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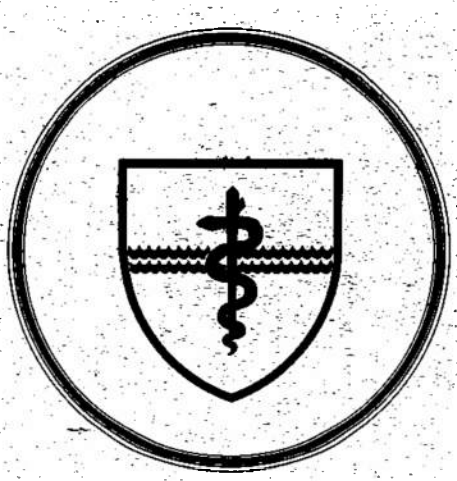

NSMRL REPORT NUMBER 1089

A Computer-Based Diagnostic/Information Patient Management System
for
Isolated Environments

MEDIC Ten Years Later

by

Bernard L. Ryack

Naval Medical Research and Development Command
Research Work Unit MF57.528.02-0001

Released by:

C. A. Harvey, CAPT, MC, USN
Commanding Officer
Naval Submarine Medical Research Laboratory

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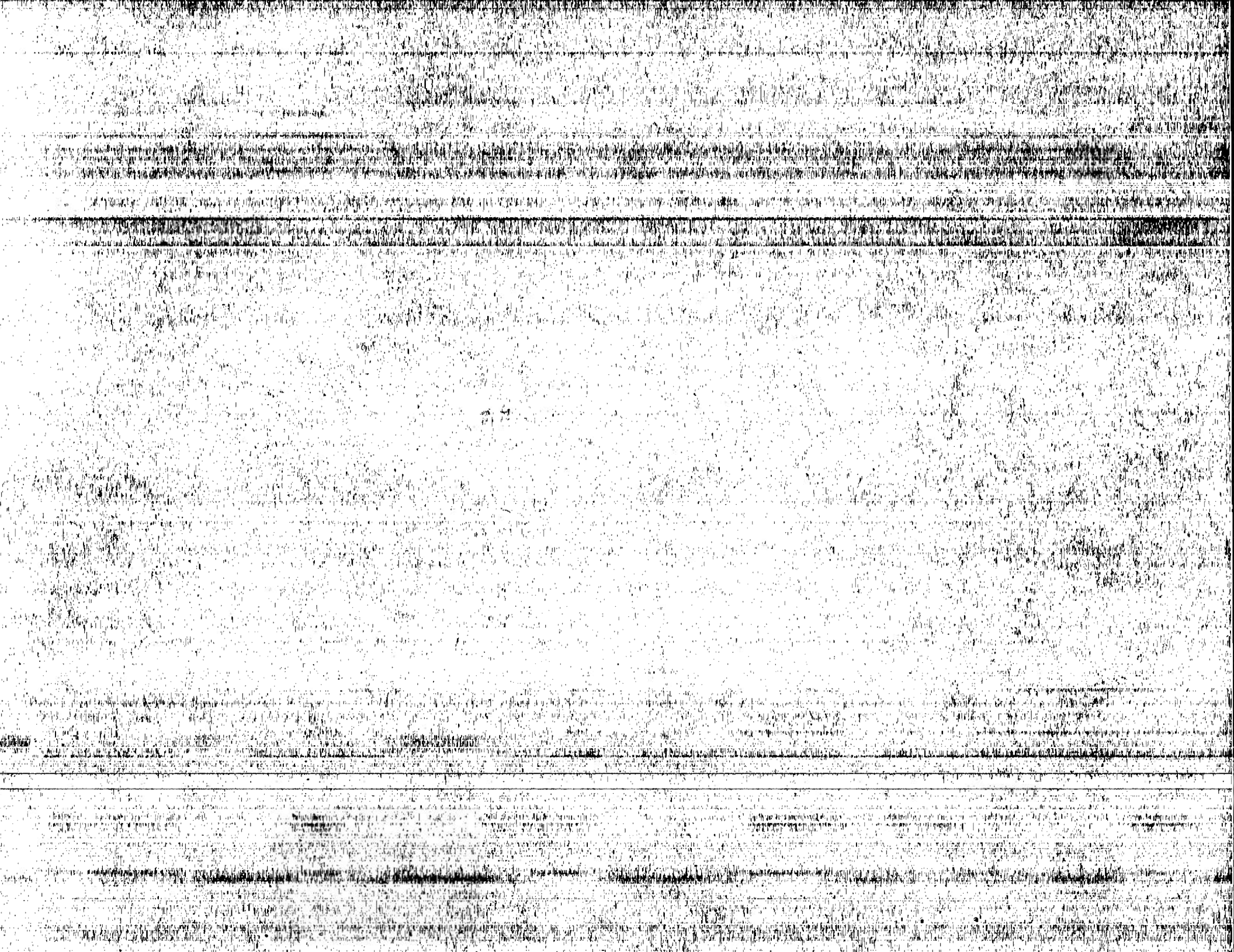

A Computer-Based Diagnostic/Information Patient Management System for Isolated Environments: MEDIC Ten Years Later

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NSMRL REPORT Number 1088

Prepared for the International Committee on Military Medicine to be considered for the Jules Voncken Prize.

Approved and Released by
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SUMMARY PAGE

THE PROBLEM

To record the history of MEDIC, a computer-based medical diagnostic and patient management system developed by NSMRL in the decade 1976-86.

THE FINDINGS:

The rationales for development of MEDIC and for each of its components are presented. Problems in conceptualization, implementation, and evaluation of the system are reviewed, as are the solutions to those problems.

APPLICATION:

The prospective user of MEDIC should be better equipped to apply its components effectively when he/she understands why the system and its components were developed in their present form(s). The administrator will be better able to assess the systems applicability to the contexts of concern to him/her knowing the contexts for which MEDIC was developed and the history of MEDIC's applications. The scientist should be able to build better systems knowing how MEDIC evolved and the problems encountered.

ADMINISTRATIVE INFORMATION

This project was conducted under Naval Medical Research and Development Command Research Work Unit MM58 527.02-001 "A computer based diagnostic/patient management system for use aboard submarines." This manuscript was submitted for review on 12-1-86 and approved for publication on 2-4-87. It has been designated as NSMRL Report No 1089.

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Abstract

A computer based patient management system for isolated environments (MEDIC) is described. Four diagnostic modules have been developed. These include: abdominal pain, chest pain, psychiatric disorders, and dental problems. Other modules, including trauma, orthopedic disorders, and medical administration, are being prepared. The paper addresses the development of MEDIC and its effectiveness after ten years of research.

Modest facilities and the absence of laboratories and consultants make it difficult to provide high quality care in isolated environments. The provision of medical service in these areas represents a challenge to the most experienced medical practitioner. The problem is magnified when the provider is a non-physician, such as a nurse, corpsman, or paramedic. The computer, with its capabilities to store and process large data bases and other medical information, can assist in the improvement of medical care.

An example of such an isolated environment is the submarine. Medical personnel aboard submarines at sea may have no communication with shore-based or other medical facilities for extended periods of time. Commonly accepted diagnostic tools such as x-ray and EKG are not available. Except for the new Trident submarines, there have been no physicians aboard U.S. submarines since 1972. With the removal of physicians, the Medical Department consists of the Hospital Corpsman. The corpsman, with significantly less training and experience than the physician, serves as the sole provider of medical care for 100 to 150 men. When a life threatening illness occurs, he must decide whether it is serious enough to recommend evacuation of the patient or whether the patient can be safely treated on board. The decision to evacuate is critical. Evacuations can endanger the lives of both the patient and the rescue party, be expensive, and threaten national security.

In 1976 the Naval Submarine Medical Research Laboratory (NSMRL), Groton, CT, initiated the development of an interactive computer based medical diagnostic/information system (MEDIC) which would serve as a medical consultant to the independent duty submarine corpsman. This patient management system provides the corpsman with diagnostic, prognostic, and treatment guides[1]. Computerized patient monitoring devices, training programs, and administrative aids are being developed as adjuncts to the system. There have also been many theoretical and methodological innovations developed as a result of our involvement with computer diagnosis in the isolated environment. These include the use of EKG data, the development of multiple algorithms, the use of patient simulations, both live and televised, to train corpsmen as evaluators[2,3,4], the use of adaptive programs in training[5], and the integration of training programs with the diagnostic system[6].

The present paper addresses the development of the MEDIC system and evaluates its effectiveness after 10 years of experience. The first step was the construction of a conceptual model[7]. There are three factors central to an effective computer based diagnostic/information system: the computer algorithm (which may require a data base), a list of signs and symptoms which are inputs to the algorithm, and the rules for obtaining the signs and symptoms. The literature7 indicates that for a computer based decision aid, the computer algorithm may be the least important and the easiest component to develop, and the establishment of a comprehensive data base, the most important and the most difficult component to develop. Because of space and other environmental constraints, it was our intent to implement the system on a mini-computer rather than a large mainframe. This decision, together with resulting memory constraints and other practical considerations, such as the desire that the system serve as a guide to the corpsman but not replace his clinical judgment, led us to develop a system which was modular requiring that triage and the selection of the appropriate disease subset be done by the corpsman.

Surveys of illness occurring aboard operational submarines[1,8] revealed that the three most frequently occurring illnesses, resulting in evacuation, were abdominal pain, chest pain and psychiatric disturbances. The development of the MEDIC system was initiated in the area of abdominal pain. In our survey of the literature[7], we found one computer diagnostic program which was demonstrating clinical effectiveness. This program, being developed by Dr. F. T. de Dombal[9] at the University of Leeds, England, met the requirements of our conceptual model. It utilized a Bayesian algorithm to generate disease probabilities for selected illnesses and did not require extensive memory. Cooperatively with Dr. de Dombal, we modified the program so that it could be used by corpsmen on a computer available to them aboard nuclear submarines, a TEKTRONIX 4051 with 32K bytes of memory and a 300K byte tape cartridge[10].

The abdominal pain program was subjected to a series of experimental evaluations. In 1978 initial trials of the system were conducted in the Emergency Room at Naval Regional Medical Center, San Diego, CA[11]. The aim of this study was to validate de Dombal's system in a Navy context using the procedures employed in his early work[12]. In this study the diagnostic accuracy of the computer-aided corpsman was determined by comparing the computer-generated diagnosis to the final diagnosis. A total of 159 patients were included in the study. This study made amply clear to the project staff that two questions, which could not be properly answered by the data obtained in San Diego, had to be resolved prior to conducting further clinical studies: What is the accuracy of the corpsmen's unaided diagnosis? Do the history and physical examination conducted by the corpsmen provide data which are accurate and appropriate to the requirements of the computer-based diagnostic system?

To evaluate the data collection procedures of the corpsmen, three studies were conducted under continuous supervision at the Boone Clinic, Little Creek, VA[11,13]. In the first study, we found the overall unaided diagnostic accuracy of the Independent Duty Corpsmen to be 83.3% for 42 cases. However, accuracy was only 28.6% for the 7 cases specifically identified by the examining physician as appendicitis, renal colic, or dyspepsia, as opposed to non-specific abdominal pain. The second study utilized trained observers to evaluate the data collection skills of the corpsman. They were rated on 33 symptom categories required for use of the computer diagnosis system. Thirty-two cases of abdominal pain were evaluated. In 50% of the total observations, there was evidence that the corpsman failed to evaluate one or more indicants; for 38% of the remaining observations, he met only the minimal evaluation requirements. These results confirmed that the corpsman data collection procedures were suboptimal for the system.

The final study in this series was directed toward the effectiveness of special training in collection of the data required by MEDIC. One group of corpsmen received no training in data collection, the other eight hours. Observations were made on 33 indicants for 38 patients examined by the uninstructed corpsmen and on 27 patients examined by the instructed corpsmen. There were 1254 opportunities for the uninstructed corpsmen to record presence or absence of an indicant and 891 opportunities for the instructed corpsmen. The uninstructed corpsmen failed to collect data on 38% of the opportunities while the instructed corpsmen missed on 8% of their opportunities. However, for the data collected by the uninstructed corpsmen, there was an agreement with the medical officer of 71%, and for the data collected by the instructed, an agreement of 77%. Thus, while the uninstructed collected less data than the instructed, the accuracy of the data that was obtained by each group was similar. The overall examination was rated as thorough only 26% of the time for the uninstructed and 56% of the time for the instructed corpsmen.

This series of studies can be summarized as follows. The diagnostic accuracy of the unaided corpsman, untrained in the specific system under evaluation can be improved through use of a properly designed computer assisted diagnostic system. Training and symptom definition improve data collection.

PATIENT NAME: _____ AGE: _____

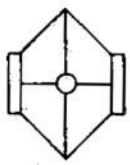
SSN: _____ DATE/TIME: _____

HISTORY

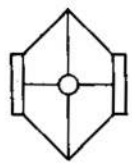
PAIN

SITE

AT ONSET (most significant when it began)



AT PRESENT (most significant at time of exam)



(11)	RUQ	(24)
(12)	LUQ	(25)
(13)	RLQ	(26)
(14)	LLQ	(27)
(15)	UPPER HALF	(28)
(16)	LOWER HALF	(29)
(17)	RIGHT HALF	(30)
(18)	LEFT HALF	(31)
(19)	CENTRAL	(32)
(20)	GENERAL	(33)
(21)	RIGHT FLANK	(34)
(22)	LEFT FLANK	(35)
(23)	NO PAIN	(36)

TYPE OF PAIN:
(at times free of pain = intermittent; constant = steady; constant and varying in intensity = colicky)
INTERMITTENT (37) STEADY (38) COLICKY (39)

SEVERITY OF PAIN:
(do not ask; obvious distress = severe; everything else = moderate)
MODERATE (40) SEVERE (41)

PROGRESS OF PAIN:
(at the time of examination)
BETTER (42) SAME (43) WORSE (44)

DURATION OF PAIN:
(duration of this episode of pain)
12h or less (45) 12-24h (46) 24-48h (47) 48+h (48)

AGGRAVATING FACTORS:
(ask specifically about each; have the patient move and cough)
MOVEMENT (49) BREATHING (51) OTHER (53)
COUGH (50) FOOD (52) NONE (54)

RELIEVING FACTORS:
(ask specifically about each)
LYING STILL (55) ANTACIDS (57) OTHER (59)
VOMITING (56) FOOD (58) NONE (60)

OTHER SYMPTOMS

NAUSEA: YES (61) NO (62)
(feeling sick to stomach)

VOMITING: YES (63) NO (64)
(being sick to stomach)

APPETITE: DECREASED (65) NORMAL (66)
(recent change in appetite)

JAUNDICE YES (67) NO (68)
(history of yellow color to skin or sclera)

BOWELS: (recent change in bowel habits)
NORMAL (69) DIARRHEA (71) MUCUS IN STOOL (73)
CONSTIPATED (70) BLOOD IN STOOL (72)

URINATION: (recent change in urination)
NORMAL (74) PAINFUL (76) BLOOD IN URINE (78)
FREQUENCY (75) DARK URINE (77)

PAST HISTORY

PREVIOUS INDIGESTION: YES (79) NO (80)
(regular problem in the past)

PREVIOUS SIMILAR PAIN: YES (81) NO (82)
(pain like this before)

PREVIOUS SURGERY: YES (83) NO (84)
(abdominal surgery or trauma - must be intraperitoneal)

PREVIOUS ILLNESS: YES (85) NO (86)
(any pertinent illness, not just abdominal; i.e., requiring hospitalization)

TAKING MEDICATIONS: YES (87) NO (88)
(medication for this pain only)

PHYSICAL EXAM

VITAL SIGNS

TEMPERATURE	PULSE	BLOOD PRESSURE systolic	BLOOD PRESSURE diastolic	WBC COUNT
<98.6 (89)	<80 (93)	<90 (96)	<70 (99)	<8,000 (102)
98.6-100.2 (90)	80-99 (94)	90-129 (97)	70-89 (100)	8,000-10,000 (103)
100.3-102 (91)	>99 (95)	>129 (98)	>89 (101)	10,100-12,000 (104)
>102 (92)				12,100-15,000 (105)
				>15,000 (106)

MOOD: NORMAL (107) DISTRESSED (108) ANXIOUS (109)
(don't ask; obvious distress or physical symptoms = distressed; just worried about illness = anxious)

COLOR: NORMAL (110) PALE (111) FLUSHED (112) JAUNDICED (113) CYANOTIC (114)
(consider environmental temp.; check conjunctiva & palms on black & oriental)

ABDOMINAL EXAMINATION

INSPECTION: (wavelike movement = visible peristalsis; pt unable to touch hand with belly button = decreased/absent)
NORMAL (115) VISIBLE PERISTALSIS (116) DECREASED ABDOMINAL MOVEMENT (117)

BOWEL SOUNDS: (pt appears ill; normal unless markedly hyperactive or absent)
NORMAL (118) ABSENT (119) HYPERACTIVE (120)

SCARS: YES (121) NO (122)
(abdominal surgical scars or significant traumatic scars)

DISTENTION: YES (123) NO (124)
(generalized swelling or bloating of entire abdomen)

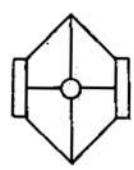
GUARDING: YES (125) NO (126)
(voluntary tightening of abdominal muscles; can relax with gentle persuasion)

RIGIDITY: YES (127) NO (128)
(involuntary tightening of abdominal muscles; cannot relax with gentle persuasion)

MASSES: YES (129) NO (130)
(localized swelling)

MURPHY'S SIGN: PRESENT (131) ABSENT (132)
(pt on back with knees bent; hook fingers under pt's right costal margin at midclavicular line; severe pain on inspiration and reflex inhibition of inspiration = Murphy's Sign PRESENT)

TENDERNESS: (area of most significant pain; palpate most painful area last)



(133) RUQ	(139) RIGHT HALF
(134) LUQ	(140) LEFT HALF
(135) RLQ	(141) CENTRAL
(136) LLQ	(142) GENERAL
(137) UPPER HALF	(143) RIGHT FLANK
(138) LOWER HALF	(144) LEFT FLANK
	(145) NO TENDERNESS

REBOUND TENDERNESS: YES (146) NO (147)
(do late in exam; slowly depress tender area, hold until pt relaxes then quickly withdraw hand to skin level; pt grimace = YES rebound)

RECTAL EXAM: (distinguish between pain and discomfort)
NORMAL (148) MASS FELT (149) LEFT TENDER (150) RIGHT TENDER (151)
GENERAL TENDERNESS (152)

CORPSMAN'S EVALUATION

MARK YOUR DIAGNOSIS:

( ) APPENDICITIS
( ) NONSPECIFIC, NONSURGICAL ABDOMINAL PAIN (e.g.: gastroenteritis, viral syndrome)
( ) RENAL COLIC
( ) PERFORATED DUODENAL ULCER
( ) CHOLECYSTITIS
( ) SMALL BOWEL OBSTRUCTION
( ) OTHER (specify):

_____

MARK YOUR RECOMMENDATION:
( ) EVACUATION ( ) NO EVACUATION

YOUR TREATMENT:
( ) OBSERVE ONLY ( ) MEDICATE
( ) PROCEDURE

DATA SHEET SEEN BY C.O.?:
( ) YES ( ) NO

RECOMMENDATION OF MEDICAL OFFICER:
( ) EVACUATION ( ) ABD PAIN TX
( ) TX FOR OTHER ( ) RETURN TO DUTY
( ) NOT CONSULTED

1981 DCA

Figure 1. Abdominal Pain data collection form. Appropriate signs and symptoms are circled for later entry into the computer.

To re-evaluate the diagnostic accuracy of the computer system, the data base originally obtained from Dr. de Dombal was modified. This modification included updating the probabilities in the data base and correcting the marginal frequencies to correspond to a submarine population. Evaluation of this data base using a retrospective population yielded a diagnostic accuracy of 75% for corpsman collected data and 88% for physician collected data[14].

In its final configuration, the abdominal pain diagnostic system consists of the data base residing in the computer, a data collection form (Figure 1) on which the corpsman records the results of his examination, definitions of indicants and guides to obtaining information required by the data sheet, treatment suggestions, a series of practice cases, and reference manuals for use with the system[15,6]. Diagnoses can be obtained for six disease categories: Appendicitis, Renal Colic, Perforated Duodenal Ulcer, Cholecystitis, Small Bowel Obstruction, and Non-Specific Abdominal Pain. These diagnoses are presented to the corpsman as shown in Figure 2. This display, which can be converted to a hard copy for storage in a medical record, consists of a list of the corpsman's inputs to the system upon which the computer bases its diagnosis, and the relative probabilities of each disease based upon the Bayesian analysis. To make interpretation easier for the corpsman, the probabilities are also presented as a bar graph. The horizontal orientation line represents a probability of 50%. The corpsman is given several choices for further action including changing previously inserted signs and symptoms to determine the effect of such changes on the diagnosis.

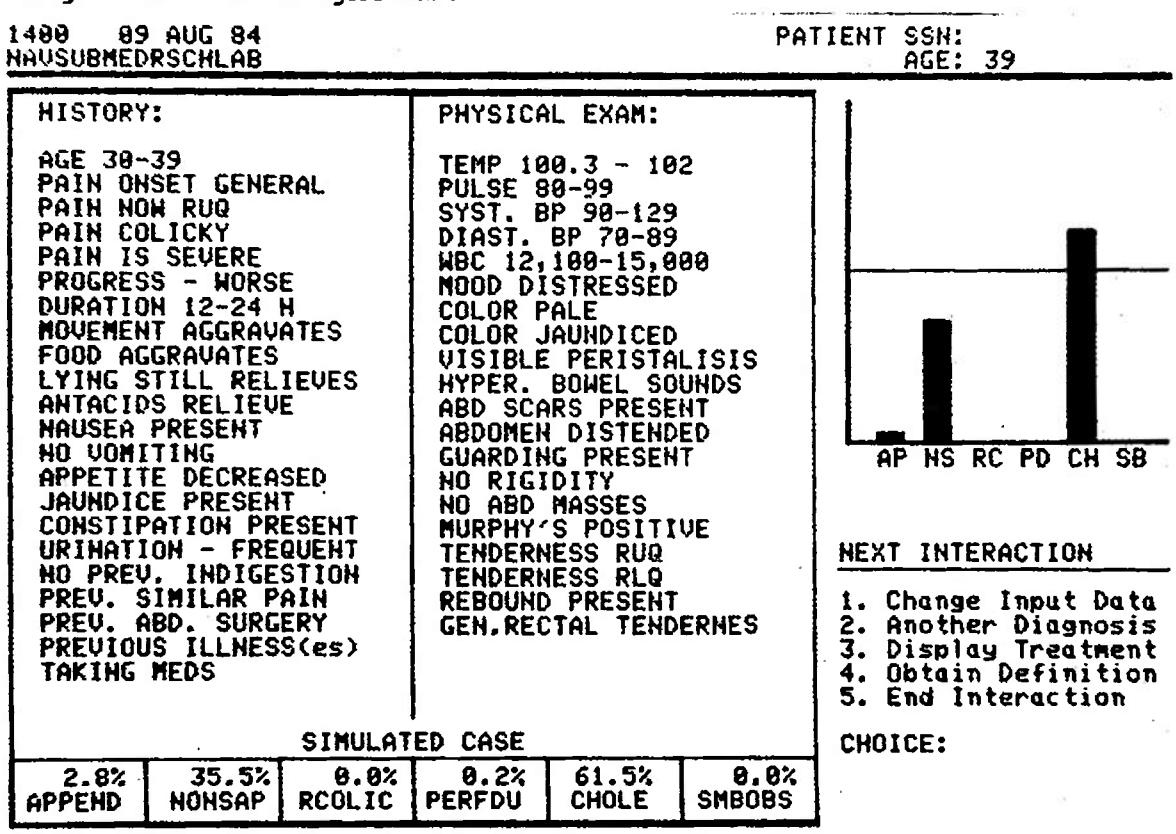


Figure 2. Summary display showing signs and symptoms entered.

In 1982 sea trials were initiated[16]. All units of the U.S. Navy Submarine Force were assigned to one of two groups, experimental and control. The experimental group was given the complete MEDIC system, the control group had all components of the system except the computer program. This study was to cover five years during which the effectiveness of the presence of the computer program would be evaluated. Concurrently, a training program for all submarine hospital corpsmen was initiated. Initial training was done at each squadron; subsequent training was a cooperative undertaking between the Naval Undersea Medical Institute (NUMI), through which all Submarine Hospital Corpsmen must pass, and NSMRL.

Between July 1982 and September 1983, 30 cases of abdominal pain had been reported to NSMRL[17]. A large number of cases remained unreported because of administrative problems. Final diagnoses were taken as those recorded by the corpsmen one week after initial presentation, except that hospital data were used when available. For the 26 fully-documented cases, the computer diagnosis was in agreement with that of the corpsman's initial diagnosis 85% of the time and with the final diagnosis 69% of the time. The corpsman's initial diagnosis was correct in 73% of the cases. Eight cases required medical evacuation. The corpsman's decision to evacuate was confirmed by the final diagnosis in 5 of the 8 cases. Although the impact of the computer appears to be positive, the limited number of cases available at this time makes any conclusions speculative.

The second program to be developed was for chest pain. The format paralleled that for abdominal pain, and the data base was again provided by Dr. de Dombal. The characteristics of the data base were similar to those for a Navy population. The program contained three modules: diagnosis, prognosis, and prediction of death and survival. To evaluate the corpsman's ability to understand and collect the data required for the computerized diagnosis of chest pain, a brief study[18] was carried out at the Naval Hospital Groton (NHG), Naval Submarine Base Groton, CT. The corpsmen did not examine patients who were judged by the emergency room staff to be in a life-threatening situation. Sixteen corpsmen were evaluated on their ability to collect the data required for input into the computer. All of the corpsmen were given two hours of training in the collection of the data required to complete the chest pain data form (Figure 3). For 24 observed cases, the corpsmen showed an accuracy of 64% and were more accurate for history than physical examination items. The corpsmen did not perform at a level which was judged to be satisfactory. However, it was felt that their performance could, as for abdominal pain, be improved with more intensive training.

CHEST PAIN DATA SHEET

RESEARCH FORM

PATIENT I.D.:

SEX:

DOB:

BEFORE YOU CONTINUE, ESTIMATE THE PROBABILITY OF MYOCARDIAL INFARCTION IN THIS PATIENT. (VERY UNLIKELY) 1 2 3 4 5 (VERY LIKELY)

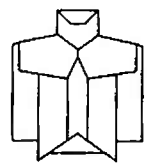
HISTORY

CHEST PAIN

SITE OF CHEST PAIN:

CENTRAL
LEFT
RIGHT
LEFT SIDE
RIGHT SIDE
EPIGASTRIC
OTHER

RADIATION:



NO
LT. ARM
RT. ARM
BOTH ARMS
BACK
CHEST
SHOULDERS
NECK
JAW
THROAT
FINGER/HANDS
EPIGASTRIC
OTHER

DURATION OF PAIN:

1 - 30 LESS
1 - 2 H
2 - 4 H
4 - 12 H
12 - 24 H
24 - 1 D
1 D OR MORE

TYPE OF PAIN:

TIGHT	GRIPPING	DULL
SHARP	BURNING	STABBING
PRESSURE/CRUSH	ACHING	NAGGING

SEVERITY OF PAIN:

MILD OR MODERATE
SEVERE

NUMBNESS (ANYWHERE):

PRESENT
ABSENT

ONSET OF PAIN:

SUDDEN
GRADUAL

TIME COURSE OF PAIN:

CONTINUOUS
INTERMITTENT

PROGRESS OF PAIN:

IMPROVING
SAME
WORSE

RELIEVING FACTORS:

NITRO
REST
WALKING
MORPHINE
OTHER DRUGS
OTHER
NONE

AGGRAVATING FACTORS:

MOVEMENT
COUGH
BREATHING
SITTING
LYING DOWN/REST
LEANING FORWARD
OTHER
NONE

OTHER SYMPTOMS

DYSPNEA:

ABSENT
ACUTE
CHRONIC

COUGH:

ABSENT
ACUTE
CHRONIC

SPUTUM:

PRESENT
ABSENT

NAUSEA:

PRESENT
ABSENT

VOMITING:

PRESENT
ABSENT

ORTHOPNEA:

PRESENT
ABSENT

PAROXYSMAL NOCTURNAL DYSPNEA

PRESENT
ABSENT

SYMPTOMS OF ESOPHAGEAL REFLUX

PRESENT
ABSENT

APPETITE:

PRESENT
ABSENT

BOWEL:

NORMAL
CONSTIPATED
DIARRHEA

OTHER HISTORY

PREVIOUS CHEST PAIN:

YES
NO

PREVIOUS CARDIO-RESPIRATORY ILLNESS:

YES
NO

PREVIOUS MAJOR SURGERY:

YES
NO

SMOKER:

YES
NO

POSITIVE HISTORY FOR

MI
ANGINA
BRONCHITIS
HYPERTENSION
DIABETES

PHYSICAL EXAM

VITAL SIGNS

TEMPERATURE:

NORMAL
INCREASED >37.8°C
DECREASED < 37.0°C

PULSE RATE

< 60
61 - 70
71 - 80
81 - 90
91 - 100
> 100

RESPIRATION

< 20
20
21 - 25
26 - 30
> 30

BLOOD PRESSURE (SYSTOLIC):

< 100
101 - 120
121 - 140
141 - 160
> 160

BLOOD PRESSURE (DIASTOLIC):

< 71
71 - 80
81 - 90
91 - 100
> 101

EXAMINATION

EDEMA:

ABSENT
ANKLES
OTHER

SWEATING:

YES
NO

SHIVERING:

YES
NO

COLD/CLAMMY:

YES
NO

CALF TENDERNESS:

YES
NO

CHEST WALL TENDERNESS:

YES
NO

RESPIRATORY MOVEMENT:

NORMAL
ABNORMAL

CHEST PERCUSSION:

NORMAL
DULL
HYPER-RESONANT

LUNG SOUNDS:

NORMAL
RHONCHI
RALES
DECREASED

JUGULAR VENOUS PULSE:

NORMAL
RAISED
LOW

HEART SOUNDS:

NORMAL
ABNORMAL

GENERAL EXAM

MOOD:

NORMAL
ANXIOUS
DEPRESSED
IN "SHOCK"

COLOR:

NORMAL
PALE
FLUSHED
CYANOTIC

LAB

EKG:

ST ELEVATION
T DEPRESSION
Q WAVES
ST DEPRESSION
ARRYTHMIA
NO APPARENT DISTRESS

SGOT:

< 25
25 - 50
51 - 100
101 - 200
> 200

DISPOSITION:

[ ] ADMITTED TO HOSPITAL
[ ] ADMITTED TO CCU, ICU
[ ] ADMITTED TO MONITORED BED
[ ] SENT HOME

Figure 3. Chest Pain data collection form.

Squadron Medical Officers suggested that they would like to have EKG data available to corpsmen to assist them in chest pain diagnosis. At this time chest pain data, which included EKG tracings, was being collected for us by physicians at NHG. The accuracy of computerized diagnosis with and without inclusion of EKG data was evaluated. It was determined that there would be sufficient improvement in diagnostic accuracy to warrant the inclusion of such data in the computer diagnostic program. The use of existing EKG recorders was not feasible because of space and weight constraints aboard submarines. Under contract with Marquette Electronics, we cooperatively developed a portable EKG machine which could be used with the computer diagnostic program (Figure 4). This very small device provides all of the

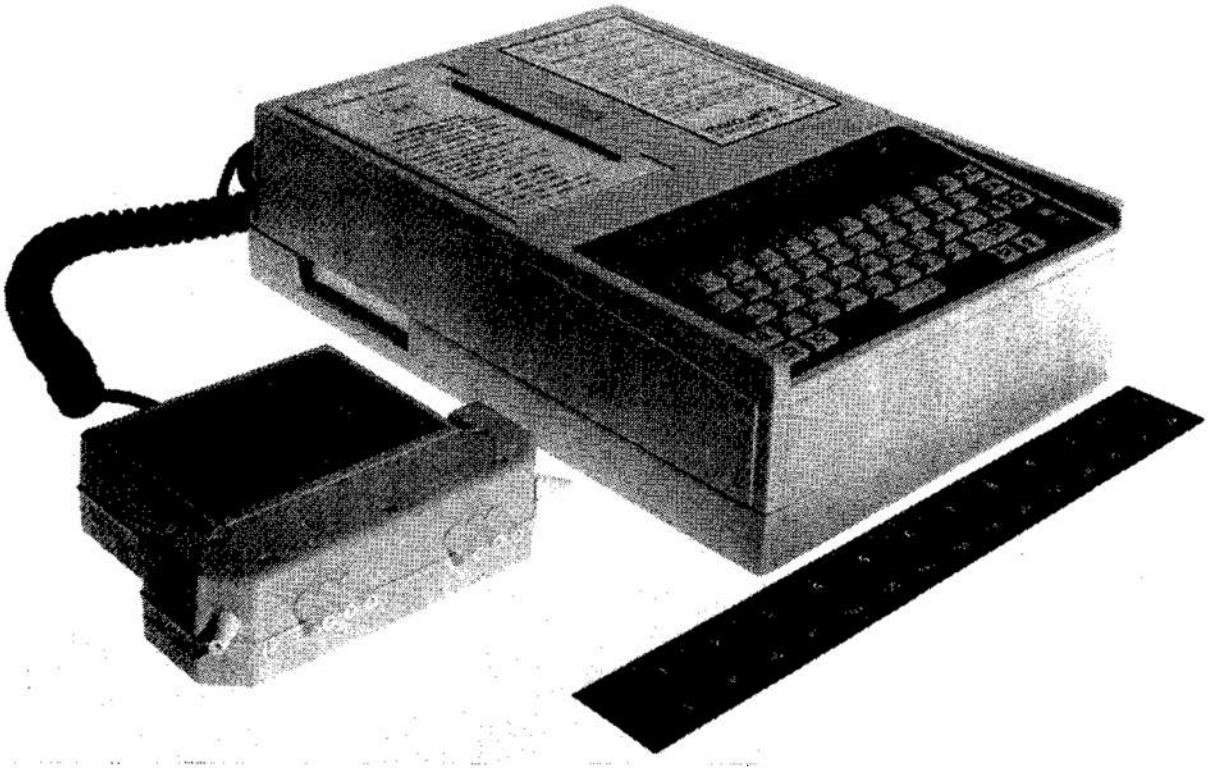


Figure 4. Portable ECG recorder. This device is 12 x 8½ x 3½ inches and can be battery operated.

capabilities of the larger MAC-II. Weighing only 10 pounds, it can be interfaced with the computer and is compatible with the Computer Assisted Processing of Cardiograms (CAPOC) system being used by the Tri-Service Medical Information Systems program (TRIMIS). Tests of the utility of this system for corpsmen have been initiated.

A new data base, which provides for the use of EKG data, has been developed at Leeds for the diagnostic program. Tests run by Dr. de Dombal resulted in a 4% improvement in diagnosis and prognosis when EKG data is used in the computer program. Data are being collected to further evaluate the diagnostic accuracy of the new system.

Two psychiatric programs have been developed, Computer Assisted Psychiatric Intervention (CAPCI) and Computer-Supported Assessment and Treatment Consultation for Emotional Crises for a Submarine (CATCEC) which incorporates the Groton Interview Schedule (GIS). The CAPCI program was developed by CDR J. Calvin, MSC, USN, primarily as a demonstration program[19,20], but it has been refined so that it can now reasonably be used in by professionals Navy psychiatric clinics. It has face validity in that it is modeled after and provides diagnoses which are similar to those provided by the DSM-III [21]. In its work on the CATCEC program, the Missouri Psychiatric Institute focused first on development of a structured interview that would be problem and treatment oriented, and appropriate to the psychiatric training and experience of the corpsman and his patient [22]. Decision rules are used to obtain the final diagnosis. This program was first validated through review by experts. Both programs provide criteria for identification and interpretation of psychiatric symptoms as well as treatment guides.

Because an empirical database relating findings from the history and physical examination to psychiatric diagnosis was not available, it was necessary for us to seek alternatives to the Bayesian algorithm. The CAPCI program is unusual in that it utilizes multiple algorithms. At the time, this was a neglected approach in computerized medical diagnosis. The program was modeled after a demonstration Orthopedic program [23] which branched to Bayesian subsets on the basis of a few decision rules. The CAPCI program combines the use of decision rules and pattern (symptom) matching (Figure 5). A decision tree consisting of 16 key questions initiates a triage process. Seven decision rules are then used to branch the program to one of five modules which develop the specific diagnosis. Additional decision rules, combined with symptom matching, develop the final diagnosis. This approach enabled us to construct a psychiatric program which could be used on a computer with limited memory.

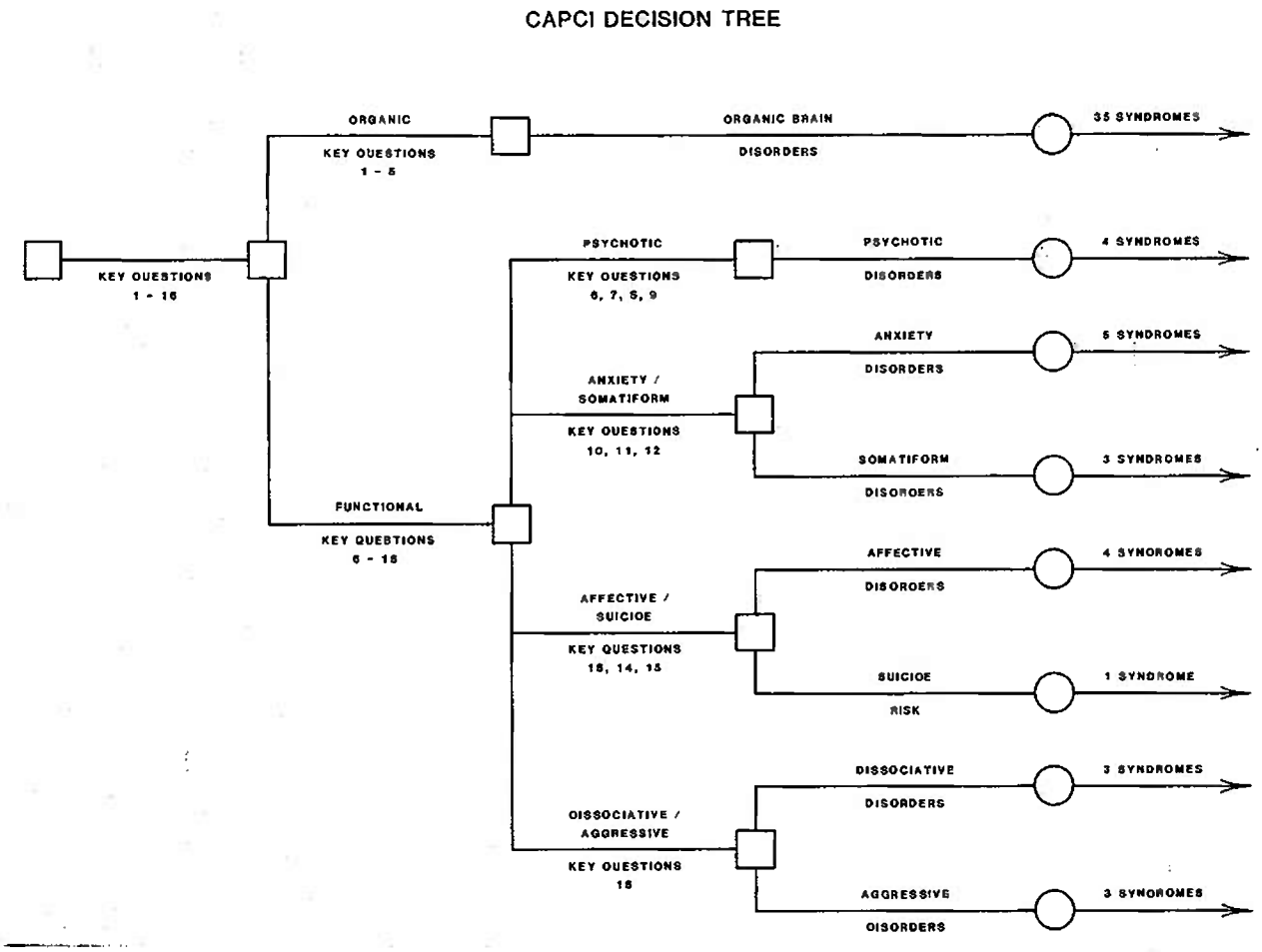


Figure 5. CAPCI decision tree illustrating use of multiple algorithms. Decision trees and rules are used to initiate pattern matching.

As our work progressed, implementation of the protocols and algorithms has been adapted to technological developments. We are presently studying the implications of providing each corpsman with his own "lap top" computer such as the one shown in Figure 6. These computers will remove the corpsman from dependence on sharing computers which are aboard the submarine for operational purposes. They contain as much as 512K bytes of memory as compared to the 32K bytes presently available, can be battery operated, and use the MS-DOS operating system which makes the programs and data usable by any IBM-compatible machine. The MEDIC system becomes completely portable with these 'lap-top' computers.

Figure 6. Portable computer with 512K bytes of memory and built in disk drive, fits into a briefcase together with a printer.

A dental program, prepared by the Naval Dental Research Institute, Great Lakes, Illinois, is to be incorporated into MEDIC. Its diagnoses are based on an algorithm similar to that of the CATCEC program. A series of diagnostic questions initiate triage into one of the disease categories within which the decision rules are used to reach a final diagnosis. Again, treatment guides are provided for the corpsman. This program will shortly be subjected to clinical evaluations. Work on an Emergency Medical Diagnosis program has only recently been initiated.

Work on aids to medical administration has paralleled that on diagnostic and treatment programs. A long range goal has been development of a computer readable medical jacket. Such programs have been widely requested by corpsmen who, in many instances, have developed their own non-standardized record keeping systems. These programs make a strong contribution to corpsman acceptance of the entire system.

Although MEDIC is presently being developed for use in operational submarine environments, it is, as has been implied, applicable to any isolated environment. We hope shortly to begin to modify the system for use aboard surface vessels and we are already interacting with the National Aeronautics and Space Administration (NASA) to explore applicability of the system aboard the orbiting space station.

Over the past 10 years, NSMRL has developed a computer based diagnostic/medical information system for use in isolated environments. To our knowledge, this is the only system, specifically designed for the isolated environment, with demonstrated functional validity. A major emphasis has been on formulating questions which can be asked by the corpsman and interpreted by the corpsman. An abdominal pain diagnostic system is being applied at sea. A chest pain diagnostic program, incorporating a portable EKG module, is to be placed aboard ship followed by a psychiatric consultation system. MEDIC will be complemented by programs for the diagnosis of dental disorders and trauma. Other programs are being considered. Throughout the course of system design, new theoretical concepts and methods have been developed and initiated. These include such innovations as multiple algorithms, patient simulation, and medical administration. Portability and miniaturization, as exemplified by lap-top computers, have been major concerns. We hope to extend the system to other environments such as surface ships and space vehicles.

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A computer based patient management system for isolated environments (MEDIC) is described. Four diagnostic modules have been developed. These include: abdominal pain, chest pain, psychiatric disorders, and dental problems. Other modules, including trauma, orthopedic disorders, and medical administration, are being prepared. The paper addresses the development of MEDIC and its effectiveness after ten years of research.

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