations			Extensive system usage data exist. The communications network in Ballabhgar Block is the first of its kind in India. No evaluation study yet undertaken. (Network provides support for medical students to obtain practical experience in are of consultancy - health care for villagers.)
Lesotho	Two-way Radio in Support of Medex	USAID	In planning stage	To provide communications for referral, administration, and education to remote Medex				
Liberia	Lofa County Rural Health Project	USAID, HEW, Indian Health Service	1975 to 1979	Part of integrated health project to extend communications from national medical center and administrative facilities in Monrovia to county hospitals and health centers	32 health posts	Continuing operational and maintenance problems - power fluctuations a major problem, equipment pilfering a problem SSB Stohner Baltene powered generator	"No clear-cut budget for this project was ever devised. Efforts were made to obtain equipment from army surplus, churches, etc." Tennison	Clearly essential to program, but radio network completely broke down - entire project had major administrative failures, of which radio operations was one.

LOCATION	PROJECT TITLE	FOUNDING ORGANIZATIONS	YEARS OPERATED	FUNCTION	# OF STATIONS	TECHNICAL DATA	COST	OUTCOME/COMMENTS
Malawi	Malawi Medical Radio Communications Systems	AMREF Netherlands Organization for International Development Cooperation (NOVIB) Malwai Ministry of Health	1977 to 1979	To assist MMOH strenthen its health care delivery system	9	PYE-SSB-130 radios, 12 volt battery, Honda generator	Equipment costs 53,000 k shilling	System used mainly for reporting on drug shortages, verifying lab reports, communicating public health matters, informing hospitals of emergencies, and consultations.
Nepal	Nepal Two-way Communication Health Project	Dooley Foundation, NASA Ministries of Health/Education	1976-1977 Feasibility Stage	To establish a HF network to support Nepalese gov't's health thrust network would be used for on-the-job training and patient management.	No decision taken	HF radio, Battery-powered generator	No definitive budget made up for project	The project never was implemented because of a number of socio/political factors, chief of which was the Nepal gov't concern that there would be no way to supervise and monitor field use of radio.
Nicaragua	Invierno Regional Development Project	USAID Nicaraguan National Hospital Board (JNAPS), Ministry of Public Health	1976	To provide a network to link local "collaborators," health centers, and regional supervisory offices to further facilitate gov't efforts at improved health care and education.	10	100 watt, Motorola FM transceivers, Mobile units, network functioned via a repeated station on a mountain top.	$50,000	When in use, system used for data transmission and and administrative purposes System broke down as a result of military government fears that non-government personnel would use system.

LOCATION	PROJECT TITLE	FOUNDING ORGANIZATIONS	YEARS OPERATED	FUNCTION	STATIONS	TECHNICAL DATA	COST	OUTCOME/COMMENTS
Arizona	Space Technology Applied to Rural Papago Advanced Health Care (STARPHAC)	NASA/HEW	1975 to Present	To demonstrate the feasibility and potential of utilizing space technology in communications and systems engineering to upgrade health care access and delivery to a large population of Indians in the Papago Indian Reservation of Arizona.		Microwave TV, Computer, Audiophone, Two-way audio/video, Slow-Scan video	$3,352,000	When the project began in 1977 computers and facsimile units were used to transmit medical records and for consultation; later discontinued because they proved unproductive for this system. The project was a success in providing primary health care education programs, technical assistance, and administrative support.
Australia	Royal Flying Doctor Service	Government of Australia/ Private Sources	Early 1960s to Present	To bring medical services to large isolated areas in Australia outback through use of radio transceivers.		Low-powered transceivers (3 or 5 watt), Battery operated aircraft		The radio service has proven significant in health care in providing talks and a means to call for medical help in the area with no other service.
California	Telemed System in North County Health Project	North County Health Services	1977 to Present	Developed to extend primary health care coverage of the nurse practitioner and physicians. To provide 24 hr., 7 day a week communication to a major primary care clinic.		Telephone One-way, slow-scan video		
Colorado	Mountain/ Plains Outreach Program		1976 to 1977	To provide improved health care to rural areas of Colorado through telecommunication and data processing linkages between urban areas and primary health care rural centers.		Computers Telephone (WATS)		Program includes a computer data system with CRIS to provide on-line patient information. Use includes: pharmacology surveillance, health education, and a medical practice unit.
Florida	Telemedicine Health Care Delivery in Dade County Penal Institutions	Jackson Memorial Hospital	1974 to 1977	The projectis aimed at evaluating and analyzing the effects of a telemedicine system on an existing health care delivery system and studying response of patient groups.		Microwave slow-scan, two-way audio/video, Fascimile, Audio-support devices	$1,205,000	

LOCATION	PROJECT TITLE	FOUNDING ORGANIZATIONS	YEARS OPERATED	FUNCTION	STATIONS	TECHNICAL DATA	COST	OUTCOME/COMMENTS
Newfoundland Canada	Experimental Use of the Communications Technology Satellite, HERMES, in Telemedicine	Educational Television Center, Memorial Hospital, Carbonear Hospital	March 1977 to June 1977	To test the satellite system as a means of consultative services and education for physicians, nurses, and allied health workers at four hospitals in Ontario.		Satellite (HERMES), One-way TV, audio, teleconferencing four-wire Darome mini-convener, slow-scan video	Cost to Memorial $2,160. Individual costs are borne by participants	The project simulated various sessions at St. Johns between a hospital and teaching center. It was used during a 3-month period for 39 teleconferences totalling 45.5 hours. Results: low response by participants, low participation in sessions, negative response to questions. Some physicians and nurses found equipment difficult to use and found it difficult to participate in discussions. Lack of confidentiality and face-to-face contact proved a problem.
Labrador, Canada	Memorial University Telemedicine	Educational Television Center; Faculty of Medicine at Memorial University	July 1976 to March 1977	Focuses primarily on in-service education programs to physicians but also used to provide consultation services and for transmission of x-rays and other medical data.	5	Satellite (HERMES), One-way video TV, Slow-scan (project met with technical difficulties associated with power sources and terminal malfunctions)		There were considerable technical problems relating to equipment malfunctions and power failures. Evaluation report indicated that despite inconvenient scheduling of program experiments, 250 people out of a maximum of 452 attended sessions at experiment sites.
Labrador, Canada	Telemedicine Teleconferencing System (Pilot Project)	Dept. of Health in the Province Gov't. Contributing Hospitals in Newfoundland and Labrador	1978 to 1980	To establish a multidisciplinary teleconferring system for use by health professionals and administrators and several hospitals and educational institutions throughout Newfoundland.		4-wire telephone line	180,000 in addition to a monthly user fee by institutions comprising the network	The system is used primarily for continuing education of health professionals but is also used for patient care, transmission of medical data. Evaluation to be conducted April 1980.
Toronto, Canada	University of Toronto/ University of Waterloo Telemedicine Project	University of Toronto, University of Waterloo	Sept. 1977 to Sept. 1979	To study the cost-effectiveness of a slow-scan video system in assisting delivery of health care to northwestern Ontario	30	Telephone, Satellite lines, radio telephone, radio, slow-scan video		Monthly reviews of the project show that its use is increasing as people become familiar with the new technology. The study evaluation will compare health care delivery patterns in communities with slow-scan video equipment and communities without the equipment.

LOCATION	PROJECT TITLE	FOUNDING ORGANIZATIONS	YEARS OPERATED	FUNCTION	STATIONS	TECHNICAL DATA	COST	OUTCOME/COMMENTS
Ohio	Ohio Telemedicine Project	University of Cincinatti	Early 70s to present	To provide information retrieval facilities for medical personnel at remote hospitals needing to use facilities of a major urban medical center.		Slow-scan TV, Telephone		The system is used to transmit data on patient care, or librar and pharmaceutical material to four hospital sites in Cincinat ti. Consultation with experts is also provided as need arises for teleconferencing.
Ohio	Ohio Valley Medical Microwave TV System	Ohio State University College of Medicine, Ohio Educational TV Network Commission	1974 to Present	To improve health services between rural towns and state hospitals in Ohio's Appalachian region as well as provide continuing medical education for professionals, consultation, diagnoses, administration, and data exchange.		Microwave, Two-way audio/ video		Designed originally to provide telediagnoses and teleconsultation, this system has evolved to provide continuing medical education for physicians, nurse allied health professionals, an undergraduate medical students.
Ontario, Canada	Canadian Telemedicine Experiment U-6	Canadian Dept. of Communications, Univ. of Western Ontario, Gov't. of Ontario	1976 to 1977	To use satellite communication technology to link a remote base hospital via one-way TV plus interaction audio and facsimile to a university hospital so as to provide improved all-around health care.		HERMES satellite, One-way video, Two-way audio, Facsimile		On the whole the response to the experiment was positive, particularly to those involving diagnostics and patient management. Of the 211 experiments recorded, nurses related 87.6% as good to excellent. Visual access provided by satellite transmission was particularly important in psychiatric consultations.
Ontario, Canada	Gov't. of Ontario, Interministry Experiment	Telecommunication Branch of the Ontario Ministry of Gov't. Services, Ontario Ministry of Health	June to August, 1978	To test the utility of audio conferencing for discussions between physicians located at isolated hospitals and specialists at a large specialized hospital.		HERMES satellite, Portable radio-units, grand terminals		During the two-month period, successful demonstrations were held in treatment of medical emergency evacuation, transmission of medical data, and EKG reading.

LOCATION	PROJECT TITLE	FOUNDING ORGANIZATIONS	YEARS OPERATED	FUNCTION	STATIONS	TECHNICAL DATA	COST	OUTCOME/COMMENTS
Nebraska	University of Nebraska Slow-Scan	University of Nebraska	1972 to Present	To develop a communication system to provide quick evaluation and processing of x-rays.		Telephone Slow-scan video	First year budget $128,654	Slow-scan video transmission is used to provide on-demand assessments of x-rays transmitted from one hospital to another. X-ray evaluations are given over the phone. The system takes 90 seconds to provide x-ray assessments.
New Hampshire	New Hampshire/ Vermont Interactive Medical TV Network (INTERACT)	Lester Hill National Ctr. for Biomedical Communications	1968 to Present	To set up a model of interactive health institutions which could provide consultation and education between physicians in urban and remote rural communities.		Microwave, Two-way audio/ video data, Video tape mobile units equipped with B/W camera and audio and video transcanners	Annual Cost approx. $208,000	60% of the system is used for health education, other benefits revealed by evaluation studies are increased extension of medical services to rural medical units.
New Mexico	Playas Telehealth System	Phelps Dodge Corp., University of New Mexico	1975 to Present	To provide comprehensive health care to employees of the Phelps Dodge Corp. in Playas via telecommunications		Microwave, Two-way audio/ video, Telephone		Playas and surrounding community residents now have consultative, diagnostic, and administrative services available to them, including primary health care, lab/x-ray services, and pharmaceuticals.
Ohio	Laser Telemedicine in Anathesia	U.S. Dept. of Education	Early 70s, Ongoing	To set up a two-way telemedicine link between an anesthesiologist in a large university hospital and another anesthesiologist a mile away to provide patient care without requiring the physical presence of a specialist.				The system links a health center in Cuba with six outreach clinics staffed by non-physician providers. The system also provides consultative services and administrative support to satellite clinics and through a home health-visit program.

LOCATION	PROJECT TITLE	FOUNDING ORGANIZATIONS	YEARS OPERATED	FUNCTION	STATIONS	TECHNICAL DATA	COST	OUTCOME/COMMENTS
	Gateway District Health Dept.	Gateway District Health Dept.	1975 to Present	To provide public health services to the population of 5 N.E. rural counties in Kentucky as well as provide administrative support services.		Mobile van, Radio telephones		A mobile radio communications system links medical support personnel in the field with base staff at a central district office. The mobile unit, staffed by a dentist, hygenist, and clerk, travel throughout the region dispensing medical care and information.
Maine	Blue-Hill - Deer Isle Telemedicine Project	Blue-Hill Memorial Hospital	1973 to 1977	To provide expert consultation services via 2-way interactive television from a major hospital to a clinic in an isolated rural community.		Microwave, Two-way audio/visual	Initial Grant - $60,000 Approx. annual cost $3,000	Patient consultation takes place between nurse practitioners at clinic on Deer Isle and physicians at Blue Hill Memorial Hospital via two-way television. Contact time is used 50% for patient care, 35% medical consultation, 10% for administration, and 5% for patient education.
Minnesota	Lakeview Clinic Bi-directional Cable TV system	Waconia, Jonathon, Ridgeview Hospitals in Waconia, Minnesota	1970 to 1974	To evaluate a 2-way audio/vidio cable link between three rural hospital clinics as well as assess the behavioral and attitudinal changes of participating physicians and allied health personnel.	3	Cable, Two-way audio/video data	Grant $207,168	The system was used for teleconsultations, telediagnoses, monitoring and augmented verbal communication follow-up exams.
Missouri	Veterans Admin. Nuclear Medicine Project		1974 to Present	To provide nuclear medical services available at the Veterans Admin-Hospital in St. Louis to rural areas around the city.		Telephone, Computer		Clinical patient studies are recorded daily and stored on magnetic discs which are reformulated into pictures and transmitted via data phones and computer to the main hospital. From these images diagnoses are determined and reports transmitted back to the clinic in 24 hours.

LOCATION	PROJECT TITLE	FOUNDING ORGANIZATIONS	YEARS OPERATED	FUNCTION	# OF STATIONS	TECHNICAL DATA	COST	OUTCOME/COMMENTS
Swaziland	Radio Communication System	Danish International Development Agency, African Medical Research Foundation	1974 to present	To establish a radio network to improve communication between peripheral and central health units in Swaziland and mobile units for administrative and consultative matters.	67	VHF radio units, 12 volt battery	Initial cost, R.39,600	No evaluative study done

LOCATION	PROJECT TITLE	FOUNDING ORGANIZATIONS	YEARS OPERATED	FUNCTION	# OF STATIONS	TECHNICAL DATA	COST	OUTCOME/COMMENTS
Sudan	Telecommunication Development in the Southern Region of the Sudan	WHO, ITU, UNESCO	1975 to 1976	Project set out to determine how two-way radio could best serve rural health workers during disasters and epidemics		VHF fixed/ mobile units, HF units	25,000	Pilot project found that immediate application for two-way radio in S.Sudan appeared to be for providing communication during epidemics Suggested that special equipment that would not need external power supply should be developed. Also that HF users develop special operating techniques peculiar to the situation.
Sudan	Communication in support of Rural Health in the Sudan	USAID, Sudan Ministry of Health	1971 Phase 1 of Planning.	The project calls form use of 2-way HF radio to connect parts of the Primary Health Care Project in South Sudan to provide more effecgive links between regional health centers, dispensaries, and primary health care workers for supervision, consultation, notification and logistics coordination.	15	Portable VHF radios, CDs, solar panels.	Aprox. 700,000	Still in planning stage.

LOCATION	PROJECT TITLE	FOUNDING ORGANIZATIONS	YEARS OPERATED	FUNCTION	# OF STATIONS	TECHNICAL DATA	COST	OUTCOME/COMMENTS
Peru continued				teleconferencing. Purpose to provide field experience and realistic data concerning costs/benefits of development-oriented rural communications services.				
South Africa	Community Medical Services Project	South Africa Government	1970 to present	To provide an adequate and practical communication system between a major hospital in NE Natal and clinics in the area which suffer from poor road/transportation conditions and an unpredictable telephone system.	11	VHF radio, battery powered generator	Cost at installation, R. 2,700	In the first 3 and a half years of operation the network significantly helped in medical and administrative problems. The system was expanded in 1971 and is used primarily for consultative and administrative matters.
South Pacific	PEACESAT Education & Communication Experiments	NASA, Univ. of Hawaii, Univ. of S.Pacific, S.Pacific Commission, Carnegie Corp. of New York Hawaii State Legislature	1971 to present	To provide a telecommunication system which would support regional development efforts; to demonstrate the benefits of current available tele-technology to sparsely populated areas.	17	Sattelite ground terminals, facsimili, computers, teletypewriters.	Funding partially through grants totalling $125,000 inital funding provided by numerou agencies.	PEACESAT has proven sucessful in support of health, education and communication service projects. An independent evaluation undertaken in 1979, howver, concludes the project's benefits appear to be minimal to the Pacific Islad because of the marginal role played in administering the system.

LOCATION	PROJECT TITLE	FOUNDING ORGANIZATIONS	YEARS OPERATED	FUNCTION	# OF STATIONS	TECHNICAL DATA	COST	OUTCOME/COMMENTS
Nicaragua	East Coast Medical Communication Network	USAID Ministry of Health Rural Health Program, University of Wisconsin Partners of America, Centro de Desarrollo Regional (CENDER)	1965 to Present	Two-way radio network established to link communication in eastern Nicaragua with regional health centers so as to better maintain referral logistics and administrative control.	7	12 watt SSB transceivers, 12 volt car batteries, solar-powered battery charger	$363,000 grant from	At present, project functioning well. The radios are used for medical/consultative purposes. Most frequent problem cited is the lack of 24 hour weekend coverage; other problems relate to maintenance of batteries.
Nigeria	Two-way Radio Communication Network	UNICEF, WHO, Nigerian Ministry of Health	1963 to 1974	Network was established as a component of the AMREF Flying Doctor Service in N. Nigeria, to transmit information on administrative and health problems	26	Pedal-operated transceivers, HF radios		System was successful in early years of operation - improved professional skills of dispensary staff increased staff morale, and patient treatment. Also made available better professional advice in emergencies. Network broke down when outside experts left and relinquished system to local personnel. Maintenance was not kept up. By 1974, most equipment was not working.
Peru	Rural Communication Services (Pilot Project)	USAID Ministry of Health	1979 to Present, Feasibility	Pilot project to provide communication satellite ground stations and radio links to villages surrounding satellite communities. Network to be used used for both 2-way telephone service, multi-point	3-6	VHF radio phones, thin-route, 3 channel earth stations with parabolic antennas	Part of	Project still in planning stage.

BIBLIOGRAPHY

AED. "Implementation, Operations and Evaluation Plan." Medex-Guayna file report, August 1979.

African Medical and Research Foundation. Report of Visit by AMREF Evaluation team to Malawi, Minsitry of Health.AMREF Radio Communication System. February 1979.

African Medical Research Foundation: AMREF REPORTS: Progress Development of various AMREF projects for the period January-June 1979. AMREF, Niarobi, Kenya.

AID: LAC Regional Project Paper Rural Communications Services. Washington DC: USAID.

Allwood, C.W. "A Community Medical Service Using Two-Way Radio: Making a little Doctor Go a Long Way. " South Africa Medical Journal. 48 (Sept. 1975): 1957-8

Anderson, C., and Rappaport, W. Technology Applications in Rural Health Care Systems. Virginia: The MITRE Corp. (MTS-7537), May 1977.

Armstrong, P.A.; Youssef, Z.I.; and Bashur, R.L. "Telemedicine in the USA: Summary Operational Programs." In: Telemedicine: Explorations in the Use of Telecommunications in Health Care. Edited by Charles Thomas. 1972, pp. 309-346.

Bashur, R.L., and Armstrong, P.A. "Telemedicine: A New Mode for the Delivery of Health Care." Inquiry Vol. 23 (1976): p. 236

Bennett, A.M.: Rappaport, W.H.; and Skinner, F.L. Telehealth Handbook: A Guide to Telecommunications Technology for Rural Health Care. DHEW Publication No. (PHS) 79-3210, May 1978.

Boor, J.L. et al "ATS-6: Technical Aspects of the Health/Education Telecommunications Experiment." IEEE Transactions on Aerospace and Electronic SystemsAES-11,6. November 1975, pp. 1015-1032.

Britt, Richard W."Interactive Television: Blue Hill/Stonington Maine." Blue Hill Memorial Hospital.

Burns, Stanley G: "Technical report to AID/Georgetown: MEDEX-Guyana" March 1979. Academy for Educational Development, MEDEX-Guyana file report.

Burns, S.G.- Wallace, Ned, "Two-Way Radio for Health and Development." Telecommunications Vol. 13, No. 12, December 1979, pp: 17-22.

Bystron, John. "PEACESAT." World Health, January 1978, pp. 10-11

Caldwell, K.S. The Veterans Administration Experiments in Health Communications on the Applications Technology Satellite (ATS-6): Final Report. Washington, D.C. Veterans Administration, February 1976

Carey, L., and Russell, E. Canadian Telemedicine Experiment U-6. University of Western Ontario, 1977.

Casey-Stahmer, A. "Telehealth Care in Canada: A Discussion of Projects, Research and Policy considerations." Evaluating New Telecommunications Services. Edited by M.C.J. Elton. NATO Conference Series, Series 11. (New York: Plenum Press) 1978.

Casey-Stahmer, A. The Hermes Communications Technology Satellite Project. An information paper submitted to USAID, January 1977.

Chan, S., and Messick, J.R. 33 Telecommunications Projects in Medical Education and Health Care. Michigan: Michigan State University, March 1975.

Christensen, Donald B., Arnaud, Juan, B:"Report: Rural Health Two-Wav Radio Feasibility Study." Submitted to USAID Mission, Nicaragua, and the Minister of Health, Nicaragua: under contract No. AID/afr-C-1131

Clearinghouse on Development Communication. Satellite Applications for Public Service: Project Summaries. USAID, April 1979.

Communications in Learning, Inc. Individuals Working Together for Creative Action. New York: Communications in Learning, Inc., 1977.

Cuba-Checkerboard Area Coordinated Health Program: A Model for a Health Delivery System in a Distressed Rural Area of New Mexico. New Mexico: Presbyterian Medical Services, July 1973.

Cowlan, B.; Foote, D; A Case Study of the ATS-6 Health, Educational and Telecommunications Projection. Office of Education and Human Resources, Bureau of Technical Assistance, Agency for International Development, August 1975.

Davis, Bob. Two-Wav Radio for Rural Health in Less Developed Countries. Unpublished Paper.

Djukanovic, V., and Mach, E.P., eds. "Nigeria: Use of Two-Way Radio in the Delivery of Health Services." Alternate Approaches to Meeting Basic Health Needs in Developing Countries, pp. 92-95. Switzerland: World Health Organization, 1975.

Dohner, C.W.; Cullen, T.J.; and Zonser, E.A. ATS-6 Satellite Evaluation: The Final Report of the Communications Satellite Demonstration. Washington: University of Washington School of Medicine, September 1975.

Dunn, E.V. and Conrath, D.W. Telemedicine Project: 1977 Year End Report. Ontario: University of Toronto.

Dunn, E.V.: Telemedicine Project: 1979 Year End Report. Ontario: University of Toronto.

Foote, E., and Hudson,H. Telemedicine in Alaska: The ATS-6 Satellite Biomedical Demonstration. Institute for Communication Research: Stanford University, 1976.

Hudson, H. Telemedicine: Some Findings from the U.S. Experience. Prepared for Bureau for Technical Assistance Educational and Human Resources, Agency for International Development, January 1977.

Hudson, H.; Goldschmidt, D.; Parker, E.B.; and Hardy, A. The Role of Telecommunications in Socio-Economic Development: A Review of the Literature with Guidelines for Further Investigations. Keewatin Communications, May 1979.

Hudson, H., and Parker, E. "Medical Communication in Alaska by Satellite." New England Journal of Medicine Vol. 289 (December 20, 1973): 1351-1356.

Hudson, H. Community Communication and Development: A Canadian Case Study. Ph.D. dissertation, Stanford University, May 1974.

Hudson, H. "Sudan Project Paper." AED, October 1979.

Jelly, D.H. A Report on the Process of Implementation. Canada: Department of Communications, July 1978.

Kenney, G.I.; Guite, Michel, J; Hudson, H.: Two-Way Radio for Rural Delivery in Lesotho. AED, Washington, D.C. January 1980.

Klapper, M.S., and Harper, I.B. "MIST-Observations and Trends." Journal of Medical Association of the State of Alabama, April 1975.

Lashman, K. An Evaluation of the Lofa County Rural Health Project Liberia. Office of International Health, Department of Health, Education and Welfare, February 1979.

Long, E.C. Health Care Extension Using Medical Auxiliaries in Guatemala. Lancet 1: 127-30, January 26, 1974.

Martin, R.; Parker; and Wallace, E. Two-Way Radio in Rural Health Care: Guatemala & Nicaragua. Unpublished. Washington DC: USAID.

McNamara, W.C., and House, A.M. Report of Memorial University on the Communications Technology Satellite Hermes in Telemedicine. St. John's, Newfoundland: Health Sciences Centre, Memorial University, 1977.

Miller, J., and Houston, A. "Solar Energy Powers Two-Way Radios." Development Communication Report, October 1979, No. 28, p.3.

M.I.S.T. Bioscience Communication Vol. 4 (1978): 67-73

Moore, G.T. "Comparison of Television & Telephone for Remote Medical Consultation." New England J. Med. Vol. 292 (April 1975): 729-732

Nath, L.M.; Kapoor, S.,; and Ramachandran, E.R. Rural Medical Communication: Case Study of the EX-AIMS Experiment in Ballabhgarh Block. India: All India Institute of Medical Sciences.

Ohlman, H. Flying Doctor Service. Geneva: WHO, October 1976.