Final Report

Westinghouse
Health Systems

# Systems Analysis Study Towards a "New Generation" of Military Hospitals

## Volume 4
## State of the Art

# DISCLAIMER NOTICE

THIS DOCUMENT IS THE BEST QUALITY AVAILABLE.

COPY FURNISHED CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

SYSTEMS ANALYSIS STUDY TOWARDS

A "NEW GENERATION" OF MILITARY HOSPITALS

VOLUME IV: STATE-OF-THE-ART

24 November 1970

Submitted by:
Westinghouse Electric Corporation
Health Systems Department
Research and Development Center
Pittsburgh, Pennsylvania 15235

Project Director:
C. A. Sadlow, Director
Health Systems Department
Telephone No. 412-256-7101

Sponsored by
Advanced Research Projects Agency
ARPA Order No. 1494
Contract No. DAHC15 69 C 0354
25 June 1969 to 24 November 1970
$892,000



This research was supported by the
Advanced Research Projects Agency of
The Department of Defense under
Contract Number DAHC15 69 C 0354.

# PREFACE

This is Volume IV, State of the Art, of a five-volume final report submitted by the Westinghouse Electric Corporation to the Department of Defense for work performed on Contract Number DAHC15 69 C 0354, Systems Analysis Study Towards a "New Generation" of Military Hospitals.

The primary task of this study was to develop alternative hospital system designs, using current state-of-the art concepts, technology, and management procedures with the objective of designing the most effective hospital for construction commencing in mid-1972. The secondary task was the definition of system improvements arising from R&D opportunities available in time for prototype construction in the 1975-1980 period.

The remaining four volumes contained in this final report are:

| VOLUME | TITLE |
|---|---|
| I | Executive Summary |
| II | Systems Analysis |
| III | Medical Health Care Review |
| V | Data Inventory |

# ACKNOWLEDGEMENT

## WESTINGHOUSE ELECTRIC CORPORATION PROJECT TEAM

The Westinghouse Project Team consisted of personnel from the following Westinghouse groups, subcontractors and universities as well as individual consultants:

### WESTINGHOUSE ELECTRIC CORPORATION

HEALTH SYSTEMS DEPARTMENT - Program Management

- Systems Simulation & Control
- Bioscience & Medical Systems
- Corporate Design Center
- Major Projects & Urban Systems
- Learning Corporation
- Medical Products Engineering
- Urban Systems
- Public Systems Management Services

Tele-Computer Systems Corp.

### SUBCONTRACTORS

ROGERS, TALIAFERRO, KOSTRITSKY, LAMB, INC. - Systems Design

McKee-Berger-Mansueto, Inc. - Construction Costs

SYBRON CORPORATION - Distribution Systems

BRANDEGEE ASSOCIATES - Technical Writing

### ADVISORY BOARD

D. J. Macer, M. S.
Assistant Vice Chancellor of Medical Professions,
College of Medicine,
University of Pittsburgh

M. J. Schaefer, Ph. D.
Dean, School of Nursing,
University of Pittsburgh

H. E. Smalley, Ph. D.
Regents Professor & Director Health Systems Research Center,
Georgia Institute of Technology

T. B. Turner, M. D.
Dean Emeritus,
Johns Hopkins School of Medicine,
Professor of Microbiology,
The Johns Hopkins University

D. S. Wenger, M. D.
Associate Professor of Surgery,
Chief of Traumatology,
Department of Surgery,
The George Washington University,
School of Medicine

* Member Health Care Review Team

### CONSULTANTS

A. Edelmann, Ph.D.
Medical and Hospital Liaison

E. G. Streidl
Health Services & Facility Planning

V. J. Treanor
Analysis and Design

GEORGIA INSTITUTE OF TECHNOLOGY

G. L. Delon, Ph.D.
Industrial & Systems Engineering, Operations Research

UNIVERSITY OF MICHIGAN

R. C. Jelinek, Ph.D.
Operations Research Industrial Engineering

F. Munson, Ph.D.
Organization Theory

THE JOHNS HOPKINS UNIVERSITY

C. D. Flagle, Ph.D.
Operations Research, Cost Benefits

R. J. Johns, M.D.
Internal Medicine, Bioengineering

R. B. Conn, M.D.
Clinical Pathology

*J. W. Love, Ph.D., M.D.
Surgery

STANFORD UNIVERSITY

R. D. Smallwood, Ph.D.
Systems Engineering

UNIVERSITY OF PITTSBURGH

*H. H. Kroeger, M.P.H.
Medical & Hospital Administration

N. Hershey, LL.B.
Health Law

*M. F. Hill, Ph.D.
Nursing Administration

*I. G. Ramey, Ph.D.
Nursing, Medical-Surgical

*E. G. Saltz, M.D.
Pediatrics

*C. T. Rumble, M.D.
Psychiatry

W. A. George, D.D.S.
Dentistry

R. A. Chez, M.D.
Obstetrics & Gynecology

VETERANS ADMINISTRATION HOSPITAL, OAKLAND, PENNSYLVANIA

*F. C. Jackson, M.D.
Surgery

*F. D. W. Lukens, M.D.
Medicine

NORTH HILLS PASSAVANT HOSPITAL, PITTSBURGH, PENNSYLVANIA

G. S. Lerman, M.D.
Radiology

Westinghouse wishes to acknowledge and thank each member of the project team for his outstanding contribution and dedication to the project. Special thanks go to all the military personnel at each of the Base Level Health Care Systems studied for their cooperation and effort, and to the Department of Defense personnel who monitored this project.

Westinghouse also wishes to acknowledge the valuable contributions of the Veteran's Administration, Kaiser Foundation Hospitals, Public Health Service-Health Education and Welfare and the Bethlehem Steel Corporation and the United States Steel Corporation.

## ABSTRACT

This volume presents the State of the Art (SOA) of sixteen areas related to the Base Level Health Care System. For each area, the SOA improvement alternatives that are now available or will be by 1972, and the advanced technology improvement alternatives likely to be available in the 1972 - 1980 time frame are presented. This survey forms a major data resource for the Systems Analyses volume of this report. The sixteen areas surveyed were:

- General Medicine
- Clinical Laboratory
- Communications & Data Management
- Construction
- Dentistry
- Dietary
- Education & Training
- Maintenance & Housekeeping
- Materiel Handling
- Multiphasic Testing
- Pharmacy
- Physiological Monitoring
- Planning
- Radiology
- Sterilization
- Ward Management

TABLE OF CONTENTS

# 1. INTRODUCTION

State of the Art (SOA)* refers to the most advanced technology, concepts, and procedures (improvement alternatives) presently used within the diverse functions of the Base Level Health Care System (BLHCS), or which can reasonably be expected to be employed in 1972 construction.

Since a detailed investigation of all health care functions is beyond the scope of this study, we used the following criteria to determine which functions should be emphasized:

- High cost
- Labor intensive areas
- Known problem areas

As a result, the following sixteen basic functions were selected:

1. General Medicine and Surgery
2. Clinical Laboratories
3. Communications and Data Management
4. Construction
5. Dentistry
6. Dietary
7. Education and Training
8. Materiel Handling
9. Multiphasic Testing
10. Maintenance and Housekeeping
11. Pharmacy
12. Physiological Monitoring
13. Planning
14. Radiology
15. Sterilization
16. Ward Management

*Appendix C contains a list of terms and definitions used in this document.

Meaningful recommendations for future health care systems depend upon an in-depth knowledge of the improvement alternatives available in these functions, their advantages and disadvantages, ways they can be improved, the improvement trends, and most importantly their impact on patient care and systems operations. In defining which improvement alternatives should be discussed in each function, we first eliminated most hardware, concepts, or procedures which are commonly known and commercially available. Moreover, we have included only those alternatives which are applicable to the military Base Level Health Care System.

This survey, along with the Data Inventory and Medical Health Care Review volumes prepared for this study, form the data base for the systems analysis. Specifically, the improvement alternatives included in the systems analysis section were selected largely from this SOA report.

Report Format

This report is divided into 16 sections, one for each function, with each section having the following general format:

1. Introduction.
2. Technical Approach: Information sources.
3. State of the Art: Concepts and technologies judged to be important and applicable to the 1972 BLHCS design plans.
4. Advanced Technology: Concepts, hardware, and procedures which could conceivably be available by 1975 to 1980 with appropriate research and development.
5. SOA Matrix: A summary in tabular form of the major uses, advantages, and disadvantages of current improvement alternatives discussed in the state-of-the-art section.
6. Bibliography.

It should be noted, however, that since various SOA surveys were prepared by independent Westinghouse study groups or consultants, this format is not rigidly adhered to in each section. In the General Medicine section, for example, SOA and advanced technology are not treated separately, since many SOA improvement alternatives must undergo extensive testing and so will be available for implementation only after 1972, the cut-off date for the SOA discussion. Moreover, some sections do not include matrices; the dentistry section, for example, primarily treats concepts and procedures which are not amenable to matrix formatting.

The various functions are discussed in alphabetical order, with the exception of General Medicine. Because the delivery of medicine and surgery is perhaps the most essential function in the Base Level Health Care System, General Medicine is placed first.

The SOA survey emphasizes the relationships and impacts of improvement alternatives on specific functions and on the entire system. Effects of an improvement alternative in one function upon other functions, however, are not evaluated or documented in this section. These interactions are studied and presented in the Systems Analysis volume.

## 2. TECHNICAL APPROACH

The personnel assigned to perform the various SOA surveys were composed of Westinghouse personnel from various divisions (Learning Corporation, Health Systems Division, R & D Laboratories, Bioscience & Medical Systems Department) as well as consultants where specific expertise was needed. Listed below are the Westinghouse Divisions and/or consultants primarily responsible for each of the sixteen functions.

1. General Medicine and Surgery
   - Westinghouse Health Systems
   - Johns Hopkins University, School of Medicine
   - University of Pittsburgh, School of Medicine
   - Veteran's Hospital, Pittsburgh, Pa.
2. Clinical Laboratories
   - Westinghouse Bioscience and Medical Systems Department
   - Johns Hopkins University School of Medicine
3. Communications and Data Management
   - Westinghouse Health Systems Department
4. Construction
   - Westinghouse Health Systems
   - Westinghouse Corporate Design Center
   - RTKL
5. Dentistry
   - Westinghouse Health Systems
   - University of Pittsburgh, School of Dentistry
   - Sybron Corporation - Ritter Division
6. Dietary
   - Westinghouse Health Systems
   - University of Pittsburgh, School of Public Health
7. Education and Training
   - Westinghouse Health Systems
   - Westinghouse Learning Corporation
8. Maintenance and Housekeeping
   - Westinghouse Health Systems
   - University of Pittsburgh, School of Public Health

9. Materiel Handling

- Westinghouse Health Systems
- Georgia Institute of Technology
- Sybron Corporation

10. Multiphasic Testing

- Westinghouse Health Systems
- Johns Hopkins School of Medicine
- University of Pittsburgh, School of Medicine

11. Pharmacy

- Westinghouse Public Systems Management Services Department

12. Physiological Monitoring

- Westinghouse Health Systems
- Westinghouse Bioscience and Medical Systems Department
- Westinghouse Medical Products Engineering
- Allegheny General Hospital

13. Planning

- Westinghouse Health Systems
- Westinghouse R & D Center

14. Radiology

- Westinghouse Health Systems
- North Hills Passavant Hospital, Pittsburgh

15. Sterilization

- Sybron Corporation - The Castle Company

16. Ward Management

- Westinghouse Health Systems
- University of Pittsburgh, School of Nursing
- University of Michigan, Program in Hospital Administration

The specific data gathering techniques used by each study group are discussed in the technical approach portion of each SOA section.

# 3. SURVEY RESULTS

## GENERAL MEDICINE

### INTRODUCTION

The present health care system in the United States is having great difficulty meeting the needs of an increasing population, and new solutions must be devised and implemented if the overall health care problem is to be solved. Our traditional medical care delivery systems have evolved with little deliberate planning for comprehensive care, although regional medical programs and comprehensive health programs represent attempts by the Federal government to deal with specific segments of the problem.

In the past decade dramatic changes -- increasing affluence, new purchasing power from private and public insurance plans (Medicare and Medicaid), more education and consciousness of health, rapid growth in the youngest and oldest segments of the population, and continuing urbanization -- have greatly increased the demand for health care. Possible developments in the near future could further intensify demand, for example, a national health insurance program. The Health Manpower Commission has projected the demand for all physician services in 1975 at $24 billion, double that of 1969.

The heart of the traditional medical-care delivery system is the physician and, therefore, any realistic solution to the medical care problem depends upon the supply and utilization of physicians. The number of doctors presently administering patient care, however, is insufficient, for the following reasons:

1. In recent years many doctors have turned away from patient care to research activities, public health, and industry. At present, approximately one-third of the total number of physicians are engaged in these activities. Consequently, despite increased demand, the number of physicians actually caring for private patients has declined. Between 1950 and 1955 the

ratio of physicians to population was 135 per 100,000; today the ratio is 92 per 100,000 population. Subtracting the specialists further reduces the physicians providing family care, i.e. the general practitioners, internists, and pediatricians, to only 50 per 100,000.

2. Geographical distribution of physicians is extremely uneven. In New York state at the end of 1967, there were 200 physicians caring for each 100,000 residents; Mississippi, on the other hand, has 69 for each 100,000. Even in the most favored states extreme distortions are common; private physicians are as difficult to find in some neighborhoods of New York City as in backward rural counties. In general, doctors are plentiful only in the suburbs and in middle sized cities where people can best afford their services.

3. Several medical schools are in poor financial condition due to the combination of rising costs and reductions in federal aid.

Even if the output of our medical schools could be doubled -- an almost impossible feat -- the supply of doctors in relation to projected population would not be sufficient 20 years from now. Consequently, we must concentrate on how to increase the efficiency of available physicians.

One method is to employ trained paramedical personnel to relieve the doctor of routine tasks. The military has pioneered this concept, utilizing the trained medical corpsman or the "medic" as an integral part of the medical corps of the three services. These men form a pool of medically trained personnel. Some corpsmen have, among other things, as many as 70 hours of experience and training in preventive medicine; from 70 to 130 hours in medicine and surgery; 92 to 190 hours in pharmacology, advanced on-the-job training in out patient clinics, and on-the-job training in general medicine; from 120 to 200 hours of trauma, minor surgery, and field surgery; perhaps 40 hours of emergency room on-the-job training; another 30 hours of on-the-job training in general surgery; 40 hours in orthopedics; 98 hours in surgical procedure; 30 to 55 hours in microbiology and laboratory medicine.

About $25,000 is invested in the training of each medic; unfortunately, this investment is usually lost when he leaves the service and enters civilian life. The National Research Council has estimated that 30,000 trained corpsmen leave the Armed Forces each year. An HEW memorandum by Doctor Roger Egeberg noted, however, that about 60 percent of medics leaving the Armed Forces are interested in additional education to qualify for civilian jobs in health care, and that about 15 percent are qualified to move immediately into civilian jobs in medicine. In 1969, HEW Secretary Finch and Assistant Secretary Egeberg established the Office of New Careers with the top priority of developing programs for medical corpsmen returning from Viet Nam. The state of Maryland has just passed a bill to permit certification of ex-medics as licensed practical nurses. Although a good idea, this program does not give enough recognition to these men who are above the usual LPN in ability and training.

The Committee on Emergency Health Manpower of the American Medical Association's Council on Health Manpower has drawn up a set of guidelines for development of new health personnel categories such as "physician's assistant." In December 1969, these guidelines were discussed with directors of physician's assistants training programs, and a cooperative program was established to clarify the roles of the physician's assistant, the educational levels desired, and the need for certification, licensure, or changes in medical practice acts.

The major training programs for physician's assistants are the Medex Program at the University of Washington, the Duke University Physician Assistant Program, and others at the Cleveland Clinic, Alderson-Broadus College in West Virginia, the University of Colorado Medical Center, Bowman Gray School of Medicine, Pacific Medical Center, Grady Memorial Hospital in Atlanta, Baylor College of Medicine, Emory University School of Medicine, University of Pittsburgh, and Ohio State University. Additional programs are in preparation at the University of Kentucky School of Allied Health Professions, the Brooklyn-Cumberland Medical Center, Oklahoma State University, and the University of Colorado.

If these programs are accepted by the medical profession, individual physicians, the states, and patients, they will not only alleviate the manpower shortage but will also tend to attract more capable men into the medical corpsmen section of the military service by providing motivation for a post-service career in the health professions. State medical practice and insurance laws will have to be reevaluated and altered, but the proponents of the physician's assistant concept believe that once the benefits are demonstrated, the changes will be made.

Another method of increasing physician efficiency is to relieve doctors of some tasks which can be automated by a computer. History taking, for example, is being automated by computer at the University of Wisconsin and elsewhere. Doctor L. Weed at the University of Vermont is developing programs for a new record format which he believes will record and highlight the pertinent information and will result in more efficient and thorough handling of the patient.

Several facilities are offering semi-automated multiphasic testing to physician-referred patients. This technique is described in the state-of-art report on multiphasic testing and is mentioned here because it aids the physician but does not substitute for him. A physician armed with the results of a test package performed at one of these centers may be able to "zero in" on the patient's health problem(s) far more expeditiously than by starting fresh with the patient. And for the asymptomatic, healthy patient, the physician time requirement for completion of the periodic health examination should be a fraction of what it is now.

Another method by which physician time can be conserved is the use of algorithms which have proven useful in both diagnosis and treatment. Algorithms, whether flow charted or not, enable less skilled personnel to guide the initial phases of diagnostic management of symptomatic patients.

Attempts are being made to develop total hospital information systems in order to improve the traditional techniques of storing and transmitting medical data which are not only inefficient in terms of today's demands but may prove detrimental to patients. The computer is also finding its way into the clinical laboratory, cardiology, radiology, nuclear medicine, and other disciplines. The present and future roles of the computer are discussed in the communications and data management section.

Increasing the amount of physician time devoted to direct patient care, however, is not the only problem. The Health Manpower Commission has declared that "if additional personnel are employed in the manner and within the present patterns and 'systems' of medical care, they will not avert, or perhaps not even alleviate the crisis. Unless we improve the system through which health care is provided, care will continue to become less satisfactory."

Extensive changes must be made in the health care system to eliminate the financial distortion and managerial redundancies. Costs could be reduced if hospitals were as efficiently administered as industrial institutions. Although only physicians are qualified to practice the art and science of patient medicine, the management of medical care can and should be delegated to administrative specialists.

Another means of upgrading health care is to institute outpatient clinics to accommodate the increasing number of people who cannot be treated by the dwindling supply of general practitioners. These patients are currently going to hospital emergency rooms or outpatient departments because they know that the hospital represents the "composite" physician -- the many doctors and paramedical personnel and equipment which are tailored to meet the patient's needs. Indeed, during the last five years, the number of visits to the emergency rooms has grown exponentially and some hospitals are now reporting a profit on their emergency departments.

Emergency rooms, however, are becoming extremely overcrowded, and group practices with or without prepaid health plans are being started to accommodate the patient overflow. The Mayo Clinic, the Lahey Clinic, and the Ochsner Clinic are perhaps the best known of these. Smaller groups, but serving their communities well, include the Geisinger Medical Center in Danville, Pennsylvania, and the Trover Clinic in Madisonville, Kentucky.

To provide improved and specialized services, some physicians are moving towards a hospital-based practice since medical technologists and specialists are readily available; sophisticated equipment is accessible; and their hospitalized patients may be within walking distance. The hospitals, however, have been unprepared for the influx of doctors seeking hospital affiliation and have had to develop additional facilities and staff.

To extend care to greater population segments, prepaid medical care delivery systems are being implemented. The Kaiser-Permanente plan, for example, presently serves over two million subscribers treated at outpatient centers, clinics, and hospitals in California, Oregon, Washington, and Hawaii, and in Cleveland and Denver. The plan provides comprehensive health care at an annual cost of $100 per capita, which is approximately two-thirds the cost of comparable care in most parts of the country.

The health plan and the hospitals are organized as nonprofit operations, and the medical groups in each area are autonomous partnerships. The plan income provides funds for teaching, training, and research and pays competitive incomes to 2,000 physicians and 13,000 non-physician employees. With the prepaid care delivery systems, the usual economics of medicine are reversed by rewarding the doctors for subscribers' good health.

Many hospitals are planning ambulatory care centers similar to those of the Kaiser-Permanente plans since the major portion of patients can be treated without being hospitalized and such centers offer a "laboratory" relatively free of the pressures and crises indigenous to the hospital. Moreover, it is believed that independent ambulatory care centers can be more quickly implemented (within three years at the community level) and have an inherently greater potential for replication (a national impact in ten years) at lower costs and with less disruption than a system designed for inpatient services. The ultimate goal, however, is to develop technological devices and methods that will have sufficient flexibility to be applicable to both inpatient and outpatient services.

Another means of improving health care is to apply industrial engineering methods and systems analysis techniques to health problems, especially those relating to the use of the physician's time and allocation of space. The Children's Bureau of HEW, for example, initiated a systems analysis of Johns Hopkins Hospital in 1967. This program is discussed below in the pediatrics section.

In the following sections medical practice is presented under the general divisions of Medicine and Surgery. These two sections are not subdivided into state of the art and advanced technology because the distinction between the two is not well defined. The practice of medicine adopts new developments at a rather slow pace, demanding that all technologies, pharmaceuticals, and concepts be tried, tested, and found true. Consequently, some state-of-the-art developments are considered advanced technology since they must undergo further study and will not be ready for implementation by 1972.

In our study of medicine, we investigated only those advances most pertinent to the military Base Level Health Care System. We further limited our discussion to those medical disciplines that show definite promise of implementing new technologies in the next ten years. These disciplines include: preventive medicine, cardio-vascular disease, pediatrics, endocrines, psychiatry, general surgery, and obstetrics.

TECHNICAL APPROACH

Information for the state-of-the-art survey of general medicine was obtained by personal interviews with health care personnel including faculty members of the colleges of medicine of:

Emory University
Johns Hopkins University
Harvard University
University of Georgia
University of Pittsburgh
Graduate School of Public Health, University of Pittsburgh
Johns Hopkins School of Hygiene
School of Nursing, University of Pittsburgh
Allied Health Science School, State University of Georgia

Also interviewed were individual physicians in private practice, as well as physicians associated with the following hospitals:

Oakland Veterans Administration Hospital, Pittsburgh
Grady Memorial Hospital, Atlanta
Georgia Mental Health Institute
Atlanta OEO Clinic

Some of the health care professionals interviewed were:

F. J. L. Blasingame, M.D., Consultant, Chicago, Illinois
A. Bollet, M.D., Medical College of Georgia, Augusta, Georgia
T. M. Botts, M.S., Beth Israel Hospital, Boston, Massachusetts
P. Bourne, M.D., Atlanta OEO Clinic, Atlanta, Georgia
E. Bronstein, M.D., Medical College of Georgia, Augusta, Georgia
R. A. Chez, M.D., University of Pittsburgh, Pittsburgh, Pa.
R. Conn, M.D., The Johns Hopkins Medical School, Baltimore, Md.
T. Fitzpatrick, M.S., University of Pittsburgh, Pittsburgh, Pa.
E. Friedman, M.D., Harvard Medical School, Boston, Massachusetts

J. R. Haverty, M.D., Georgia State University, Atlanta, Georgia

M. F. Hill, Ph.D., University of Pittsburgh, Pittsburgh, Pa.

F. C. Jackson, M.D., U.S. Veterans Administration Hospital, Pittsburgh, Pa.

R. J. Johns, M.D., The Johns Hopkins Medical School, Baltimore, Md.

D. Kendrick, M.D., Grady Memorial Hospital, Atlanta, Georgia

H. J. Kroeger, M.D., University of Pittsburgh, Pittsburgh, Pa.

G. C. Lawrence, M.D., Atlanta OEO Clinic, Atlanta, Georgia

J. W. Love, M.D., The Johns Hopkins University, Baltimore, Md.

F. D. W. Lukens, M.D., U.S. Veterans Administration Hospital, Pittsburgh, Pa.

E. J. McCranie, M.D., Medical College of Georgia, Augusta, Georgia

W. Moretz, M.D., Medical College of Georgia, Augusta, Georgia

I. Ramey, Ph.D., University of Pittsburgh, Pittsburgh, Pa.

C. Rumble, M.D., University of Pittsburgh, and private practice Pittsburgh, Pa.

E. Saltz, M.D., University of Pittsburgh, Pittsburgh, Pa.

B. S. Schifrin, M.D., Harvard Medical School, Boston, Massachusetts

W. A. Scoggin, M.D., Medical College of Georgia, Augusta, Georgia

T. Sellers, M.D., Grady Memorial Hospital, Atlanta, Georgia

J. Skobba, M.D., Georgia Mental Health Institute, Atlanta, Georgia

T. B. Turner, M.D., The Johns Hopkins Medical School, Baltimore, Md.

P. D. Webster, M.D., Medical College of Georgia, Augusta, Georgia

R. Wells, M.D., Emory University, Atlanta, Georgia

D. Wenger, M.D., George Washington University, Washington, D.C.

K. L. White, M.D., The Johns Hopkins University, Baltimore, Md.

S. Zimbler, M.D., Harvard Medical School, Boston, Massachusetts

A number of periodicals, journals, and books were reviewed. Those from which material was obtained are listed in the bibliography at the end of this section.

Preventive Medicine -- Virus Prophylaxis and Therapy

During the last few years, and especially in 1969, advances have been made in virus prophylaxis in the areas of vaccines, antibiotics, and multiphasic screening/testing.

Vaccines

New rubella and measles vaccines were recently developed and a drive is currently underway to vaccinate 50 million school children by 1971. These two vaccines will reduce the incidence of these diseases in children and thus reduce the clinical load on general practitioners and pediatricians. Their biggest impact, however, will be in the future; if, as has been predicted, rubella and measles are eliminated, the damaging effects upon the fetus of a pregnancy complicated by rubella will also be eliminated.

Other advances expected are listed below:

1. A viral agent that causes infectious hepatitis has been discovered. While this agent may not be the only etiological factor, significant advances in the therapy and prevention of hepatitis will be made.
2. A vaccine against type C meningococcal meningitis has been developed by the Walter Reed Institute of Research and is being tested at military installations.
3. Another vaccine has given complete protection against pseudomas infection to almost 100 badly burned patients at the Shriners' Burn Institute at the University of Cincinnati.
4. During the 1970's a safe and effective mumps vaccine should be available.

5. Influenza vaccination may be added to routine child immunization programs, although it is doubtful that the public will accept the repeated vaccinations needed to ensure immunity. Improved inactivated vaccines are likely to be available in the early 1970's and safe attenuated vaccines by 1980.
6. Since flu vaccine will often not contain the appropriate non-resident strains of virus, prophylactic chemotherapy may also be employed at the approach of an epidemic. Although effective vaccination against rhinoviruses is difficult because of the many different serotypes, multiple oral vaccines may become available and be accepted by the public which has always sought protection from the common cold.
7. By 1980 attenuated vaccines may prevent viruses which cause bronchitis in very young children.

Antiviral Compounds

Since vaccines alone cannot control virus infections, antiviral compounds may be valuable particularly in prolonged diseases such as hepatitis. However, many antiviral compounds which have some prophylactic action are too weak to have any therapeutic effect. The development of more potent antiviral compounds against respiratory infections in particular is likely to come by 1975, but several problems have to be overcome. First, since antiviral compounds must act on the virus within a living cell, a compound must be found which attacks the virus without interfering with the cell's metabolism. Thus the initial compounds are likely to have a very specific action and to be effective against only a narrow range of viruses. Antiviral compounds are also likely to act on the replication process, but the peak of replication of the viruses often occurs before the symptoms appear. Because antiviral agents may be inherently toxic, they will probably not be used for minor diseases for 20 years or more.

Antibiotics

Available antibiotics will continue to increase in number and specificity and are likely to be cheaper and more convenient. An experimental antibiotic, rifampin, being tested at the University of Florida, has proved to be effective as a prophylactic agent in meningococci carriers. It is also being clinically evaluated as an antituberculous and antigonorrhea agent.

A new drug, Hycanthon, is a potential preventive against schistosomiasis, a disease second only to malaria in global morbidity.

More research will be directed toward discovering the mechanisms of bacterial infections and then to neutralizing them, leading to a new generation of antibacterial substances by the 1980's. Progress is likely to come in two main stages. First, by the mid-1970's we will have a better understanding of the natural history of chronic infections. More prompt and precise use of currently available antibiotics should start to bring a significant reduction in the number of people suffering progressive deterioration from recurring infections, especially if pollution controls start taking effect. Fewer persons will have permanent respiratory difficulties and fewer people will require renal dialysis or kidney transplants by the late 1970's or 1980's. Pyelonephritis in those under 20 may have been arrested by that time.

The second stage of progress will come by the 1980's with the introduction of more specific antibacterial substances resulting from present research. Routine methods of screening high risk groups, e.g. pregnant women, for renal infection should be efficient and economical. By these means early diagnosis and control of urinary infections, for example, will be routine by the 1980's. There will also be progress in identifying additional high risk groups from the individual's life history.

The problem of antibiotic resistance is likely to become greater but will be kept within reasonable limits by a better understanding of antibiotics and specific measures. From about 1975 on, antibiotics will increasingly be used in association with antibiograms. In hospitals there will be an overall strategy for the use of antibiotics to limit the risks of cross infection. Moreover, improvements in public health policy will speed the identification of the pathogens responsible for the outbreaks of infection.

Multiphasic Screening and Testing

Preventive medicine will receive increasing emphasis in the future. The military is ahead of the civilian sector in this area, with its programs of periodic health check-ups, metabolic tests, and environmental controls. However, the increased number of prepaid health care plans available to the public, such as the Kaiser-Permanente plan, will enable more families to have periodic examinations.

With the automation of the clinical laboratories, more diverse series of tests can be performed on a single sample without increasing cost. Such automation is one of the economic bases of multiphasic screening and testing. Multiphasic screening of apparently healthy people can detect abnormal conditions early enough to permit preventive measures to be taken. However, the data obtained to date indicate that the yield of abnormal findings which are conducive to preventive measures has been too low to justify, on an economic basis alone, the installation of multiphasic screening centers.

The relative inaccuracy of the mechanized methodology presents a problem which may be overcome, however, when improvements are made in present testing procedures. Another problem is that automatic analytical procedures have not been developed for all tests. Research is continuing, and automated analytical equipment will be developed for more precise and accurate determinations of a wider range of medically important parameters.

Multiphasic testing of patients admitted to the hospital provides rapid analysis of a number of diagnostically important factors from a single sample. Indeed it is cheaper to perform all the multiple analyses for which the system is designed than to perform only selected tests. More potentially valuable information is, therefore, available to the doctor. Diagnosis time may be shortened since fewer additional tests will need to be requested after the first set of tests is reviewed.

Results from multiphasic testing are more accurate than screening results, since additional information is known about the patient and, if there are any questions, he is available for a second determination.

Branching computer programs in conjunction with automated laboratory equipment will permit the performance of a second test or a series of tests as a result of an abnormal finding by the initial procedure. In many instances such systems will enable the programmed sequence of tests to be performed on the original sample thus eliminating delays of one or more days.

Cardio-vascular Disease

Abnormalities of blood lipids, high blood pressure, diabetes, obesity, and cigarette smoking are considered important contributors to coronary heart disease. Other suggested risk factors which are less amenable to control are lack of exercise, an inherited tendency to the disease, and stress.

Great emphasis has been placed upon blood lipid levels, especially those of cholesterol in cardiovascular, particularly cornary, disease. A definite answer as to how dietary changes affect blood lipids will not be available until 1980, if then. However, it is generally expected that the most likely means of decreasing the body's absorption or synthesis of lipoproteins will not be dietary changes but pharmaceuticals; the effectiveness of one important cholesterol-lowering compound will be known by 1975.

When and if high blood lipid values are shown to be an etiologic factor in vascular disease and effective remedial compounds are found, a screening process will be used to identify abnormal blood levels in young adults and children. Safe and effective medications are available for prophylaxis of raised blood pressure. Routine blood pressure screening will be offered by 1975, and by 1980 annual blood pressure screening, possibly either by trained technicians or by self-measurement, will be done.

The association of diabetes with coronary heart disease, strokes, and diseases of limb arteries is already established. The value of anti-diabetic treatment in preventing these diseases from developing in border-line diabetics is now being clinically tested. Once proof is available, widespread preventive measures can be undertaken, including the screening for mild and pre-diabetics as well as the institution of individualized treatment regimens.

Obesity is already regarded as a medical problem, but experimental patient educational and training methods are not very effective. Compounds which will effectively "use" calories without undesirable side effects are being sought and may be available by 1980.

Evidence incriminating cigarette smoking will be stronger by 1975, and the number of high risk subjects who smoke will be reduced by 50 percent.

The effects of emotional stress upon the heart present a formidable problem, but no counter measures seem likely by 1980.

Substantial progress in treating vascular disease must wait for the better understanding of the mechanisms of vascular changes and hypertension. The following cardio-vascular developments, however, are underway:

1. Blood clots may be prevented by new anti-coagulant compounds which will be available by 1975. There are some doubts, however, as to the effectiveness of anticoagulants in reducing the incidence and mortality of coronary disease.
2. The mortality rate in the first hour after coronary thrombosis is very high. It is conceivable that a treatment modality will be developed to be used immediately after the patient is seen by his family doctor or possibly even by the patient himself as soon as he senses an attack symptom. Hopefully such treatment will protect the patient for some hours against the dangerous disturbances of the heart's rhythm.

3. The balloon diastolic augmentation system, which is being clinically tested, is expected to be an effective aid in coronary attacks and cardiogenic shock. The balloon is inserted into the femoral artery through a small incision and threaded up to the aorta. Depending on the signal from the electrocardiogram, the balloon is inflated with carbon dioxide and deflated at appropriate times during the pressure pulse to increase the mean pressure. If proved effective, this mechanism will be available by 1975.
4. A recently developed method employs ultrasonics to measure the precise interior ventricular dimensions at end-systole and end-disatole permitting the exact calculation of the stroke volume. This value plus the heart rate can be used to calculate cardiac output. This ultrasonic method for determining cardiac output is simpler, cheaper, less traumatic, and probably no less accurate than standard methods, such as the Fick, the dye-dilution, and the angiogram techniques. Acceptance or rejection of this method by the scientific and medical community should be forthcoming by 1975.
5. In regard to angina pectoris, a condition allied to coronary thrombosis, long acting preparations, such as sustained release nitroglycerine-like compounds, are now being used to increase the blood supply to the heart muscle. More effective ones should be available by 1975, such as compounds which prevent anginal attacks without depressing the cardiac muscle.
6. The identification of trace metals and other micronutrients whose absence may be responsible for vascular damage is a promising area for research. Development of sensitive quantitative tests for these substances should be available by 1975, and replacement therapy should be available by 1980.

## Pediatrics

In the last decade the most significant developments in pediatrics have been:

- The children's and youths' programs of the Children's Bureau
- The attack on viral diseases through vaccines such as those against measles and rubella
- The increasing realization that the placenta is not a protective barrier and that the developing fetus may be influenced by a number of factors such as drugs and maternal health
- The development of fetal and maternal monitoring devices in labor and delivery
- The recognition of a new subspecialty, neonatology, concerned with the critical period of neonatal homeostasis
- The development of pediatric surgery for the correction of congenital anomalies in the newborn, open heart work, and kidney transplants.

Advances in pediatrics in the next decade, many of which will be extensions of the above, are discussed below:

1. In this country, the need for uniformly high quality comprehensive health care, particularly for children, is being increasingly recognized. Gross inadequacies exist in the distribution of child health care services, and to alleviate this problem the Children's Bureau's comprehensive care clinic program will be extended to additional population segments in more areas of the country. These clinics or centers will also provide preventive medicine services including parent and child "patient" education programs which should help reduce the acute demands on the pediatrician.

2. As in all health care segments, pediatrics is burdened by insufficient manpower. By 1980 the American child population is expected to be greater than 76 million. At today's patient physician ratio, an additional 100,000

pediatricians will be required to care for these children. Since, however, only about 12,000 physicians will enter pediatric practice by 1980, the only practical solution is to increase the pediatrician's efficiency. His training, skills and talents should be employed only where they are essential, and his direct role with the patient redefined.

Trained pediatricians spend 75 percent of their time in the management of well babies; the wider use of non-medical personnel to perform such routine duties is now being investigated. These non-medical personnel could be recruited from the nursing and allied health professions and occupy positions such as "pediatrics associate" and "pediatrics assistant." As the population of well children expands, the need will increase for non-physician experts who can identify ancillary and contributing health problems as they arise.

3. In 1967 the Children's Bureau initiated a program at Johns Hopkins Hospital designed to apply systems analysis techniques to hospital and medical problems. The operations of the Comprehensive Child Care Clinic are being studied by means of total clinical procedural time studies, staff interviews, work sampling, patient sequential floor analysis, information network analysis, and the use of computerized clinic simulation. The information collected and analyzed thus far has helped to define the portions of pediatric examinations that can be performed by paramedical personnel. The data, which are being compiled in a Clinic Self-Help Manual, will be disseminated to other clinics through the Children's Bureau. This manual will provide a clinic director with step-by-step suggestions to improve the effectiveness of his particular clinic, including reviewing objectives, dividing the clinic into subsystems, and using qualitative and quantitative measuring and analysis techniques. The manual will also provide guidelines to determine how well a clinic is performing, as well as suggest changes and the means to effect them.

4. The vaccines developed against measles and rubella, which are being administered to young children in a nation-wide program, will reduce the incidence of these diseases and their effects on the fetuses of the next generations.

5. Drugs, infections, and other factors such as radiation which influence the developing fetus will be better understood through advances in prenatal diagnosis, and more immature infants and newborns will be saved by improved surgical techniques and instrumentation. However, if abnormalities are due to chromosomal observations resulting in genetic damage, increased fetal salvage could contribute to a rising incidence of congenital malformations in the neonate. Continued developments in organ and tissue transplants, however, may result in a better salvage rate of infants and children with serious congenital abnormalities.

6. Increasing knowledge of genetic transmission of disease, chromosomes, and nucleic acid biochemistry, especially DNA, will result in better genetic consulting and better, quicker, and simpler screening methods for various metabolic defects and disorders, both pre- and postnatal. Intrauterine diagnosis by such means as amniocentesis will improve and become more widespread. Improved diagnosis of metabolic and chromosome disorders in utero may prevent many neurological disorders associated with metabolic defects. Indeed, the first successful intrauterine diagnosis of Tay-Sachs disease was just reported. The potential of intrauterine diagnosis and chromosome and DNA analysis has led to the concept of "cellular" or "genetic engineering," with correction of immunologic defects and artificial introduction of genetic information into the cells of individuals with inborn metabolism errors and other genetic disorders. Early intrauterine diagnosis will become even more important as more states liberalize or repeal existing abortion laws.

7. Because of spiraling hospital costs, more mothers are "rooming in" during the hospitalization of pediatrics cases. At the University of Kentucky Medical Center, for example, the average daily cost per patient in the care-by-parent unit is \$20.50, including maintenance of the parent, as compared with \$44.50 in the general pediatric ward. The care-by-parent unit frees more nurses to care for other patients; provides an excellent opportunity for parent education particularly for those with high-risk,premature, chronically ill, or retarded children; drastically reduces the cost of hospitalizing children both

for the parents and the hospital; and provides an opportunity for medical trainees to observe young parents in a more realistic setting -- almost a "home" environment. In addition, the patient and parents benefit, since the more parent participation, the less emotional trauma.

8. The computer offers the potential of entering the entire national population in a health registry -- a monumental undertaking. Within the next decade a start could be made to register each child and record birth defects, illnesses, immunizations, operations, and so forth. Records would be transferable from physician to physician or institution to institution.

9. Since a child's physical health is only one facet of his total wellbeing, there is need to provide for total care of the family constellation.

10. A new medical specialty, adolescent medicine, will develop because this group has unique metabolic and normal changes, psychosexual characteristics, drug-addiction characteristics, and special diseases which are more relevant to or frequent at this age.

Endocrines

Very sensitive procedures, especially immunological and physical methods, are rapidly being developed to quantitatively determine biochemical substances and enzyme activity in all body organs. These techniques will permit studies of the pathogenesis of many disorders, particularly endocrine and related metabolic disturbances, leading to understanding and significant progress in their control. Some specific developments should be that:

1. Diabetes should be completely controlled by oral agents by 1975.
2. Treatment of thyrotoxicosis and ovarian disease will be simplified.
3. Atherosclerosis, which some consider to be a disease largely of endocrine origin, may be controlled by 1980.
4. Protein hormones presently are natural products and are, therefore, expensive. By 1980 improved peptide synthesis techniques should make these hormones generally available at economic prices.

## Psychiatry

During the next 10 years over-population and the spread of technology will probably increase both anxiety states and neurotic depressive states in the general population. To cope with the expected increased demand for improved mental health care, the trend is to implement "community" psychiatric techniques, to use more paramedical personnel, and to develop drugs to aid in diagnosis and treatment.

### Community or Front Line Psychiatry

Community psychiatry, wherein the psychiatrist attempts to correct group problems and so indirectly prevent individual problems, is coming to the forefront. This type of psychiatry will be facilitated by the establishment of community health centers with departments of mental health.

Psychiatrists now feel that treatment for these problems should be given as outpatient care where the patient remains in his customary surroundings, with his friends and other usual contact points. This trend will emphasize less bed care and more community type counseling. Although ten percent of a general hospital's beds are usually devoted to psychiatry, during the next five to ten years this should be reduced to only five percent.

Community psychiatric practice has recently been introduced into the military with beneficial results. Termed "front line" psychiatry, it deals with personality and emotional problems at the dispensary level and at times reaches into the barracks, involving interviews with the patient's officers and fellow soldiers.

There is a growing recognition that all patients have some psychological or psychiatric problems; therefore, patients -- particularly those hospitalized for long periods such as orthopedic patients -- should be given psychological examinations and any necessary treatment, as well as be educated to cope with any psychological problems that arise.

To ensure quality control in psychiatry, video tape and other audio-visual methodology for recording interviews and treatment will be used increasingly in the next five years.

## Paramedical Personnel

To alleviate the problem of insufficient personnel in psychiatry, it is proposed that "mental health associates" be added to the existing psychologists, social workers, and others on the roster of the psychiatric service. The two levels of mental health associates, which are being used at the Georgia Mental Health Institute in Atlanta with good results, would have two years of college and on-the-job training and four years of college and on-the-job training, respectively.

## Therapeutic Drugs

The psychiatrist has no laboratory or chemical tests to aid him in diagnosis or treatment, and has only a limited armamentarium of drugs for therapy. Although tranquilizers are a great help, present compounds are nonspecific and are merely considered the crude beginnings of therapeutic drug measures. Much drug research, however, is being done by pharmaceutical companies.

- Researchers are trying to define the biochemical changes involved in psychoses, an understanding of which should lead to several more efficient and more specific medicines in the next decades particularly for psychotic depressive illness.
- More powerful antidepressants of the types presently available are forecast by 1975.
- Mood-normalizing compounds for manic-depressive states and new antidepressant agents will be available by 1980.
- By 1985 there will be stabilizing compounds for patients whose manic-depressive states are associated with environmental and personality factors.
- Lithium salts are being used today in regulating some psychoses, but the dosage control requirements are so strict as to almost preclude their use.
- Progress towards specific medication for schizophrenia will be slower. While there will be long acting (sustained release)

compounds of existing materials, truly specific medicines will not appear in the next decade.

- In the organic psychoses, the control and prevention of dementia will definitely progress by 1980.
- There will be progress towards control of psychoses having origins in genetic or biochemical abnormalities. Genetic counseling will reduce the incidence of certain types of mental deficiencies, and better neonatal care will lead to the early correction of nutritional and other casual deficiences.

## STATE OF THE ART -- SURGERY

Advances in surgery will be the result of new and improved technology, developments in immunology, and better understanding of pathogenesis. Improved instrumentation, moreover, will enable surgeons to operate on and care for their patients with greater safety and accuracy. As a result of these scientific and technical developments:

1. Complex surgical procedures will become more commonplace.
2. The use of more sophisticated equipments will be dictated.
3. New design concepts and building requirements for operating rooms will be developed.
4. The staffing of operating rooms will be altered.
5. Some surgical procedures may be performed outside the hospital.

### Surgical Procedures

1. Various high-energy techniques for "bloodless surgery" are being developed, including upgrading radio frequency electrocautery, the plasma scalpel, and various lasers that could both cut and effect hemostasis. The

Laser Laboratory at the Cincinnati Children's Hospital and biomedical scientists at the University of Utah are doing extensive research on the use of the laser technique.

2. The development of an open pore fiber titanium composite, which can be molded into various shapes, sizes, and degrees of porosity, and into which bone can grow is an exciting advance in the development of total joint prosthesis, especially in the hip. More work must be done,but it is predicted that this development will be one of the most important in orthopedic surgery in the next five years.

3. Stapling devices, which were pioneered in Russia and are available in several Russian, American, and Japanese models, have been used clinically for vascular and intestinal anastomosis and various types of resectional surgery including pulmonary surgery. There are problems associated with currently available models, but great improvements in design and manufacture will likely occur in the next five years. Stapling devices have the potential of reducing the operating time in some procedures involving much suturing by as much as 50 percent and, therefore, can reduce the requirement for operating room time and space.

4. A variety of human organs have been transplanted, including kidney, heart, liver, lung, pancreas, endocrine and stomach and intestine. Of these, only renal transplantation has been successful enough to have become established as a therapeutic measure. The phenomenon of rejection remains the greatest drawback to widespread application of transplant techniques, and this tremendous problem will probably not be solved in the next ten years. However, as in all sciences, the time of a significant breakthrough is unpredictable.

5. More engineered devices will be implanted in the human body to assist or take over vital functions. Currently more than 100,000 cardiac pacemakers are implanted every year, and other cardiac devices are being developed. A balloon circulatory assist or augmentation system, which is currently being clinically evaluated by the National Heart Institute, aids a failing heart by giving

it a chance to recover. However, a more permanent implantable device is required to aid a patient who still maintains a basal level of cardiac performance but could benefit from an additional 50 percent cardiac function. The patient could then pursue a more active life, but, if the device fails, could still rely on his residual cardiac capacity.

Mechanical hearts are being developed. If successful, they will probably replace heart transplants, since even if rejection problems are solved, the supply of transplantable hearts will be insufficient.

Artificial kidneys are now being used as an extracorporeal renal assist device, as are other methods such as peritoneal dialysis. The chances of developing an implantable artificial kidney appear remote because of the large surface area required. Additional research is also needed on power sources, removal of wastes, and coagulation.

6. Although the cause of the duodenal ulcer is unknown, recent evidence suggests that it results from an endocrine deficiency. If this diagnosis is correct, the need to correct peptic ulcer disease by surgery will end in the next decade.

It is also possible that some forms of human cancer will be better controlled, if not eradicated in this decade. Choriocarcinoma, for example, appears to have been cured by chemotherapy, and viral etiologies are being seriously considered for several types of cancer including leukemia. Such advances may help to alleviate the surgical workload.

7. Doctor James L. Goddard has estimated that one million wound infections occur each year among the 15 million people undergoing surgery. These post-operative infections result in increased mortality, morbidity, and economic loss, and often double the length of hospitalization required. Although many researchers have attacked this problem, no immediate solutions are apparent.

Surgical Equipment

The surgical monitoring instruments which are on the horizon continuously measure critical physiologic phenomena, such as the oxygen level of the blood, or partial pressure of oxygen; carbon dioxide level in the blood; pH or acidity of the blood; cardiac output; the volume of circulating blood; and blood pressure. Small dedicated computers will monitor these functions, recognize trends, and alert the surgeon or anesthesiologist immediately in any emergency.

Although current oxygenators are considered adequate for the time consumed by heart surgery, engineers are working on new types of oxygenator membranes that can transfer enough oxygen and carbon dioxide to sustain life for longer periods, especially during post-operative care. The biggest development in this field is the prevention of toxic denaturation as the blood is being oxygenated, a phenomenon caused by direct contact between blood and the gas. An additional research device is the heart-lung machine, which is far from a fully developed device.

Continous monitoring, which is more likely to enable early identification of trends and permit immediate corrective action to be taken, will be used more often than intermittent monitoring. It is far better to watch a continuous monitor and spot a falling $pO_2$ and a rising pH in a patient with incipient respiratory insufficiency than to use these measurements to confirm a problem that has already developed.

Another aid to surgery has been fiber-optic systems which offer flexibility and "cold" light. The advent of fiber optics has greatly improved endoscopy, and wound retractors with integral fiber optic illumination are being used, especially in cardiac surgery. Although the fiber optic tips are occasionally covered with blood which then must be removed, this nuisance is considered minor in comparison to the advantages of good illumination of the operative field.

Disposable goods, which eliminate the need for laundering, instrument cleaning, and sterilization, are becoming increasingly popular, since they assist in reducing personnel cost, perhaps the fastest rising of all hospital costs. It is projected that by 1978 disposables will account for ten percent of all hospital supplies and equipment. A wide variety of single use items for surgical areas are available, such as:

a. Sterile operating gowns, caps, face masks, and conductive foot covers

b. Basic operating room packs, containing such things as outerwrap, table cover, Mayo Stand cover, operating room towels, and utility drapes, which may be used in combination with drapes adapted to specific procedures: mastectomy, laparotomy, cystoscopy, lithotomy, obstetrics

c. Tapes, dressings, incise drapes, prep razors, pads, and underpads.

Surgical Suite

Although the American Hospital Association design check list (1965) identifies 161 items to be considered in designing an operating room suite, the ideal suite has not yet been built. However, the Hill-Burton program office is working on surgical suite guidelines for publication in 1971.

The size of the operating room is a changing requirement since general surgery requires 450 square feet; cardiovascular surgery requires 540 square feet; and endoscopy requires only 350 square feet. Ceilings should be 10.5 to 11.5 feet high.

Conductive flooring, as well as explosion-proof electrical outlets and equipment, will still be required through 1975. It is expected, however, that by that time all anesthetic agents will be non-flammable, thereby eliminating the danger of explosion.

Communication between the operating room and other hospital areas will be markedly improved during the next few years. Television cameras with full tilt, zoom capability, and remote control are now being incorporated in the overhead surgical light to enable remote viewing of operations. Audio is also incorporated so that surgeon can describe the procedure. The number of students and physicians who can observe surgical procedures is no longer limited to the few who can "look over the surgeon's shoulder."

As a result of recently developed magnetic video disc systems, high quality images can be called up by an easily operated access system and displayed on a monitor in the surgery area. Radiographs, laboratory results, and other information are instantaneously available, and an image of a frozen section of a pathological specimen could be transmitted to the operating room from the pathologist's microscope. Another development permits a modified black and white television camera to image a microscope field in color.

In the next few years most operating rooms will mount a diagnostic X-ray unit on the ceiling so that it can be positioned for radiography and fluoroscopy during surgical procedures.

## Staffing

Operating room experience has recently been deleted from the curriculum in virtually all nursing schools, whether diploma, associate degree, or baccalaureate program; these nurses will be replaced by surgical technicians who are being trained in increasing numbers for this purpose.

## Outpatient Surgery

About 20 percent of all surgery being performed in hospitals is estimated to fall in the category of procedures too complicated for the physician's office but not of a magnitude requiring pre- or postoperative hospitalization. To relieve the surgical suites of these cases, the concept of outpatient surgery under general anesthesia is being implemented by the medical schools of U.C.L.A. and George Washington University.

The ability to perform many surgical procedures on an outpatient basis is the result of the use of short-acting anesthetics allowing rapid recovery. By

1975 substantial improvements in short-acting anesthetics may lead to recovery as abrupt as waking from ordinary sleep. After 1975 chemical methods should be replaced largely by electrical anesthesia, which should reduce surgical shock and other complications of surgery.

This year, two anesthesiologists in Phoenix, Arizona, have extended the concept of outpatient surgery by building a Surgicenter which provides surgical services in a building totally detached from a hospital and without, in fact, any sponsoring parent hospital. The objective is to provide streamlined, efficient medical care.

The Surgicenter is a one story building approximately 90 x 65 feet and housing 4 operating rooms, a 12 bed recovery room, a reception-waiting area, dressing rooms, and lounge rooms for doctors and nurses. Conductive flooring was not required because inflammable anesthetic agents are not being used.

The two anesthesiologists who founded Surgicenter decide which patients and which surgical procedures are suitable for the center. Physicians, both surgeons and anesthesiologists, are allowed to do procedures at the Surgicenter if they have corresponding privileges at the local community hospitals. All anesthesia is administered by fully trained and certified anesthesiologists.

Surgicenter is designed for patients who arrive in the morning, have their operation performed under general or any other type of anesthesia, and then return home the same day in the company of a responsible adult. Patients, who must be the best possible anesthetic risks, are examined, diagnosed, and given a recommendation for surgery by their private physicians. A complete blood count and routine urinalysis must be done within a week of the scheduled operation, and a small laboratory at Surgicenter may be used for this purpose. All tissues removed are submitted for pathological examination, and the tissue report then serves as an index of quality control. Transfer agreements have been negotiated with local hospitals in case a patient unexpectedly requires hospitalization.

## TABLE 1: PROCEDURES PERFORMED AT SURGICENTER

### INTEGUMENTARY

- Excision of skin, subcutaneous tissue or mucous membrane for biopsy
- Avulsion of nail
- Split skin grafts
- Full thickness skin grafts
- Abrasion of skin
- Change dressings or remove stitches
- Electro-surgical destruction
- Biopsy of breast
- Excision cyst or tumor
- Mammoplasty, augmentation

### MALE GENITAL SYSTEM

- Dorsal slit
- Biopsy of penis
- Circumcision, infant
- Circumcision, adult
- Testicular biopsy, needle
- Testicular biopsy, incisional
- Biopsy of epididymis, needle
- Exploration of epididymis
- Aspiration of hydrocele
- Vasectomy
- Biopsy, prostate, needle

### FEMALE GENITAL SYSTEM

- Biopsy of vulva
- Hymenectomy
- Excision of Bartholin's
- Biopsy of vaginal mucosa
- Dilation of vagina under anesthesia
- Pelvic exam under anesthesia
- Culdoscopy
- Biopsy of cervix
- Insertion of I.U.C.D.
- D & C
- D & C & biopsy
- Hysterosalpingogram

### RESPIRATORY

- Biopsy, soft tissue, nose
- Excision of nasal polyp(s)
- Submucous resection
- Rhinoplasty
- Antral lavage or puncture
- Laryngoscopy
- Laryngoscopy with F.B. removal
- Tracheotomy
- Bronchoscopy
- Bronchoscopy with biopsy
- Bronchoscopy with injection of contrast media
- Closure of tracheostomy

### DIGESTIVE

- Lip peel (Vermilionectomy)
- Esophagoscopy
- Esophagoscopy with biopsy
- Esophagoscopy with F.B. removal
- Gastroscopy
- Gastroscopy with biopsy
- Proctosigmoidoscopy
- Above with biopsy
- Above with removal of polyp
- Endoscopic removal of F.B.
- Enucleation or excision of external thrombotic hemorrhoid

### URINARY SYSTEM

- Renal biopsy, trochar or needle
- Transurethral resection, vesical neck, female or child
- Cystoscopy only
- Cystoscopy and retrograde
- Cystoscopy with biopsy
- Cystoscopy with fulguration
- Cystoscopy with dilatation of bladder

## TABLE 1: PROCEDURES PERFORMED AT SURGICENTER - (Cont'd)

### URINARY SYSTEM - (Cont'd)

Cystoscopy with removal of foreign body from urethra or bladder
Meatotomy
Urethroscopy
Dilation of urethral stricture

### MUSCULOSKELETAL

Biopsy of bone marrow
Reduction nasal fracture, open
Reduction nasal fracture, closed
Reduction fracture of mandible, closed, with wiring
(and similar): - Closed reduction of simple fracture of shaft with cast and X-ray
(and similar):-Arthrotomy and/or synovectomy of finger and other small joints
Closed reduction, dislocation shoulder
Incision of fibrous sheath of tendon for stenosing tenosynovitis, including freeing of tendons or removal of foreign body
Tenotomies
Fasciotomies and fasciectomies
Tendon repair and tenolysis

### EAR

Biopsy of ear
Otoscopy with or without removal of foreign body in external auditory canal
Otoplasty, of cartilage
Myringotomy with or without insertion of poly tubes
Myringoplasty
Tympanoplasty without mastoidectomy

### NERVOUS SYSTEM

Subdural tap through fontanelle (Infant)
Spinal puncture, diagnostic, initial, with study of hydrodynamics
Injection procedure for myelography
Nerve blocks
Neurography and neuroplastics

### EYE

Gonioscopy, adult or infant
Fundoscopic
Goniotomy
Secondary implantation of integrated implant
Keratotomy
Paracentesis
Removal of foreign body from surface of cornea
Pterygium
Sclerotomy
Irrigation and/or air injection into anterior chamber
Excision of lesion of iris
Iridectomy
Extraction of lens
Reattachment of retina
Any type of muscle operation
Chalazion
Ectropion repair
Suture of conjuctiva
Biopsy of conjuctiva
Excision of cyst
Excision of lacrimal gland
Excision of lacrimal sac
Catheterization of nasolacrimal duct with implantation of tube or stent
Dilation of punctum
Probing of nasolacrimal duct
Probing and/or irrigation of canaliculus

The Surgicenter patient is charged a single, all-inclusive fee ranging from $60 for the simplest procedures to $135 for the more involved procedures. These figures represent approximately a 50 percent reduction in past hospital charges. A list of procedures appears in Table I.

Obstetrics

Some developments in the initial stages in obstetrics will undoubtedly exert increasing influences during the next several years, including fetal monitoring in labor, the analysis of amniotic fluid aliquots during pregnancy, and indirect tests to ascertain placental function.

Fetal monitoring, which is being instituted in more and more hospital obstetrical departments, is usually applied to well defined predictable high risk patients. Current intrapartum fetal monitoring consists of continuous monitoring of the fetal pulse rate and intrauterine pressure, and intermittent monitoring of the maternal and fetal blood pH and blood gases. The fetal heart rate pattern is influenced in specific ways by anoxia and pH imbalance. Changes in these parameters alert the staff to perform remedial action including immediate delivery, which can significantly reduce perinatal morbidity and mortality.

An extension of fetal monitoring is the concept of a "perinatal intensive care unit" specifically equipped with monitoring equipment with both bedside and nurse station displays and organized for the controlled induction of labor.

Increased knowledge of the physiology of the uterus during pregnancy and delivery has enabled the obstetrician to control and schedule the time of delivery with the use of exogenous hormones and to accurately observe and manage this critical life process. The elective induction and then control of labor is expected to become widely used, if not routine, by 1975 and will have an impact on staffing and facility utilization. Non-invasive instrumentation for obtaining the fetal electrocardiogram or pulse rate is being developed and will be available within one year, and continuous monitoring of blood gases and pH should be available by 1973. These and other inputs will provide servomechanism relationships to the induced labor pattern.

A comparatively new method of assessing fetal well-being is the analysis of amniotic fluid constituents during pregnancy by a procedure called abdominal amniocentesis. Amniotic fluid and its solutes are in dynamic equilibrium with both mother and fetus; the concentrations of various constituents such as creatinine and bilirubin provide information hitherto unattainable as to gestational age and hemolysis.

Technology is now available to culture fetal cells from amniotic fluid and then to determine chromosome abnormalities and sex by means of cytogenetic methods. The nature of any abnormalities could affect the decision on whether to terminate a pregnancy or could indicate whether the defect is correctable. Intrauterine fetal blood transfusion is now practiced, and corrective fetal surgery will be performed in a routine manner by 1980.

Increased certainty that the placenta elaborates some hormones, metabolizes others, and selectively transfers various drugs and agents has increased the accuracy of assessing placental function by examining maternal blood and urine and amniotic fluid. This trend will continue and as chemical methodology improves, may become part of the routine prenatal care for all patients.

The use of ultrasonics is just being introduced in obstetrics and is expected to expand in the next few years. Ultrasonics can locate the position of the fetus and placenta without the inherent risks of radiological or nuclear medicine techniques. It can also accurately determine the biparietal diameter of the fetus, which is needed to pin-point the gestational age, and can diagnose an early pregnancy, as well as the presence of pelvic masses.

Other recent developments which will diminish infant mortality are the newly developed vaccines against measles and rubella and sensitization to rhesus factor. Continued advances in these areas are expected.

High quality in-hospital care, however, is not the total answer to obstetrical problems. Socio-economic factors play an important role and where adverse problems exist beyond the hospital, the physician and his staff must attempt to recognize and eliminate them. The implementation of a comprehensive health care program will aid greatly. Moreover, the present level of prenatal care and education should be extended by using audio tapes, motion picture films, and video tapes for instructing patients before and after delivery. These education techniques, moreover, will relieve the physician and nurse of some time-consuming duties.

The significant effect of family planning on hospital obstetrical departments is reflected in the decreased number of beds in use, and, in some cases, their elimination. In the United States today, about $25 to $35 are spent per patient per year for this purpose. Since one premise of family planning is that the wanted pregnancy should have every advantage of resulting in a healthy infant, the money and effort devoted to family planning is likely to increase.

"Authorities Assess the '60s, Forecast the '70s." Pediatric News (January 1970).

Barnard, Christiäan. "The New Surgery Depends on the New Technology." Modern Hospital (January 1970):73-4.

Barnett, G. O.; Grossman, J. H.; and Greenes, R. A. "The Computer's Role in Health-Service Research." Technology Review 72 (1970):56-60.

Becker, Harry J. "Health Services in the United States." In Forecast - 1975: A System of Health Care Services in the United States. Proceedings of Sixth Hospital Administrators Conference, September 1967.

Budd, M.; Reiffer, B.; Rodman, M.; and Sherman, H. A Program for an Ambulatory Care Service. Lexington, Massachusetts: MIT Lincoln Laboratory, January 27, 1969.

Cordtz, Dan. "Change Begins in the Doctor's Office." Fortune (January 1970):84.

Englebardt, S. L. "Care-by-Parent Relieves Emotional Strain on Children, Financial Strain on Parents." Modern Hospital (December 1969):94-7.

Erickson, Stanford. "New Instruments Will Improve the Care, Increase the Problems." Modern Hospital (January 1970):75-8.

Faltermayer, E. K. "Better Care at Less Cost Without Miracles." Fortune (January 1970):80.

Garfield, S. R. "The Delivery of Medical Care." Scientific American (April 1970):15.

Ginsberg, Frances. "Improved Surgical Techniques Will Increase Pressure on O. R. Personnel, Facilities." Modern Hospital (January 1970):81-4.

Hicks, Allen M. and Bech, Rita M. "This Trend-Setting O. R. of the Future Is Being Built Today." Modern Hospital (January 1970):85-9.

"Hormonal Clock Set - Stork Works 9 to 5." Medical World News (May 22, 1970):15-7.

"It's Time to Operate." Fortune (January 1970):79.

Labouré, Sister Mary. "The Changing General Hospital." In Forecast - 1975: A System of Health Care Services in the United States. Proceedings of Sixth Hospital Administrators Conference, September 1967.

Lepkowski, W. "N. I. H. Sees Monitors, Computers, Lasers, Prefabs and Outpatients in the Future O. R." Modern Hospital (January 1970):79-81.

Medicines in the 1990's: A Technological Forecast. London: Office of Health Economics, 1969.

"1969: A Look at the Final Year of a Tumultuous Medical Decade." Medical World News (December 26, 1969).

Trends on Health Care: A Symposium. Philadelphia: Smith, Kline, and French Laboratories, May 1968.

"Ultrasound for Heart Stroke Victims." Medical World News (April 24, 1970).

Medical World News (April 20, 1970):5.

Weinerman, E. Richard. "The Concept of a Health Care System." In Forecast - 1975: A System of Health Care Services in the United States. Proceedings of Sixth Hospital Administrators Conference, September 1967.

"What's Ahead for Medicine in the 1970's?" Medical World News (January 16, 1970).

Wilson, P. D., Jr. "What's New in Surgery: Orthopedic Surgery." Surgery, Gynecology, and Obstetrics (February 1970):306-9.

# CLINICAL LABORATORY

## INTRODUCTION

The clinical laboratory is a service function which qualitatively and/or quantitatively examines body fluids and tissues for diagnostic and therapeutic purposes. The clinical laboratory attempts to provide objective evidence of pathological conditions to confirm a presumptive diagnosis, and supplies information important in assessing the degree of perturbation essential in making a patient's prognosis.

Additional objectives of the clinical laboratories are: (1) to improve the quality of test results, and (2) to decrease the time lag between the physician's authorization of a particular test or series of tests and his final reception of the test results. Too frequently, because of the time lag, test results provide only academic information instead of information needed for diagnostic and therapeutic decision making.

To assist in defining the objectives of improvement alternatives for the clinical laboratory, the following questions should be considered.

1. How can the physician most effectively communicate with the laboratory to reduce the time lag between request for test procedures and the final result report?
2. How can laboratory personnel ensure they are collecting the specimen from the correct patient?
3. How can the specimen and analysis results be distinctly identified throughout the entire test cycle, even when samples are collected on a batch basis or when aliquots of a sample are tested in several laboratory areas?
4. How can a single sample or a batch of samples be analyzed in the minimum amount of time and yet maintain quality test results?

5. How can the various test results from aliquots of a single sample be brought together and then transmitted to the physician?
6. What is the most effective way of providing administration with billing information?
7. What is the most efficient way of maintaining test records for a particular patient for future reference? Should test copies be kept in the hospital records as well as in the pathology file for compiling annual work load information and evaluating personnel laboratory performance?
8. How can stat procedures and transmittal of test results to the physician be handled in the laboratory without interrupting the routine activities?
9. How can laboratory test procedures be standardized to decrease the necessity for individual specimen treatment?
10. How can physicians be encouraged to order batteries of tests on admission to eliminate multiple individual test ordering during the patient's hospitalization period?
11. Does the volume of laboratory work justify the installation of high volume automated analyzers, and do such analyzers necessitate an automated data handling system?
12. Is the hospital concerned with multiphasic screening?

In the following state-of-the-art discussion, some general trends in the clinical laboratory are listed and then improvement alternatives in the various clinical departments are detailed. The advanced technology section includes concepts or techniques that are in the research and development stage and will not be available for implementation by 1972.

TECHNICAL APPROACH

In conducting the state-of-the-art study of clinical laboratories, we first reviewed pertinent articles appearing over the last five years in periodicals such as Laboratory Management, Clinical Chemistry, Journal of the American Medical Association, Laboratory Investigation, and Medical Laboratory. Selected articles are included in a bibliography at the end of this section.

We contacted manufacturing specialists such as the Instrument Division of the Perkin Elmer Corporation in Norwalk, Connecticut, the Fisher Scientific Company in Pittsburgh, and Beckman Instruments, Pittsburgh. After gaining a knowledge of what clinical hardware is on the market, we visited universities and hospitals to see how these instruments are being applied in a clinical setting and conducted the following interviews:

Doctor Alex Kaplan, Director, Chemistry Laboratories, University of Washington, Seattle, Washington.

Doctor J. Strumford, Chairman, Department of Pathology, University of Alabama, Birmingham, Alabama.

Doctor Sylvan Sax, Director of Clinical Chemistry, Western Pennsylvania Hospital, Pittsburgh, Pennsylvania.

To complete our research and keep abreast of any new developments, we attended the following technical meetings:

American Association of Clinical Chemists, Denver, Colorado, August 1969.

American Association of Advancement of Medical Instrumentation, Boston, Massachusetts, March 1970.

High Resolution Analysis Symposium, Oakridge, Tennessee, March 12-13, 1970.

Physiological Society for the Federation of American Societies for Experimental Biology, Atlantic City, New Jersey, April 12, 1970.

Nineteenth Annual Research Equipment Exhibit and Instrument Symposium, U.S. Department of Health Education and Welfare, National Institute of Health, Bethesda, Maryland, October 6-9, 1969.

Thirty-eighth Annual Convention of the American Society of American Technologists, Detroit, Michigan, June 14, 1970.

STATE OF THE ART

The objective of the Clinical Laboratory is to achieve effective and efficient specimen analysis, possibly through the use of automated techniques and equipment.

General trends are:

1. To reduce clerical work associated with the test cycle and to speed communication through advanced computer techniques.
2. To use automated equipment to cope with large test workloads.
3. To develop procedures for positive patient and sample identification.
4. To establish a query procedure so the physician may check the status of tests without involving laboratory personnel.
5. To establish a standard specimen collecting procedure and battery of tests to be performed on all patients even though only one test may be requested.
6. To automate accession of specimens into the automated analyzer with minimal interference.
7. To establish standard test methodologies and normal ranges for the constituents analyzed so that the values will be standardized for all laboratories.
8. To use clinical laboratory tests for screening hospital admissions.
9. To use small dedicated computers with manual and automated input facilities to perform many of the calculations required for automated and non-automated equipment.

During the past ten years the number of available laboratory tests has increased from 12 to approximately 100. Moreover, the tendency to use batteries of clinical tests as screening procedures for hospital admissions and the possibility of using multiphasic screening for annual patient check-ups have greatly increased the number of routine laboratory tests. Since the physician dictates the laboratory load, his changing attitude has been largely responsible for laboratory growth during recent years. An increased emphasis on laboratory sciences by the medical schools has encouraged clinicians to seek more laboratory consultation.

This tremendous increase in work load is forcing many laboratories to install automated equipment to process the requested tests. In evaluating automated devices, criteria such as speed, specificity or quality of test results, or a memory that can be interrogated or updated should be considered. The trends in clinical laboratories defined by specific departments are as follows:

Urine Analysis

Automation in the routine urine analysis laboratory is practically non-existent for two reasons. First, urine is a heterogeneous solution containing metabolic end products whose concentrations vary with time of day, age, sex. According to available information, variations occur over a wide range even in normal individuals. It is generally felt that semi-quantitative methods have been adequate for the detection of protein, sugar, ketones, bile, specific gravity, and pH. Second, it is difficult to produce an automated system with greater speed than that offered by conventional quick indicator dip sticks.

A considerable amount of interest is being shown in the recently introduced, relatively inexpensive but extremely time-consuming procedure of high resolution liquid chromatography used to analyze metabolites of urine. Such analysis appears to produce important diagnostic and prognostic information. This approach with further refinement in resolution and automated data handling will be used as a screening tool.

Bacteriology

Next to urine analysis, bacteriology is probably the least automated clinical laboratory area. However, automation is being attempted primarily in three areas: (1) identification of bacteria by serological reactions with known antigens, (2) identification of bacteria species and type by the use of serological reactions and (3) counting bacteria colonies by light scattering techniques. The AMICO Counter, American Instrument Company, employs the third technique and can be used only for the quantitation of bacteria in a fluid and the evaluation of antibiotic effects on the growth of bacteria. Manufacturers claim it can also decrease the test turnaround time by eight to ten hours.

Serology

High volume tests in serology have been automated by Technicon. The Technicon instrument is reasonably well known but has had some early unfavorable performance field reports. More extensive field experience will be needed to fully evaluate its performance. The activities performed by the instrument are mainly those of cell separation and preparing a solution to be examined by a serologist. A significant contribution is that the instrument allows a less skilled operator to prepare the sample for a more skilled serologist to examine.

Chemistry

The chemistry department enjoys the greatest amount of automation and mechanization--up to 95 percent of the workload can be partially automated. In general, the automated or mechanized systems in the clinical laboratory utilize a spectrophotometric readout of a color complex, produced by reaction of various substances in the serum or plasma with organic reagents. Three basic approaches are taken to the automation of analytical procedures in this area:

(1) the continuous flow system,

(2) discrete sample analysis,

(3) the parallel chemistry concept, which analyzes discrete samples but performs up to 90 tests simultaneously and provides continuous reaction monitoring.

The major drawback of continuous flow is that identification of the sample is not possible as it passes through the analyzer and patient identification is entirely dependent upon the time sequence from start to finish. The discrete sample and parallel chemistry analyzers provide better sample identification, because each sample is contained in a separate vessel. With few exceptions, such as ACA and Dupont, they do not, however, have automated sample identification systems. Therefore, sample identification is also dependent on position of the specimen.

A major drawback for most manual and automated clinical techniques is the lack of specificity for the particular compound being analyzed. Up to fifteen per cent of some test results are due to substances other than the one being tested. These non-specific substances unfortunately are usually unstable and fluctuate in concentrations. The inability of most of the chemistry analyzers to analyze the substances in whole blood necessitates centrifugation of the sample prior to machine loading.

The following are chemistry improvement alternatives that may help to alleviate problems and provide quality test results:

(a) The Technicon SMA 12/60 is a continuous flow processor capable of simultaneously performing up to 12 different tests at the rate of 60 per hour; SMA 12/Jr. can produce 30 per hour. These instruments offer the best improvement alternatives in hospitals using standardized battery tests for each patient admitted.

(b) The Mark X Discrete Sample Analyzer manufactured by Hycel

Company can perform ten simultaneous tests or can be operated using only a single channel without activating or disturbing the others. From a design consideration this instrument appears to meet the needs of a hospital engaged in profile testing as well as discrete sample analysis.

(c) The DSA-560, Beckman Instrument Company, is the most popular discrete sample analyzer. Its major contribution to the smaller laboratories is that the selection of tests and methodologies available enable a larger percentage of the workload to be automated. In the larger laboratory it functions primarily as a backup for higher volume systems, since it can perform only two or three large volume tests on a daily basis. Its major disadvantages are that it is a four-channel analyzer and has a relatively long test turnaround time.

(d) The C-4 Automated Chemistry Analyzer, Perkin-Elmer Company, is similar to the DSA-560 produced by Beckman Instruments with the exception that the sample holders or channels are located around the disc's periphery instead of attached to a rotating horizontal belt. This extremely versatile instrument can potentially perform a larger variety of laboratory tests than any of the systems on the market. It is a relative newcomer and field test information has not been released.

(e) The GeMSAC Concept has been used by Union Carbide, Electro-Nucleonics, Inc., and American Instrument Company. This approach to automated clinical laboratory test analysis is one of the most significant breakthroughs in the last decade and provides monitoring of chemistry reactions from zero time until the reaction is completed. The test results are displayed on an oscilloscope which can be used to monitor the reactions, to compare tests' rate reactions on unknown samples with those of quality control samples, and also to serve as a multiple point-in-time analyzer for determining enzyme reaction rates. This concept appears to have the greatest potential of any of the discrete sample analyzers for high speed test analysis and continuous monitoring of enzyme reactions. This becomes even more important since enzymes offer the potential for increasing test specificity and decreasing turnaround time.

(f) The DuPont Analyzer, which has received a minimum amount of field testing and evaluation, appears to be the most accurate and reproducible and possibly the most specific test analyzer on the market. It utilizes gel chromatography and ion-exchange columns to remove interfering substances from serum before initiating the chemical reactions. This instrument provides positive patient specimen identification from the test request to the hard copy test results. Moreover, any number of samples can be analyzed in any sequence.

(g) The Technicon Autoanalyzer II is a two channel, flow-through. low volume instrument used for routine tests. Its modular design allows channels to be easily added. It can perform 120 tests per hour. Expanded to 3 channels, the Autoanalyzer II is a flow-through analyzer used to back-up profile analyzers. It can complete 180 tests per hour.

(h) The ACA is an emergency (fast turn-around) single channel analyzer capable of 75 tests per hour.

(i) Centrifuge-chem is a single channel kinetic rate analyzer used for enzyme tests. It can perform 120 to 600 tests per hour, depending upon test complexity.

(j) Ames/BMI blood analyzer can perform 14 separate tests, 20 to 60 tests per hour, using a spectrophotometer with four available wave lengths.

(k) The Unitest analyzer can perform 13 separate tests, 20 to 40 tests per hour, using a single wavelength spectrophotometer.

(l) The Dow analyzer can perform 9 separate tests, at 20 to 40 tests per hour using a single wavelength spectrophotometer.

Blood Bank

Technicon has automated one of the major activities of the blood bank, namely, blood typing and cross-matching. It is capable of high volume processing and is therefore used primarily in large blood donor centers. The introduction of automated cell washing instruments have decreased the processing time and standardized the Coombs test. Next to the automated cell typer, it is the most automated instrument seen in most small and medium sized hospital laboratories.

Improved communication systems can make a significant impact on the time required for blood bank inventory by decreasing clerical activities associated with the inventory and the area where blood is utilized.

Cytology

With the exception of several mechanized cytology slide standards, this area has little automation. However, a considerable amount of effort is being focused on automated smear reading for screening slides containing suspicious cells indicative of cervical cancer. For this task, companies such as Perkin-Elmer, Upjohn, and a group of Boston researchers are developing computer control systems, based on pattern recognition analysis by computers.

Hematology

In hematology the largest workload is the determinations of total, red blood, and white blood cell count. Several manufacturers produce instrumentation which automates these tasks. The Coulter Counter Model FN uses a single channel particle counter, while Model S uses a seven channel device. Both have capabilities for determining particle sizes. Another single channel automated blood cell counter, the Autocytometer, is manufactured by Fisher. The seven channel SMA 7A, manufactured by Technichon, automates the blood cell counting plus other blood determinations, such as hematocrit and hemoglobin.

Histology

Automation in this area is primarily related to the preparation of pathological tissues by dehydrating and infiltration with paraffin prior to sectioning and staining for examination by the pathologist. Such an instrument is available from Technicon and is used for preparing specimens and staining tissues.

Autopsy

The most recent development in this area is the storage of tissues in high strength plastic bags rather than glass containers. Standardized methods for describing the gross and microscopic examination of healthy and diseased tissues are emerging. High resolution photography could conceivably eliminate the need for the pathologist to spend a significant part of his time examining and describing gross specimens.

Computer

The decision to use a computer in the clinical laboratory must be based on the following considerations: amount of laboratory data to be automated; compatibility of a computer with existing equipment; ease of operation; availability of a computer, operating technologist, and computer program tailored to the particular laboratory; and the possibility of using the computer for research and development activities. A further consideration is whether the computer can control automated systems and correct for drift with time as well as for unexpected alterations such as line voltage.

## ADVANCED TECHNOLOGY

By 1980 the design of the clinical laboratory will be somewhat altered and new analytical techniques will be in use. Satellite stations will perform all laboratory tests not essential to immediate diagnostic and therapeutic decision making. Using techniques other than ground transportation, samples will be rapidly transported from the satellite to a central processing station. The quality of testing by the satellite laboratories will be monitored by the central laboratory, while the central laboratory will be monitored by a more remote reference laboratory.

With regard to laboratory layout, more attention will be paid to sample flow patterns and to positioning the analytical modules and accessories to minimize operator travel time and maximize space utilization.

The following are some analytical techniques which should be in use by 1980:

1. Chromatographic techniques will be routinely available that can analyze numerous compounds in body fluids (saliva, urine). The absolute amounts of these compounds will be related to demographic and geographic factors.

2. Microwave techniques will be developed that stabilize enzymes in body fluids. Consequently, samples will not degenerate during transport, and blood for transfusions will be stabilized, extending shelf life two to three times.

3. Larger laboratories (300-bed hospitals) will increasingly use dedicated computers for identification of samples and their locations, instrument operation, result reporting, filing, and billing. The physician will be able to interrogate the computer for test results, summaries of laboratory tests for an identified patient, normal test ranges with instrument accuracy, and the effect of drugs the patient is receiving on the laboratory tests ordered. It is conceivable that computers using pattern recognition could recognize abnormal microscopic specimens and diagnose the disease process occurring in the tissue.

4. Laboratory test requests will be directly entered into a communication system bypassing the present step of transcribing the physician's order from the patient's chart onto a laboratory test requisition form, for example, by using the REACH system, National Data Communications, Inc.

5. New techniques for collecting blood samples and transporting them to the laboratory must be developed before laboratory costs can be reduced. Sample collection usually costs as much as sample analysis, and in some cases, costs twice as much as analysis. The major portion of sample collection cost accrues from technician travel, i.e., to and from the laboratory, locating the requisition and the patient.

6. Whole blood may be loaded onto an analyzer that automatically separates the cellular components from the liquid portion and their proceeds and performs the requested test on the appropriate fraction. Mass spectrographs, gas chromatographs, and infrared spectrometers, common analytical tools of industrial laboratories, will find increasing application as integral parts of such systems.

7. Advanced technology, such as that being conducted at the Stanford University using laser microprobe technology for histochemical analysis, will undoubtedly have an impact in histology in the next five to ten years. By these techniques, ultra-micro concentrations of trace metals such as zinc, magnesium, and cobalt may be measured within a single cell. It is anticipated that these methods will provide vital information on the relationship of various metallic trace elements to disease; for example, the relationship of zinc to cirrhosis and cancer, cadmium to kidney disease, and aluminum to lung diseases.

8. Disc storage of gross and microscopic tissue pictures (colored) will be used to improve information quality and decrease record retrieval time. Physicians will be able to automatically retrieve tissue section pictures when they request the patient's history.

9. Outpatient laboratory test loads will approach those of the inpatient department as instrumentation becomes available to speed test results before the patient leaves the hospital. Multi-testing will also increase as more sensitive analytical systems are developed.

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: CLINICAL LABORATORY**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| AMINCO Microscan Colony Counter (American Instrument Company) | Automatically counts bacteria colonies - including aerobic, anaerobic, and facultative organisms - in a nutrient media, in less than 2 seconds. Also quantitates growth inhibition powers of various antibiotic concentrations. | $5,000 | 1. Reduces counting errors.<br>2. Cuts counting time by 75 percent.<br>3. Provides hard copy of record on each culture.<br>4. Eliminates calculations; provides direct readout. | 1. Counts only viable colonies.<br>2. Increases time needed for manual preparation of media. |
| Automated Cell Washing System (Ivan Sorvall, Inc. Norwalk, Conn.) | Segments and automatically washes protein from red blood cells. | $350<br>(5¢ per test) | 1. Standardizes Coombs Test procedures.<br>2. Speeds return of test results.<br>3. Increases test result quality.<br>4. Decreases test cost by 50 percent. | 1. Does not provide positive sample identification.<br>2. Technician still must interpret reading. |
| SMA 12/Jr.<br>a. Survey Model<br>b. Hospital Model<br>(Technicon Corp., Chauncey, N.Y.) | Performs 12 chemistry tests on one serum sample at 30 samples per hour. | Survey Model: $51,000<br>Hospital Model: $53,000<br>(16¢ per test)<br>SMA 12/60: $64,000<br>(15¢ per test) | 1. Can perform 360 tests per hour.<br>2. Reduces required lab space by 50 to 60 percent.<br>3. Reduces lab maintenance.<br>4. Recorder chart becomes test result hard copy.<br>5. Needs only one technician.<br>6. From $11 000 to $13,000 less than the SMA 12/60. | 1. Preparation time creates about 45-minute delay on stat samples.<br>2. Test values do not coincide with manually produced values despite identical methodologies.<br>3. Positive patient identification not included.<br>4. Some sample cross-contamination.<br>5. False elevations of SGOT can occur if serum has abnormal levels of acetic acid.<br>6. Cannot handle whole-blood specimens.<br>7. Requires careful and time consuming maintenance. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: CLINICAL LABORATORY**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| MSAS/360 Micro Sample Analyzer (Scientific Industries) | Performs several chemistry tests using micro samples on a series of paper tapes carrying absorbant pads impregnated with premeasured quantities of reagents. | \$9,000 (10¢ per test) | 1. Needs only one drop (70 lambda) of blood per test.<br>2. Has analysis speed of many multiple-channel units -- 360 tests per hour.<br>3. Could do stat testing. | 1. To date, only glucose and blood urea nitrogen tests available.<br>2. Method not yet approved by American Society of Clinical Pathologists (A.S.C.P.). |
| Fisher Seromatic (Fisher Scientific) | Automates FTA-ABS Syphilis Test. | \$15,000 (\$5 per test for reagents) | 1. Processes 150 to 200 samples per day.<br>2. Permits Syphilis testing in hospital's lab.<br>3. Results returned in one day.<br>4. One technician can do the work of three.<br>5. Standardizes slide preparation procedures.<br>6. Cost per test reduced by two-thirds. | 1. Needs more field testing. |
| $FEA^2$ Model #4 Blood Serum Spectrophotometer (Philips Electronic Instruments) | A uniquely designed polychromator combines atomic absorption and flame emission in an instrument able to perform four determinations (sodium, potassium, calcium, and magnesium) simultaneously on the same sample. | \$6,800 | 1. Automated electrolyte analysis eliminates dilution and calculation errors.<br>2. Can perform stat procedures in 5 minutes.<br>3. Saves considerable time and labor on all tests. | 1. Same volume of sample and reagent needed for one as for the four tests combined.<br>2. Serum preparation necessary.<br>3. No provision for sample identification on printout sheet. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: CLINICAL LABORATORY

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Automatic Blood Gas Analyzer Model 313 (Instrumentation Laboratories) | Analyzes one small whole-blood sample per minute for pH, $pCO_2$, and $pO_2$. | $4,950 | 1. Results not dependent on manual measuring of blood sample.<br>2. Eliminates lengthy, complicated calibration; automatic standardization with calibrating gases containing known concentrations of $O_2$ and $CO_2$. | 1. Membrane permeability changes with time due to protein film formation and electrode $O_2$ decays.<br>2. Daily maintenance is essential for troublefree operation. |
| Digecon Model 1011 (Sherwood Medical Industries) | Continuously and automatically measures enzyme reaction rates. Its digital logic sequencer remembers exact timing of sample introduction, reaction, results, printout, sample discharge, and cuvette washing. | $12,770 (25¢ per test) | 1. Can be used for either micro or macro methods.<br>2. Unit is mobile.<br>3. Can perform kinetic or equilibrium reactions. | 1. No sample identification during analysis.<br>2. Requires manual sample transfer.<br>3. Low test volume output (40 to 45 per hour) necessitates skilled, full time operator.<br>4. Test result quality still affected by operator's skill. |
| Mark X Discrete Sample Analyzer (Hyeel) | Self-contained fully automated system which can perform 10 different tests on 40 plasma or serum samples in one hour. Tests now available include glucose, urea nitrogen, globulin, total protein, cholesterol, uric acid alkaline phosphatase, phosphorous, and total bilirubin. Provides direct readout in units of concentration. | $75,000 but must lease at $1,250/month (22-1/2 ¢ per test) | 1. Less floor space per test needed.<br>2. Does 400 tests per hour; 0.1 cc sample size.<br>3. No phasing adjustments, absolute timing of all sequential functions.<br>4. Automated results recording can be sent directly to physician. | 1. Test batteries cannot be altered so offers no flexibility in test methodologies.<br>2. Cannot handle whole blood.<br>3. Manual transfer of patient chart and identification necessary. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: CLINICAL LABORATORY**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Clinical Chemistry Discrete Sample Analyzer (Clay Adams) | A six-channel discrete sample analyzer with positive patient identification which can be expanded into 12 channels. Its disposable calibrated syringes which are easily inserted into the dispensing unit hold enough reagent for 300 tests. | $29,000 or can lease at $635/month | 1. Automatically prepares serum sample from whole blood.<br>2. Digital as well as hard copy display of calculated values.<br>3. Positive patient identification carried with sample from collection to test result. | 1. Has neither been field tested nor approved by A.S.C.P.<br>2. Test methodologies are inflexible. |
| Zymat 340 (Bausch and Lomb) | Completely automated instrument which performs three enzyme tests (SGOZ, SGPZ, and LDH) on 0.2 ml samples at one sample every two minutes. | $9,850 | 1. Analyzes stat samples in 14 to 20 minutes.<br>2. Decreases test analysis time by half. | 1. Enzyme analysis restricted to those within a 340 ml wave-length range.<br>2. Cannot blank out interfering substances in plasma or serum. |
| Automatic Clinical Analyzer - ACA (E.I. DuPont) | An automated discrete sample analyzer, it can perform 30 tests including glucose, urea nitrogen, alkaline phosphotase, pediatric bilirubin, dehydrogenase pseudo-cholinesterase, lactic dehydrogenase, hydroxybutyric dehydrogenase, aspartate aminotransferase calcium, and total protein at 100 tests per hour. | $65,000 or can lease at $1,200 to $1,500 per month (60¢ to $1.10 per test) | 1. Eliminates sample contamination.<br>2. Positive patient identification.<br>3. Unusually stable test results of two to three percent independent of operator, specimen type, or instrument location.<br>4. Produces hard copy printout with patient identification, number and kinds of tests, and results. | 1. Test rate low -- 50 to 100 samples per hour.<br>2. Cannot automatically handle whole blood; so samples must be centrifuged. |
| Accu-Stat Blood-Chemistry (Clay Adams) | Designed to provide a wide testing range when low test volume does not justify automation. In addition to a hemaglobin determination, it performs glucose, cholesterol bilirubin, urea, BUN, uric acid, total protein albumin, alkaline phosphatase, creatinine, calcium, and SGOT tests. | $700 to $900 ($1 per test) | 1. Microtechniques reduce sample size and reagent consumption.<br>2. Patient identification capability. | 1. No digital readout.<br>2. Output cannot be fed into a computer without modification, for example, A-D conversion. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: CLINICAL LABORATORY

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| DSA-560 (Beckman) | A discrete micro sample analyzer for plasma or serum samples with concentration calculation and teletype printout of results. | $17,175 with analog output; $19,425 with digital output | 1. Reduces labor and overhead costs.<br>2. Digital display of results reduces time and error factors in their calculation.<br>3. All test methodologies approved by A.S.C.P. | 1. Stat samples not quickly run due to 20 to 30 minute change-over time.<br>2. Requires separate centrifugation of all samples. |
| C-4 Automatic Analyzer (Perkin Elmer) | A discrete micro sample analyzer for plasma or serum samples with concentration calculation and teletype printout of results. | $25,000 for basic unit plus $3,500 for teletype output (5¢ to 10¢ per test) | 1. Automated sample identification should eliminate sample mixups.<br>2. Can adapt to any manual technique not exceeding four reagent additions.<br>3. Simultaneously performs four analyses on one sample.<br>4. Eliminates calculations. | 1. Test volume capability only 120 per hour or about 500 to 600 tests per shift.<br>2. Minimum 30-minute stat analysis time.<br>3. Insufficient field testing. |
| Phoro Slide Electrophoresis System (Millipore Corp.) | A compact electrophoresis instrument with cathode ray tube for instantaneous visual representation of electro-phoretogram and percent readout meter. | $2,500 (10¢ per test) | 1. Test results can be obtained in one day.<br>2. Does not require a highly-skilled technologist. | 1. Meter rather than digital display. |
| GEMSAEC Fast Analyzer (General Medical Sciences AEC) | Analyzes substances in blood by mixing whole-blood samples with reagent via centrifugation and then transferring them automatically to cuvettes for spectro-photometic detection. | $21,500 (5¢ per test) | 1. Tests small samples - one to 50 lambda of serum.<br>2. Does stat analyses rapidly - 30 seconds to 10 minutes.<br>3. Standards for a stat test can be run parallel with the unknown without increasing analysis time.<br>4. Simultaneously analyzes up to 28 enzyme tests plus a standard and monitors absorbance changes almost continuously. | 1. Lacks extensive field testing.<br>2. Lacks positive patient and test identification.<br>3. Cannot handle whole blood.<br>4. Has not been evaluated by A.S.C.P. |

## BIBLIOGRAPHY — CLINICAL LABORATORY


"A Chemical Profile of Man Shapes Up: New Automated Analyzers Open the Route to Total Fluid Assay." Medical World News (April 11, 1969).

"A New Scientific Breed." Scientific Research (May 27, 1968):13.

Becker, W.; Schwich, H. G.; Störiko, K. "Immunologic Determination of Proteins Found in Low Concentrations in Human Serum." Clinical Chemistry 15 (1969):649-660.

Beyvl, James. "Untangling the Complexities of Laboratory Designs." American Laboratory (September 1969):37.

Buyra, M. Y. "The Quantitative Coombs Employing Fluorescein-Antisera." Technical Bulletin of the Registry of Medical Technologists 38 (1968):164.

Collen, Morris. "Many Problems Seen in Delaying Use of Automated Screening." Medical Tribune (February 9, 1970):1.

"DSA: Automation Plus Sample Identification". Laboratory Management (June 1969):30.

"Donor Blood Test: Pros and Cons." Medical World News (December 19, 1969):15.

"Engineer/Physician Teams Evolve Life-Saving Systems." Chemical Engineering (March 10, 1969):50.

Files, James B.; Van Peenen, Hubert A.; Lindberg, Donald A. B. "Use of 'Normal Range' in Multiphasic Screening." Journal of the American Medical Association 205 (September 2, 1968):94.

Finch, Edmund P., Owens, S. E. "How to Measure Laboratory Productivity." Modern Hospital (June 1960):98.

Karasek, F. W. "Advances in Chromatography." Research/Development (April 1969):390.

Lucas, F. B.; Lincoln, T. L.; Kinney, T. B. "Clinical Laboratory Sciences: A Look to the Future." Laboratory Investigation 20 (1969):400.

Mandel, Irwin D. "Saliva: Just How Useful in Diagnosis?" Medical World News (November 21, 1969):25.

"Mini Computer Survey." Medical Electronic News 10 (January 1970):1.

"News and Notes: Medical Computer Databases." Medical Research Engineering (February 1970):4.

Reece, R. L. "An Analysis of 4000 Chemistry Graphs: Comments on Disease Patterns." Technicon Quarterly (Fall 1968). Reprinted from Minnesota Medicine (March 1968).

Rose, Robert E., Bradly, William J. "Using the Membrane Filter in Clinical Microbiology." Medical Laboratory (April 1969):32.

Schultz, C. A., and Bellamy, D., "Continuous Flow Cell Washing System." Transfusion (September - October 1968):299-303.

Seligson, David. "Clinical Laboratory Automation." Journal of Chronic Diseases (1966):509-17.

Seward, Owens E., Finch, E. P. "How to Calculate the Laboratory Work Load." Journal of Modern Hospital (1965):105.

"Shall We Automate?: Management Decisions that Must be Faced." Laboratory Management (September 1969):40-42.

Smith, Robert A. "Cryogic Blood Banking." Laboratory Management (September 1969):22.

Stout, G. W., et al. "Evaluation of an Automated Fluorescent Treponemial, Antibody Test." Interm Report Presented at the Laboratory Section, American Health Association Meeting, Detroit, Michigan, November 10-15, 1968.

"Upjohn Clinical Laboratory: Operational Flexibility for Today's Laboratory." Laboratory Management (August 1969):32.

Walsh, John W. "Planning Health Care for Veterans." American Journal of Public Health 59 (December 1969):2211.

Weber, T. B. "Recent Bioengineering Techniques in Multiphasic Screening for Early Detection of Disease." In Digest of the Seventh International Congress on Medicine and Biologic Engineering, p. 177. Stockholm, Sweden, 1967.

Wetlake, George; McKay, Donald K.; Seligson, David. "Automatic Discrete Sample Processing: Automation in a Clinical Chemistry Laboratory Based on Discrete Sample Handling and Computerized Data Processing." Clinical Chemistry 15 (July 1969):600.

Young, D. S., Mears, Thomas W. "Measurement and Standard Reference Materials in Chemistry." Clinical Industry 14 (1968):929-942.

## COMMUNICATIONS AND DATA MANAGEMENT

### INTRODUCTION

The purpose of communications and data management is to transmit, receive, store, process, and display data useful to hospital personnel. As the binding functions, they are critical to system operations and significantly affect system planning, construction, maintenance, and training.

An average of 25 percent of a new hospital's initial cost is earmarked for communications and data management equipment. This significant percentage indicates the importance of selecting the correct components and improvement alternatives, and of studying the communications and data management functions relative to system needs and interfaces. This percentage also indicates that an increasing amount of the total hospital cost is being devoted to information handling because of growing interest in advanced but initially expensive equipment and techniques.

Although several improvement alternatives are described by manufacturers as "Total Hospital Information Systems," in reality no single improvement alternative can fulfill all the BLHC system needs for patient and administrative data management. Instead, combinations of improvement alternatives, some comprehensive, some emphasizing a single specific hospital activity, have been considered.

The primary criterion for the selection of state-of-the-art improvement alternatives discussed below was their uniqueness in the health care field. Only applications with a high potential for operational success in the BLHC system have been studied in detail. Each alternative described herein and in the attached matrix reduces the cost in medical care or improves the efficiency of health care delivery.

The Health Systems Department recognizes the need for new improved information systems, both clinical and administrative, intra- and inter-hospital. Accordingly, it expended a major effort to determine the current methods of data storage, retrieval, and communication and the current and projected hardware systems, subsystems and components. The results of this effort are discussed in the following state-of-the-art section and are summarized in matrices which define the equipment's operation, features, and costs. It should be noted that costs presented in the matrix do not represent direct system or hardware quotes from the manufacturer but rather estimated dollars needed to perform a given function. The hardware and specific system details, moreover, are subject to change due to time and market constraints.

The advanced technology section discusses concepts, hardware, or systems which are presently in the research-and-development stage and will not be on the market by 1972.

## TECHNICAL APPROACH

In inaugurating this state-of-the- art study, we contacted more than 300 companies with product lines applicable to the New Generation of Military Hospitals. Information on each company's equipment was obtained from descriptive literature and/or discussions with company representatives. In some cases, devices were evaluated by Health Systems Engineers in Pittsburgh. Some of the companies contacted are listed below:

Dictaphone Corporation, Rye, New York
Executone Incorporated, Long Island City, New York
General Electric Corporation, Milwaukee, Wisconsin
Hewlett Packard Company, Waltham, Massachusetts
Zenith Radio Corporation, Chicago, Illinois
Altec Lansing, Anaheim, California
ESB Couch, North Quincy, Massachusetts
MEDELCO Incorporated, Wood-Dale, Illinois
IBM, Washington, D. C.
TRW, Medical Information Systems, Redondo Beach, California
Control Data Corporation, Minneapolis, Minnesota
Bradford Computer and System Incorporated, New York, New York

Doctors Business Bureau, Philadelphia, Pennsylvania
Honeywell, Wellesley Hills, Massachusetts
Samat Systems, New York, New York
Edstan Company, Orange, California
Central Bank Computer Bureau, Oakland, California
Automated Business Systems Division, Litton Industries, New Jersey
Bio-Logics, Salt Lake City, Utah
Bell Hospital Systems, Incorporated, Bridgeport, Connecticut
Medical Systems Division, Lockheed Missile and Space Company, Sunnyvale California
Norelco Medical Division, Professional Products, New York, New York
Siemans-Reiniger, Ag, Erlangen, Germany
National Data Communications, Incorporated, Dallas, Texas
Climc Visible Records, Incorporated, Croget, Virginia
Burroughs Corporation, Detroit, Michigan
Hamilton Standard Division, United Aircraft Corporation, Farmington, Connecticut
Sanders Associates, Incorporated, Nashua, New Hampshire
Mosler Information System, Hamilton, Ohio
Motorola Communications and Electronics, Incorporated, Buffalo, New York
Preventicare Systems Incorporated, Ypsilanti, Michigan
Bio-Medical Computer Science, Incorporated, Minneapolis, Minnesota
Diversified Numberic Applications, Minneapolis, Minnesota
National Cash Register Company, Pittsburgh, Pennsylvania

To see how communications and data management hardware is being applied, on-site visits were made to the following locations:

Diversified Numeric Applications, Minneapolis, Minnesota
Automated laboratory information system
Bio-Medical Computer Science, Minneapolis, Minnesota
Total Hospital Information System
Control Data Corporation, Minneapolis, Minnesota
Major computer manufacturing
Diebold Corporation, Canton, Ohio
Power Files

Mosler Information System, New York, New York

Computer Control Microfilm Retrieval

Mayo Clinic, Rochester, Minnesota

Mechanized records systems

Burroughs Corporation, Detroit, Michigan

IBM Corporation, Washington, D. C.

Automated Hospital Information Systems

Medi-Data, Incorporated, Charlotte, North Carolina

Kaiser Foundation, Oakland, California

Sanders Clini-Call under Development

Automated Multi-testing Facility

Presbyterian Hospital, San Francisco, California

Automated Patient Monitoring

Saint Mary's Hospital, Rochester, Minnesota

Automated Patient Monitoring

Latter Day Saints Hospital, Salt Lake City, Utah

Automated Hospital Information System

Loyola University Hospital, Chicago, Illinois

IBM-MISP Application

Saint Mary's Hospital, Saint Louis, Missouri

MEDELCO application

Downstate Hospital, New York, New York

THOMAS

El Camino Hospital, Sunnyvale, California

Lockheed, MISC application

National Data Communications, Dallas, Texas

Automated Hospital Information System

Presbyterian Hospital, Charlotte, North Carolina

Burrough's Corporation, Medi-Data Application

Spring Valley Medical Group, Washington, D. C.

Medi-Data Science Corporation, Multi-testing Application

Walter Reed General Hospital, Washington, D. C.

COMPSY Project

DeWitt Army Hospital, Fort Belvoir, Virginia

AMOS Project

Medicus Corporation, Dallas, Texas

AHIS Planning and Design

University of Vermont, Burlington, Vermont

Automation of Doctor Laurence Weed's POMR Concept

Beckman Instrument, Fullerton, California

Patient Monitoring

Texas Institute of Rehabilitation and Research, Houston, Texas

Automated Patient Record System

Tulane University, New Orleans, Louisiana

J. Balintfy's Computer Assisted Menu Planning

Touro Infirmary, New Orleans, Louisiana

Predictive Nurse Staff Utilization Model

Information on additional hardware was provided by manufacturer's representatives from the following companies who visited the Westinghouse Research and Development Center:

Medelco Incorporated, Wood-Dale, Illinois

T.H.I.S

Medical Electronics Division, Hewlett Packard, Waltham, Massachusetts

Patient Monitoring Equipment

Medidata Sciences, Incorporated, Waltham, Massachusetts

Automated Multi-testing Facilities

Health Auto-Data Incorporated, Rockville, Maryland

Automated Multi-testing Facilities

Honeywell Corporation, Washington, D. C.

Hospital Automated Accounting System

We also compiled extensive bibliographies for both communications and data management which are included at the end of this section. Few books were available in this tightly defined area of interest, but conversely, recent articles (less than two years) and reports generated by government contracts contained valuable information. The Clearinghouse for Scientific and Technical Information proved to be an excellent tool for screening documents of this type. Each of its biweekly indexes was scanned against a keyword to locate documents of interest. A microfilm copy of each document was ordered for appropriate study team members.

STATE OF THE ART

The many communications and data management improvement alternatives should complement each other to fulfill system needs. When planning a new Base Level Health Care System, the following questions must be considered:

1. How can improvements enable medical, medical support, administrative, and administrative support personnel to use their time more efficiently and effectively? How can their routine clerical tasks be reduced or even eliminated?
2. How can patient status data be best determined?
3. How can patient history be quickly recorded without consuming professional time?
4. How can data reliability be improved and monitored?
5. How can the patient most easily and quickly communicate with the nurse?
6. How can data files be organized, enabling many diverse functions within the system to share common segments?
7. How can laboratory test results be displayed more quickly?
8. How can costs be best accumulated and displayed?
9. What is the expected volume and frequency of information flow between any two activities?
10. How will computerized techniques affect system planning, construction, maintenance, and training?
11. How can data management storage, retrieval, and display techniques be improved to aid medical diagnoses?

The general objective of the communication and data management function is to increase facilities and personnel efficiency in order to decrease health care costs while improving or maintaining the current quality of care. To accomplish this, the general trends are:

1. To improve the use of computer technology in every facet of preventive medicine and health care.
2. To reduce clerical work by facilitating data input, retrieval, and display of patient and resource management data.
3. To provide the capability for source data collection.
4. To speed data transmission electronically.
5. To increase data reliability and accuracy by employing electronic monitoring devices to identify data which varies from normal set parameters.
6. To expand available statistical data to include diagnostic data useful in analyzing a patient's condition based on statistical norms.
7. To accumulate reliable cost data per patient and per unit of work which can be used for budget comparisons.
8. To maintain status records for each patient and available bed to aid admissions, housekeeping, and dietary activities.
9. To establish national resource centers where specialized information can be stored and be readily available to hospitals equipped with proper communication devices.

To organize the large volume of data available on information handling, we have divided our discussion somewhat arbitrarily into communications and data management. Communications indicates a direct point-to-point transfer of information. Data management concerns information that undergoes additional processes, such as storage and retrieval, often via computer. In the advanced technology section, which deals with concepts, procedures, or equipment that will be available only after 1972, communications and data management are treated jointly.

## STATE OF THE ART--COMMUNICATIONS

Several communication improvement alternatives are not reported in this document because they are commonly used and well known, for example, messengers, U. S. Government mail, private mail, public address, motion pictures, and the telephone.

Other communications components and improvement alternatives, more advanced because of new equipment, concepts, or uses, can be broadly grouped into six categories: teletype, intercom, paging, telewriters and facsimile equipment, closed-circuit television, and microfilm.

Coordination of information within the function and with other functions is a characteristic shared by all the improvement alternatives studied. For example, touch-tone telephones and teletypes can be used for data input; teletypes can also be used for data display; special closed-circuit television can be used for input and display; data phones and couplers connect computers to conventional telephone lines so hospital personnel can "converse" with the computer; and newly developed general computer terminals with magnetic tape storage vastly expand input and display capabilities and flexibility.

The following material gives a brief description of the six improvement alternative areas, emphasizing how each can partially fulfill the needs of the BLHC System within the general trend parameters.

1. Teletype can establish communications between hospitals, between remote health care facilities and the hospital, or within the hospital. It is extremely useful for data transfer when hard copy is needed to provide permanent records.

More recently teletype has been used as a remote computer terminal for data input to large time-shared computers or to small special purpose computers within the hospital. The teletype/computer combination can be used to process laboratory data, store patient's history and automate patient history taking, and perform many other storage, transmission, and retrieval activities.

2. Intercom improvement alternatives are available in a wide range of types and sizes, all of which provide two-way communications

and can handle several simultaneous messages. Intercoms, used largely for private conversations between patient and nurse, can greatly increase the nurse's efficiency by reducing unnecessary travel between her station and the patient's bed. Optional features include devices to store patient calls received when the nurse is away from her post and devices to integrate intercoms with other improvement alternatives such as closed-circuit television.

Options available on highly sophisticated intercoms can extend their usefulness to all hospital operations. One option effectively ties in all internal telephone communications to eliminate the standard telephone for internal communications.

3. Paging has come a long way from the simple loudspeaker broadcasting randomly within wide areas of the hospital. Today, radio paging and Alpha Numeric Display paging offer advantages over conventional paging methods and eliminate distractions and annoying background noises.

Radio paging transmits a coded signal to a miniature receiver carried by key personnel. When the person is needed, only his receiver gives a signal and he telephones a specific number for his message.

Alpha Numeric Display paging uses a standard TV screen to display all active pages. Urgent or long-standing pages can be put on a special blinking sequence.

4. Telewriters and Facsimile Equipment transmit hard copy over closed-circuit wire, standard telephone lines, or microwave. The telewriter instantaneously transmits information in the sender's own handwriting. The message is written on a sender unit and received immediately on a receiver unit; the method is useful to all hospital operations. For example, admissions and discharge information can be instantly transmitted to key hospital areas; drugs can be prescribed in the doctor's own handwriting without the doctor going to the pharmacy or making duplicate prescriptions which the nurse must have filled; the kitchen can be

notified of diet changes. These documents must be filed with the patient's medical records.

Facsimile equipment can transmit any form of hard copy from one location to another. The received data is an exact duplicate of the original. Facsimile senders can be used for transmitting hard copy data such as patient history, status, and diagnosis; requisitioning supplies; providing blueprints for maintenance; and updating manuals between a major medical facility and a satellite facility. Some facsimile equipment requires coupling with data-phone sets; recent models include a telephone acoustic coupler,

5. Closed-circuit Television (CCTV) can be subdivided into minimum, medium, and high performance improvement alternatives, and improvement alternatives used for special applications.

Minimum performance CCTV and videotape can be used for security surveillance because circuit design cannot produce more than a 4 $MH_z$ bandwidth. Its use can eliminate most guard stations inside and outside of the hospital and allow one central guard to service the entire facility.

Medium performance CCTV, either color or black and white, can be used for security and for monitoring patients in such areas as the ICU and CCU. A television display for each patient may be placed beside the remote heart-rate display at the head nursing station, permitting continuous visual monitoring of all beds. CCTV is also a valuable adjunct to physiological monitoring. When a patient's heart-rate alarm is triggered, the nurse can immediately determine if an emergency has developed or if the alarm was activated by normal body movement.

In addition, medium performance CCTV can significantly advance personnel training levels. Video tapes, customized to each hospital's operating methods, can be made in-house for teaching repetitive tasks and can be played as needed to indoctrinate new personnel.

High performance CCTV produces high resolution pictures which may be necessary in more sophisticated medical and medical support uses.

Isotope scans can be transmitted from one location to another, X-rays can also be communicated to a remotely located radiologist, intricate surgery in confined areas can be displayed for physician training.

Special application CCTV equipment includes equipment such as the Westinghouse Secondary Emission Conduction Camera Tube which is 100 times more sensitive to light than the standard CCTV vidicon. With minimal lighting, this camera produces pictures equal in quality to those of a standard camera with proper lighting and is applicable for surveillance viewing and patient monitoring in darkened areas.

Another CCTV special application device is the video disk, a metallic disk capable of magnetically recording still images, storing, and displaying them with higher resolution than conventional methods. The disk's flexibility allows it to record two pictures in a given sequence, electronically subtract them, and display only those portions needed; or it can highlight particular gray shadings for reliable X-ray interpretation.

The video disk has many important uses in medical and medical support operations, such as improving picture fidelity for remote X-ray viewing, color pathology and bacteriology display, and rapid data and picture transmission from pathology or radiology to surgery.

6. Microfilm components can be used to store, retrieve, and remotely display data. Microfilm improvement alternatives vary from those capable of storing less than 73,000 pages, photographed on 16 mm film and without data transmission capabilities, to those capable of storing 25 million 8-1/2" by 11" documents in a cart about the size of an executive desk and capable of almost instantaneous retrieval and transmission to a video screen. In addition COM (Computer Output Microfilm) equipment permits today's computers to directly generate microfilm without creating paper copy.

Microfilm can be used in all hospital operations. The doctor can use it to store abstracts of technical articles; the clinical laboratory can use it to store records; administrative support personnel can use it for maintaining records; and the administrator can use it to store financial records. Retrieval and transmission of stored data can be manual or automatic depending upon the improvement alternative selected.

Video File has functions and uses identical to microfilm, but stores documents on video tape rather than 16 mm film. The document to be stored is merely placed under a TV camera for 1/15 second, and electronically scanned and stored for very rapid retrieval. Optional hard copy prints are available. Data is stored in extremely high density and space requirements are consequently reduced.

Options available for microfilm or video storage equipment allow data input from remotely located keyboards or cathode ray tube (CRT) terminals. Another option allows data display on remote CRTs or Teletypes.

## STATE OF THE ART--DATA MANAGEMENT

All improvement alternatives considered include computers and computer-related hardware and software packages which, when coordinated, fulfill one or more data-management needs. To facilitate this discussion, improvement alternatives have been categorized as follows:

1. Multi-purpose Intra-hospital Capabilities--broad in scope and can possibly be expanded to cover hospital information networks.
2. Clinical Laboratory Test Data Analysis--emphasizes data collection, storage, and analysis of clinical laboratory data used for medical diagnosis.
3. Computerized Accounting--designed to assist administrative personnel maintain accurate and current cost data.
4. Patient Data Information Network--transmits patient status data among selected hospital departments.
5. Diagnostic Support--emphasizes patient history data which assists the physician in diagnostic decision making.

1. Multi-purpose Intra-hospital Capabilities

a. National Data Communications Corporation's Real-time Electronic Access Communications for Hospitals (REACH) System is a totally integrated communication and data management network system which allows direct access to the computerized data base via a specially designed cathode ray tube (CRT).

A user identification card in conjunction with twenty function keys located at the left of the CRT screen allows the physician, nurse, or technician to select standard phrases which can be stored in the patient's record. If required, a pharmacy label will simultaneously be printed in the pharmacy. Most medical or administrative data can be handled by the programmed statements that appear on the CRT screen. Used in conjunction with a standard typewriter keyboard the function keys can enter information such as pre-admission scheduling of ancillary services, patient accounting, or narrative medical data into the system. Nurse's notes, doctor's orders, patient history, and narrative progress notes can be typed into the patient record by typists or ward clerks. Alternatively, structured phrases or programmed text can be entered by the physician or nurse.

The REACH software is proprietary to the National Data Communications Corporation and is provided to a hospital as a utility, together with a complete operations and maintenance staff. Limited batch processing is performed in the user hospital on the system's Honeywell 516 computers which can handle up to 40 CRT terminals per central processor. Additional computer processing is performed in the Regional Center in Dallas, Texas, on Honeywell 1200 computers. The REACH service includes a computer-output-microfilm of major administrative reports and medical records of discharged patients.

b. The IBM Corporation's Medical Information System Processor (MISP) is the most widely used hospital information system today. The MISP package, which requires a 32K core memory, is an executive control program capable of providing message switching and a communication network from remote terminals on a real-time basis. MISP is designed for DOS and OS and is programmed for both the IBM 360/20/30 series of computers and larger systems. It is currently operating on Models 30, 40 and 50. Application programs such as the shared hospital accounting system are available from IBM and from the Hospital Information System Sharing Group, Inc. The Sharing Group company is a nonprofit group of IBM System users that have agreed to exchange application programs and experience.

Data entry and output are primarily from IBM 1092/1093 programmed keyboards and the 1052 typewriter. Other input/output components of the IBM/MISP system are the split screen optical image device which shows fixed data projected from a 16 millimeter film strip cartridge on the right side and transparent overlays on the left. The operator communicates with the computer using a light-sensitive probe to touch the appropriate information displayed on either the left or right or both sides of the screen. A CRT (model 2260), with or without light-pen device, is available and is in use at several locations for admissions procedures and rapid file access applications.

The goal of the MISP is to provide a framework which allows each hospital to write programs and tailor the system to its individual needs. In combination with user programs, MISP accepts doctor's orders for patient treatment, requests for laboratory analysis, laboratory results, and other items of information entered at the terminals located in each area of the hospital. This information is stored in the central files of the computer. From the central files, schedules are printed, appointments are scheduled and accounted for, patient data is printed, and necessary messages and reports are prepared and transmitted. Current patient information maintained in the central files is available to each hospital functional area, usually the nursing station.

Use of the system for preparing medication schedules and shift change reports can reduce clerical tasks. Each order can be positively verified in printed form before acceptance by the system, and routine procedures are automatically charged by the system. Periodic summaries of patient activity and test results, and service area workload schedules are prepared.

Data for administrative reports is a by-product of day-to-day system activity. This data can be used to help increase hospital efficiency, provide greater cash flow, and keep management informed on utilization of facilities.

c. The On-line Medi-data System of Burroughs Corporation is a totally time-shared concept capable of serving 1500 beds in multiple locations. The distinction of the Burroughs System is that the user can directly interface with the central files by a CRT in conjunction with a typewriter keyboard. There may be up to 250 terminals. However, all remote teletypes (RO35) are controlled by a small computer (B300) located at a remote hospital which interfaces with the central data processing facility. The central facility has three maximum core capacity Burroughs 5500 computers. The Burroughs' concept maintains the hand-written doctor's orders and patient history. A specially trained terminal operator (ward clerk) may enter all orders and results into the CRT terminal; expanded orders are immediately printed.

Departmental work schedules, statistical logs or test results, patient bills, and administration reports are available through an information retrieval program at each CRT terminal. Results of work done by auxiliary services, such as test results, are transmitted to the central computer facility and redirected to the appropriate nursing station where the printout is manually inserted into the patient's chart.

The major advantage of the "On-line Medi-data System" is that remote sites can use large scale computers.

d. Sanders Associates' CLINI-CALL Hospital Information System integrates three major subsystems for business accounting, medical data management, and laboratory data management. For maximum reliability and minimum response time, CRT terminals with hard copy printers (up to 50 per central processing unit), and all peripheral devices are "hardwired" to Honeywell 516 and 416 main frame computers.

Formatted messages must be complete before being transmitted to appropriate departments for record storage. Data is inputted via a photo-pen device which is used to select standard phrases or words or by using the keyboard associated with each CRT terminal. The terminal also has two read stations for pre-punched plastic cards, one for user ID and one for patient ID. The processor files, looks up, sorts, posts, summarizes and routes all data. Computer checks can be made on drug requests and other ancillary services against a stored list of normal limits, patient histories, and other established parameters using Sanders programming language.

The business accounting subsystem handles the routine administrative services such as accounting, payroll, inventory, control, and general ledgers.

The medical data management subsystem provides the source data collection for admissions, physician orders, test results, and diet requests. All operations are interlocked to prevent orders or information from being released without proper approval or verification. Message routing, queuing, and storage retrieval functions are handled automatically by the system's processor.

The laboratory data management subsystem uses the common data base of the total system for maximum efficiency. This subsystem relieves the technicians of the posting, recording, and verifying of test results in hand-written logs and worksheets, it converts laboratory requests into patient's incomplete worksheet files, specimen collection lists by ward and patient, special labels, worksheets for various laboratory sites, specimen load verification, and printouts of all test results.

e. The Lockheed Space and Missile Company's Medical Information System (MIS-I) is a centralized medical data service center that provides hospitals within a 50 mile radius with natural language interactive CRT terminals with a light sensing pen and typewriter keyboard. The Lockheed System, which can serve up to 2400 beds, combines the time-sharing concept previously discussed in the Burroughs System with the rapid access to the time-shared 360/40 computer by all system users. A distinct advantage of the MIS-I is the efficient data formulation and review procedure for physicians at the CRT terminals. Quiet inktronic print terminals manufactured by A.B. Dick Company are available. System operation is very similar to that of REACH, Medi-Data, and Sanders' Systems, a major difference being that local printers are available at each nursing station. This is especially advantageous since nursing stations prepare numerous reports for patient and administrative management including:

Discharge Summary
24-Hour Summary
Shift Summary
Admitting Record
Medications Due List
Bed Status Report
Transfer Notice
New Medical Orders
Admitting Notice
Requisitions
Test Results
Discharge Notice
Diet Orders
Specimen Pickup List
Correction and Cancellation Notices
Other Miscellaneous Summaries and Worksheets.

f. The MEDELCO Improvement Alternative (T.H.I.S.) is used primarily as a data input and transmission device, rather than for data retrieval. Card readers feed data from coded, pre-punched cards into the main central processor. The central processor then sorts the data and instantly transmits it to appropriate print terminal locations throughout the hospital. Charges are generated in a daily batch output compatible with most computer systems. For example, to schedule a patient for radiology, a nurse would place the patient's identification card and card-punched instructions to radiology in the card reader at the nursing station. Information is printed at the nursing station for verification and simultaneously transmitted to radiology for scheduling. Other messages initiated by this same action would include transmitting diet change information to the kitchen, and calculating patient charges which are stored in the central processor until the end of the day. Scheduling beds or clinic appointments are examples of other general communications needs that can be programmed into the MEDELCO hardware.

Although considerably less expensive, the MEDELCO system has serious limitations when compared with the systems described above. It does, however, provide an alternative to the BLHC system for the process identification of work procedures in the various ancillary service areas, and the scheduling capability provides a workload leveling tool.

## 2. Clinical Laboratory Test Data Analysis

a. The automated clinical laboratory system of the Diversified Numeric Applications (DNA -- a division of AVCO) provides a dedicated laboratory computer that accepts analog or digital output from the auto-analyzer and other laboratory equipment. The system automatically monitors laboratory analysis; handles remote inquiries; prepares task lists, results, reports, billing reports, cumulative chart reports, and other statistical reports. Special keyboards are tailored to each laboratory section for easier sample identification and rapid input of test results. The multi-programmed real-time, random access turnkey concept can maintain patient laboratory test results for remote retrieval for at least seven days.

b. The Berkeley Scientific Laboratories "Clinidata Mark II" is supplied in ten modular levels to fit the needs of different laboratories. The Berkeley System uses a PDP central processor and Veridata consoles and operates in a manner similar to the DNA System described above. It does not, however, have the capability to store patient data for access from remote terminals. A unique feature of Clinidata Mark II is the digital voltmeter plug-in for the laboratory console which will convert the analog signal directly from a laboratory device to a digital signal and feed the results into the main data register of the data input console. After an operator has examined the input and verified the data are correct, the data are transmitted from the console to the computer by depressing the send button. A complete patient report is printed out or teletyped within 15 seconds of completion of the last test on that patient.

Additional dedicated clinical laboratory test data analysis systems were examined such as the Spear 'CLAS', the EAI "PACE III", Digital Equipment Corporation's "LINC 8", and the Varian/Cary Spectro-Systems 100/200. Operationally, these systems are similar to the DNA and Berkeley systems described above. Variations consist of operational programs to accept on-line input from gas chromatograph, mass spectrometers and discrete chemical analyzers (other than Technicon's Autoanalyzer).

3. Computerized Accounting

The computerized accounting components are discussed collectively since each performs in basically the same way with only minor differences in procedures and output. The major manufacturers and their software acronyms are:

- International Business Machines - Shares Hospital Accounting Systems (SHAS)
- Burroughs Corporation - Burroughs Hospital Administrative System (BHAS)

- Control Data Corporation - MEDICOST
- Honeywell - Hospital Computer Sharing System (HCSS)
- National Cash Register - Hospital Accounting Package
- General Electric - MEDINET

Numerous banks and computer service centers use the computer hardware of a major manufacturer in conjunction with individually designed software to provide accounting, billing, inventory, ancillary statistics, cost reporting, payroll and miscellaneous administrative reporting services. Most systems are batch made operations with limited on-line capability. IBM, Burroughs, and Honeywell offer shared system packages capable of handling 2000 beds upward.

4. <u>Patient Data Information Network</u>

a. <u>The ITT-Standard Radio System</u> stores and displays at specified intervals or continuously only patient status data affecting the patient's condition. Data is fed into the computer via remote touch-tone telephone or keyboard, stored, and can be instantaneously retrieved and displayed at any remote CRT location. Graphs, laboratory reports, test results, and other patient data are transmitted among intensive care units, operating feeder laboratories, nurses' offices, head physician's office, the X-ray consultation room, and other selected locations. The most critical data requirements are computerized first, making the routine data handling automation a secondary effort. The system has the capability of expanding to a total information system, and long range plans to integrate the system with the National Medical Information System are presently under development at the Danyard Hospital in Stockholm County, Sweden.

Similar projects with a more limited approach in data communication but directed at computer analysis of monitored patient physiology such as vital signs, atrial and arterial blood pressure, and cardiac output are in advanced stages of research at Saint Mary's Hospital in Rochester, Minnesota, University Hospital, Birmingham, Alabama, Presbyterian Hospital, San Francisco, and Latter Day Saints Hospital in Salt Lake City.

Relatively simple patient information systems that routinely collect and store selected patient data are emerging at various hospitals. The National System in Sweden is building a medical data base from the census data already available in machine processable form. Additional data elements will be previous hospital stays, allergies, and immunization data. Patient status within the hospital is readily available from systems such as the Edstan wireless bed status system or the bed availability system with Bunker-Ramo CRT's in use at Children's Hospital of Boston.

5. Diagnostic Support

The Medidata Sciences Concept for patient history taking uses a display unit which has carousel slides coupled to a PDP 8 computer. Patient questionnaires are programmed so that comprehensive histories can be taken quickly and without requiring professional personnel. Up to 100 patients can be processed through the system in eight hours. An 80-slide carousel projects images which carry four pages of questions. The carousel is controlled by the PDP 8 in response to the patient pushing one of four selection buttons on the screen panel. The SADE manufactured by Biomedical Computer, Inc., is a similar history-taking device.

Time shared programs are becoming available in certain specialties that allow the physician to input systems and diagnostic probabilities to the computer which then generates the most likely diagnosis.

No single system is currently capable of handling all data management problems from patient monitoring to supply management. However, research projects and some operational endeavors are developing in every facet of data management. The only computer applications that will satisfy the comprehensive requirements of the military medical environment are those currently in use or those developed with military sponsorship.

The only exceptions to this would be a few direct patient care applications such as patient monitoring subsystems or the on-line analysis of clinical laboratory test. Even here, a total hospital data management system would require special integration, if adequate priority is to be given segments which place an extremely high priority in a time-shared environment.

## ADVANCED TECHNOLOGY

The ideal collection of advanced technological data would include interviewing "all" designers, potential users, and company representatives to find out where they feel their industry was going in the future. The performance of such a task, however, is beyond the scope of this contract. Since a study of 85 hardware and software companies* of data processing exists, we opted to use this report as our research source. From this excellent industry forecast 87 key items were selected because of their potential impact in the medical area. The items have been arranged chronologically rather than by product category as originally presented, and are listed below.

*Washington, D.C.: Naval Supply Systems Command, Research and Development Division, January, 1969.

## ADVANCED TECHNOLOGY
## COMMUNICATIONS AND DATA MANAGEMENT

| CONCEPT | WIDESPREAD APPLICATION |
|---|---|
| 1. "Smart" terminals will be developed to permit most of the computing and processing to be done in the terminal (going over a communications line to a larger computer only when necessary) to minimize communications costs. | 1970 |
| 2. Hard-copy devices (known as first-generation types) such as teletypewriters, electric typewriters, and high-speed printers will continue to have a cost advantage (probability decrease with time). | 1970 |
| 3. A solid state vidicon will be available. | 1971 |
| 4. Modern speeds of: | |
| (1) 7200 bps data transmission reliably performed on voice grade (nominal 3kHz) lines. | 1972 |
| (2) 9600 bps data transmission reliably performed on voice grade lines. | 1973 |
| (3) 12,000 bps data transmission reliably performed on voice grade lines. | 1975 |
| 5. Desk top, low-cost, manually operated data communication terminals using DDD network will be commonplace. | 1972 |
| 6. Soft-copy, e.g., cathode ray tube (CRT) displays, known as second-generation equipment, will increase in use rapidly as they operate at electronic speeds. | 1972 |
| 7. In many system purchases, components will be obtained from different manufacturers, e.g., main frame from manufacturer A, memory from manufacturer B, peripherals from other manufacturers, etc. | 1972 |
| 8. Widespread use of LSI in processor circuitry. The cost of peripherals will become the major system cost. | 1973 |
| 9. TV-raster I/O devices will be a replacement for many direct CRT displays because of capability for accepting both digital and video (background data from optical storage) inputs. | 1973 |

ADVANCED TECHNOLOGY (cont'd.)

| CONCEPT | WIDESPREAD APPLICATION |
|---|---|
| 10. Mechanical laser scanners will be used to scan aperture cards for input to a computer. | 1973 |
| 11. Development of low-cost hard-copy adapters to be used in conjunction with electronic display devices (CRT's) with resolution equal to that of display devices and with printout time being less than 5 seconds (external) for displayed screen. | 1973 |
| 12. High resolution TV viewers will come into being, providing the flexibility of electronic magnification, variation and aspect ratio control to give a user a "universal" viewer for a wide variety of optical format microfilms. | 1973 |
| 13. Microfilm transmission to hard copy. | 1973 |
| 14. Touch Tone input to remote microfilm Retrieval Systems and graphic print out. | 1973 |
| 15. Universal punched card specification will be promulgated. | 1973 |
| 16. Low cost OCR reader (less than $20,000). | 1974 |
| 17. Sophisticated micro-electronics will permit design of very compact self-contained modular input terminals. | 1974 |
| 18. Microforms will become important input media. | 1974 |
| 19. Technology will develop the ability to "correct" microform images by erasing and reprinting on the same frame. (A camera from Pfaff is available to do this on Kalvar.) | 1974 |
| 20. Images may be added to blank spaces in microforms. | 1974 |
| 21. Combination of digital and photograph (e.g., microfilm) storage and retrieval techniques will become a significant field. | 1974 |
| 22. Microfilm recording systems will utilize instant photography. | 1974 |

| | CONCEPT | WIDESPREAD APPLICATION |
|---|---|---|
| 23. | Microfilm recording systems could utilize laser writing ability. | 1974 |
| 24. | A portable document copier will be in common use. | 1974 |
| 25. | High-speed, photosensitive, non-chemically developable paper for hard copy recording. | 1974 |
| 26. | The conversion of electrical signals to hard copy will be considerably improved by the availability of high power electro-optic transducers, and the development of electro-sensitive papers and other marking processes. | 1974 |
| 27. | Expanded use of private transmission systems; microwave; coaxial cable and wire for transmission within plant complexes/metropolitan areas. | 1974 |
| 28. | Pattern reader used commercially in medical field analysis (hospitals). | 1975 |
| 29. | Very cheap special purpose computers to solve specific data processing problems in standardized ways may be available. | 1975 |
| 30. | Computers able to "understand" and communicate in limited English may be available | 1975 |
| | (1) limited vocabulary of a few dozen words. | 1980 |
| | (2) a significantly enlarged vocabulary. | 1985 |
| 31. | Low cost computers less than $3,000/unit will be available using software to replace high cost arithmetic units in the CPU - eventually leading to portable - rugged units. | 1975 |
| 32. | The number of small computers put on-line scientific experiments will increase at a greater rate than the rest of the market. | 1975 |
| 33. | Plug-in jacks on some telephones will allow convenient portable use of digital communication devices at moderate speeds. | 1975 |

| | CONCEPT | WIDESPREAD APPLICATION |
|---|---|---|
| 34. | Voice answer-back from computer data base will find widespread use for simple inquiry-response systems using the touch-tone phone as a remote terminal. | 1975 |
| 35. | Standard television sets will come into substantial use as I/O terminals. | 1975 |
| 36. | Development of low-cost scan converters. | 1975 |
| 37. | A 3-color vidicon will be available, leading to relatively inexpensive color cameras. | 1975 |
| 38. | Inexpensive, high sensitivity vidicons for low light level applications will be available. | 1975 |
| 39. | Telephone coupled soft copy capability can be commonly used for information retrieval and presented to the individual viewer. | 1975 |
| 40. | Personal terminals which "simulate" routine activities of employees in functional departments (e.g., personnel, contract administration, pricing, etc.) so as to increase productivity of administrative work. | 1975 |
| 41. | Submicrosecond core memories will be available of 10 million ($10^7$ bits), costing 2.5 to 3 cents/bit. | 1975 |
| 42. | Holographic techniques will be utilized to store digital, or possibly even alpha-numeric information, as a main storage element in a computer. | 1975 |
| 43. | Use of laser beam recording on magnetic media for wide band analog and higher speed digital recording (50 megabit/sec.); increasing packing density by 10; improving access time by a factor of 10. | 1975 |
| 44. | The costs associated with card and perforated tape equipments may not be economical in the light of advances in such media as incremental magnetic tape recorders. | 1975 |

| CONCEPT | | WIDESPREAD APPLICATION |
|---|---|---|
| 45. | Information automatically retrieved aperture cards can be updated and rerecorded using computer aided operation on new records. Turn around time will be a few minutes. | 1975 |
| 46. | Development of software and languages necessary to permit close man-machine interaction and to facilitate use of display terminals by casual users rather than skilled operators. | 1975 |
| 47. | Development of OCR standards compatible with both upper- and lower-case characters. | 1975 |
| 48. | More logical functions will be incorporated into the hardware, thereby increasing hardware complexity, but reducing that of software. | 1976 |
| 49. | Solid state direct view display devices with selective erasure characteristics will be available. | 1976 |
| 50. | Film plotters will produce a finished aperture card in approximately 30 sec. | 1976 |
| 51. | Disc packs will take over a major portion of the magnetic tape market due to increased reliability and performance. | 1976 |
| 52. | Acoustically coupled peripheral devices (low cost, portable, and inexpensive) will be used for personal computation. Terminals may even be rented for short periods of time to be used in the home. | 1976 |
| 53. | It will be found in many cases that microfiche is a better medium than roll film for a particular application. A converter will be designed for converting from roll to microfiche. If a system in which this is used proves practicable, it is likely that this type of conversion may increase. Improved techniques and materials as well as equipment may make it entirely practical to go to high reductions satisfactorily and we will convert from one medium to another. Much of the conversion may come as a result of greater standardization of equipments and film formats. | 1976 |

| CONCEPT | WIDESPREAD APPLICATION |
|---|---|
| 54. Low-cost microfiche production equipment. | 1976 |
| 55. Light sensitive (ultra-violet and non-u-v) paper and film which does not require wet processing will be widely used for hard copy, etc. in quiet, non-impact, high speed, terminal and peripheral equipments. Some of the materials will have instant image formation and may require heat or light for fixing; other materials will require a dry auxiliary step for simultaneous latent image development and fixing. The materials will have wide grey scale range and high resolution. | 1976 |
| 56. Transmission charges based on distance and bit rate as well as time, i.e. based on data volume transferred. | 1976 |
| 57. Dial-a-document and remote delivery over low-cost line from automatic S & R Systems. Political action is required to make low-cost lines available. | 1976 |
| 58. Microform film sizes and types will be standardized, as well as product terms. 40X or 8 mm image will become predominant. | 1976 |
| 59. Optical character readers capable of automatically reading multifont characters (i.e., greater than 20 fonts) will be available. | 1977 |
| 60. Need for facsimile and OCR (Optical Character Readers) may be eliminated by use of dual-mode documents containing both digital, machine-readable, high density codes and conventional man readable printing. | 1977 |
| 61. Magnetic tape storage will decline in cost from millicent per bit to less than .1 millicent per bit. | 1977 |
| 62. Laser devices will be used as computer fixed storage. | 1977 |
| 63. Microform printers will be capable of printing in color. | 1977 |

ADVANCED TECHNOLOGY (cont'd.)

| | CONCEPT | WIDESPREAD APPLICATION |
|---|---|---|
| 64. | Natural syntax is badly suited to computer use because it requires sophisticated knowledge of context to resolve ambiguities. Restricted quasi-natural syntax is a likely precedent to natural syntax. | 1977 |
| 65. | Cheaper, smaller, and faster circuitry will permit more power at remote terminals tied to central systems. | 1978 |
| 66. | A flat TV tube providing reduced glare, will be available on the market at reduced cost. | 1978 |
| 67. | All TV circuitry will be microelectronic. | 1978 |
| 68. | Cost of high-speed operating storage will be 100 times less than in 1965. | 1978 |
| 69. | Cards will be substantially reduced as an input medium. | 1978 |
| 70. | Marriage of microforms with other information processing equipment will continue to increase the utility of microform from only a storage medium to a dynamic and important element in active current systems. | 1978 |
| 71. | 75% of all programs will be machine independent. Technically, this can be made feasible after a concerted effort to make the machine accept a different type of program. Politically and economically, this requires planned R&D and a purchasing effort that would force a complete change in the machine usage pattern. | 1978 |
| 72. | Processing of data directly into CRT for making of movies depicting solution of problem. | 1978 |
| 73. | Use of microforms in the home will be accelerated by merchandising in color microfiche catalogues read on home TV viewers. | 1978 |
| 74. | A comprehensive standardization program covering character sets and codes, input, output media, transmission control procedures, data elements and their codes. This will tend to reduce costs and tend to produce compatability of computers and terminal device. | 1978 |

| | CONCEPT | WIDESPREAD APPLICATION |
|---|---|---|
| 75. | Cheaper, smaller, and faster circuitry in CPU will permit greater parallelism (circuit redundancy), too expensive to contemplate today. | 1979 |
| 76. | A new class of machines available will be the information retrieval system. They will be characterized by very large memory requirements, and the ability to handle large memories including multiple peripheral systems. | 1979 |
| 77. | Large screen color television with laser beams and mechanical mirror scanning will be available. | 1979 |
| 78. | Laser-oriented memory and file storage. This type of memory opens new possibilities. Using the laser beam to interrogate mass random access memories, implemented as fixed arrays, would result in capacities of $10^9$ to $10^{10}$ bits at a cost of a few mills per bit. This opens up the possibility of combining file storage with operating memory for file-oriented logistics information systems. | 1979 |
| 79. | Widespread use of LSI for computer memories. | 1979 |
| 80. | Erasable mass storage units of $10^{10}$ bit capacity will have access times less than 10 milli-seconds and cost .1 millicent per bit. | 1979 |
| 81. | Increase in use of fluidic devices for certain control and logic functions, automatic, etc., will result in increased reliability, but will only have a negligible effect on speed. | 1980 |
| 82. | Holographic techniques may compete with and/or supersede the use of TV consoles for man/machine interface. | 1980 |
| 83. | Erasable mass storage units of $10^{13}$ bits capacity will have access times of less than 1 sec. and cost less than .1 mill/bit. | 1981 |
| 84. | There is an extremely great need for a revolutionary new type of microfilm reading device. It should be as easy or easier to use than a book, portable, and can be read leaning back in a chair. You should be able to take it to bed with you if you like. The system surrounding it should be one which will allow the user to carry with him, or have at his disposal, large amounts of information. | 1980 |

ADVANCED TECHNOLOGY (cont'd.)

| | CONCEPT | WIDESPREAD APPLICATION |
|---|---|---|
| 85. | The use of facsimile devices will increase to such an extent that scanners and printers may become common office equipment. | 1980 |
| 86. | Charges for use of public telephone network based on access (number of calls) rather than time and distance. | 1980 |
| 87. | Widespread production of motion picture and TV for both education and entertainment utilizing computers for both design and display. | 1980 |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: COMMUNICATION**
**COMPONENT: TELETYPE**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Teletype Model 33 (Teletype Corporation, Skokie, Illinois) | A bottom line standard-duty, send-receive page-printer set with an optional tape perforator and reader. Can be used for communication between hospital and satellite facility, as a terminal for remote time sharing and small dedicated computers, and to process clinical laboratory data. | $750 | 1. Gives continuous hard copy without an operator in attendance.<br>2. Its full duplex system can simultaneously send and receive separate information.<br>3. With tape perforator, messages can be prepared off line, eliminating use of telephone line connection. | 1. Noise suppressant measures are needed such as acoustical material or placement where operating noise will least affect other operations.<br>2. Requires installation of a telephone line capable of sending U.S. ACSII Code.<br>3. If used as computer terminal, printing speed is slow and characters and font styles are limited. |
| Teletype Model 35 (Teletype Corporation, Skokie, Illinois) | A heavy-duty machine with the same uses as model 33 above. | $2,560 | 1. Same as Model 33 above.<br>2. Extended trouble-free running time reduces maintenance. | 1. Same as Model 33 above. |
| Teletype Model 37 (Teletype Corporation, Skokie, Illinois) | Two to three times larger than the Model 33 above, it has several system options including two-color printout horizontal tabulation and upper and lower case letters. | $3,700 | 1. Same as Model 33 above.<br>2. Available options previously described make lab reports more accurate. | 1. Same as Model 33 above.<br>2. Requires more highly skilled operators. |
| Portacom PC8110 Teletype (Data Products, Inc., Woodland Hills, California) | Same as Model 33 but smaller – resembles standard typewriter. | $2,400 | 1. Same as Model 33 above.<br>2. Has built-in acoustic coupler that can be attached to any standard phone receiver. | 1. Same as Model 33 above. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: COMMUNICATION**
**COMPONENT: INTERCOM**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Mark II Intercom (Motorola) | Used for intra-hospital communication. | $280 to $320 per bed. | 1. Nurse can assign call priorities by each patient's condition<br>2. Options include:<br>a. nurse follower<br>b. stores the phone numbers of unanswered calls.<br>3. Solid state circuitry makes it highly reliable. | 1. As all intercom systems, cannot produce hard copy.<br>2. Intercom systems cannot positively identify receiver.<br>3. Cannot store content of unanswered calls. |
| Altecom 4000 Series (Altec, Inc.) | Intercom system which has options for expanding regular patient-nurse system to all internal hospital areas. | $230 per bed. | 1. Designed to eliminate costly internal communications by standard telephone. | 1. Conduit placement and other system necessities must be considered in expanding intercom facilities. |
| Hospital Interphone (Bell Telephone) | In addition to handling 40 patient-nurse calls, system has 4 central incoming lines. | $90 per month for main console and $4.50 per month per room, plus installation cost. | 1. Same as Mark II above. | 1. Same as Mark II above. |
| Pagemaster 500 (Bogen) | Radio paging system for communication with key personnel not reachable by intercom or standard paging system. Beep tone from receiver carried by individual means call in immediately for a message. | $1,700 (5 receivers) | 1. Offers unrestricted accessibility to key personnel. | 1. One-way communication only.<br>2. No hard copy message.<br>3. Improper antenna installation creates "dead" reception areas. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: COMMUNICATION**

**COMPONENT: PAGING**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Alpha Numeric Display<br>a. KDT-IA (Infoton)<br>b. WAND (Westinghouse) | A video paging system. Lights on display board blink to indicate urgent message. | a. Infoton (600 characters): $1,195.<br>b. WAND (320 characters): $5,000. | 1. Can replace a teletype.<br>2. Optional blinking character permits call out of significant information.<br>3. Information greater than one display frame can be shown consecutively.<br>4. Optional magnetic tape storage.<br>5. Output can be superimposed over conventional TV pictures. | 1. Unit's memory size limits number of characters which can be displayed. |
| **COMPONENT: TELEWRITERS AND FACSIMILE EQUIPMENT** | | | | |
| Touchtone Phone (Bell Telephone) | Excellent as a data entry tool to a computer. Has standard touchtone button configuration. | Service: $1.50 more per month per phone.<br>Card and auxiliary dialers, $2.50 per month.<br>Pad: $2.00 per month.<br>Automatic calling unit: $9.50 per month. | 1. Uniform and accurate data input increases reliability of computer output.<br>2. Offers rapid data transmission. | 1. Considerable planning time for installation needed.<br>2. Continual system monitoring necessary to prevent overloading. |
| Data Phones (Bell Telephone)<br>a. Series 100<br>b. Series 200<br>c. Series 100 | Enables computers to converse with terminal equipment over conventional phone lines. | Installation: $15 to $25.<br>Series 100: $8 per month.<br>Series 200: $10 per month.<br>Series 100: $30 per month. | 1. Eliminates need for special lines.<br>2. Devices can be placed wherever there is a phone and a 110 volt outlet. | 1. Device wired to phone line so is not portable. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: COMMUNICATION

COMPONENT: TELEWRITERS AND FACSIMILE EQUIPMENT

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Data Phone Series 600 (Bell Telephone) | Converts analog signal from one machine so it can be sent through a conventional telephone line and reconstructed at the other end. Transmits, for example, an ECG from emergency room to coronary care unit or nursing station. | Installation: $15 to $25. 603A sender: $12 per month. 603 receiver: $25 per month. | 1. Generates hard copy of analog signals at remote locations.<br>2. Can be connected to any analog signal-producing equipment. | 1. Coding of patient number and other medical data on ECG signal is cumbersome. |
| Telephone Couplers (Inter-continental Systems, Dura Division; Omnitec) | Smaller versions of the Bell data phone, they are not hard wired to telephone lines, but cradled in the phone's receiver to send and receive signals. | $125 to $550 for standard Dura (260, 300) and Omnitec (701, 702) models. Omnitec 703 with automatic answering capa-bilities: $900. Omnitec 805 with magnetic tape storage: $1,560. | 1. Same as Bell data phones.<br>2. Units are easily portable. | 1. Not significant. |
| Data Transferral Typewriter (Tele-autograph Corporation) | Comprised of a sender and receiver unit, it provides instantaneous transmission of information and instructions in the sender's own handwriting. | $2,000 for each unit; or lease at $25 per month for each unit. | 1. Does not require a trained operator.<br>2. Speeds transactions such as prescription filling, where proper authorization is necessary. | 1. Privileged information cannot be sent. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: COMMUNICATION**

**COMPONENT: TELEWRITERS AND FACSIMILE EQUIPMENT**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Facsimile System (Tele-autograph Corporation) | Transmits hard copy from one location to another by either standard phone lines, microwaves, or closed circuit terminal connections. Documents can be 8 1/2 in. wide and 400 ft. long and transmitted at 3 to 6 minutes per 8 1/2 in. by 11 in. page. Copies received are identical in all respects. The system has a resolution of 100 lines per inch. | $6,000; or lease for $230 per month. | 1. Provides hard copy.<br>2. Requires no special operator.<br>3. Transmits signatures so speeds authorization.<br>4. Sends messages faster than mail or messenger. | 1. Permits only one-way communication.<br>2. Privileged communication cannot be sent.<br>3. Handles only one message at a time.<br>4 Transmitting time is 6 minutes. |
| Facsimile (Xerox Corporation) | Same as Tele-autograph above. | $75 per month. | 1. Same as Tele-autograph.<br>2. Eliminates leasing of a Series 600 data phone, since it transmits hard copy without phone. | 1. Same as Tele-autograph. |

**COMPONENT: CLOSED CIRCUIT TELEVISION**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Closed Circuit Television — high performance equipment:<br>a. STV & STV 611X cameras (Westinghouse)<br>b. Model ST-3 camera (Diamond Power Corporation<br>c. Model CQF17-R monitor (Conrac) | This equipment provides excellent picture quality and high resolution of very small objects. Can transmit isotope scans with adequate picture fidelity from one hospital location to another as well as X-rays from cast or emergency room directly to the radiologist. | STV: $2,000;<br>STV 611X: $4,000.<br>Model ST-3: $1,900.<br>Model CQF17-R: $605. | 1. Can televise miniature surgery, such as eye and ear, which can be invaluable in educating nursing and medical students. | 1 Skilled camera operator needed. |

IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: COMMUNICATION
COMPONENT: CLOSED CIRCUIT TELEVISION

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Closed Circuit Television – medium performance equipment<br>a. Westinghouse<br>b. Raytheon | Designed for rugged 24-hour use, this equipment monitors patients in ICU areas and can be used in conjunction with physiological monitoring apparatus to determine a patient's condition. | Camera: $700 and up.<br>Monitors: $350 and up. | 1. Can be used as an educational tool.<br>2. Permits medical personnel to observe procedures without disturbing ICU patients or activities.<br>3. Its flexibility makes it easily interchangeable with other forms of closed circuit TV equipment. | Need to establish adequate lighting for TV cameras. |
| Closed Circuit Television – minimum performance equipment (Craig Panorama, Inc.) | Designed for surveillance only. | Camera Model 6102: $248.<br>Recorder Model 6401: $1,035.<br>Monitor Model 6201: $197. | 1. Equipment costs relatively low. | 1. Line resolution capability not great enough to reproduce very small objects.<br>2. Permits only one-way communication.<br>3. Produces no hard copy. |
| In-house Video Taping Equipment – Closed Circuit TV (Ampex Corporation) | Equipment for producing video tape of closed circuit TV broadcast for instructing medical and hospital personnel as well as new patients and their families. It includes a video tape recorder, TV tuner, 9 in. monitors, and cameras. | VR 7000: $2,500.<br>VR 7500: $4,350.<br>VR 500C: $5,300.<br>VR 7100: $5,945. | 1. Will lower teaching cost since an instructor needed only occasionally to answer special questions.<br>2. Tapes can be replayed.<br>3. Since made in-house, can reflect the particular hospital's individuality and thus may increase personnel understanding and performance. | 1. A TV studio will be required. |

IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: COMMUNICATION

COMPONENT: CLOSED CIRCUIT TELEVISION

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| In-house Video Tape Equipment — Alpha II (Diamond Power Corporation) | Same as Ampex above. | $9,975 | Same as Ampex above. | Same as Ampex above. |
| In-house Video Tape Equipment — WAVE (Westinghouse) | A complete TV system which, in addition to Ampex (above) includes an AM-FM phonograph and two mic inputs and is able to televise motion pictures, film strips, and 2 in. by 2 in. slides. | $17,000 | Same as Ampex above. | Same as Ampex above. |
| In-house Video Tape Equipment — Model 2020, Model 2970 (Bell and Howell) | Model 2020 is a portable, color video tape recorder. Model 2970 is a color TV camera with viewfinder. | Model 2020: $2,335.<br>Model 2970: $12,300. | 1. Same as Ampex above.<br>2. Color reproduction. | 1. Same as Ampex above. |
| In-house Video Tape Equipment (RCA) | Models PK701 and PK730 are color TV cameras. Model PFS710 is a color TV film system which includes a camera for use with a 16 mm sound projector plus a slide projector. All equipment is portable. | System for televising operations and cystoscopy: $25,000.<br>Model PK701: $6,500.<br>Model PK730: $9,800.<br>PFS710: $9,850. | 1. Same as Ampex above.<br>2. Color capability. | 1. Same as Ampex above. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: COMMUNICATION**

**COMPONENT: CLOSED CIRCUIT TELEVISION**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| STV-706 TV Camera — special equipment for C.C.T.V. (Westinghouse) | This camera can photograph in the dark with a 35 mm lens optics. Its Westinghouse-developed Secondary Electron Conduction Camera Tube is 100 times more sensitive than standard TV vidicon. | $4,000 | 1. Can monitor patients or provide security surveillance in the dark. | 1. Not significant. |
| Video Disk (Westinghouse; MVR Corporation) | An electronic device with a metallic disk on which still images can be magnetically recorded. Depending upon magentic head arrangements and procedures, it can record up to several hundred images. | $10,000 to $30,000 and up depending upon the system's sophistication. | 1. Is an extremely useful diagnostic tool for radiology.<br>2. Improves and speeds communications of X-rays, isotope scans, and slides.<br>3. Useful in training pathologists, bacteriologists, and radiologists. | 1. Cannot produce or store hard copy. |
| Motion Pictures (Eastman Kodak) | Primarily an educational tool. | Standard projector: $106.50. Model AV 256 TV projector: $725. Cameras: $239.50 to more than $650. | 1. Permits frame-by-frame replay and analysis of film and sound sections.<br>2. Skilled operators are not required. | 1. Only provides one-way communication.<br>2. Cannot update films. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: COMMUNICATION**
**COMPONENT: MICROFILM**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Microfilm — Computer Automated and Display (CARD) System (Houston Fearless) | A data storage system which uses microfilm exclusively. Itcan typically be used for storing clinical, maintenance, and financial records. | $3,485. Model 301 Printer System (the hard copy option): $5,000. | 1. Speeds access to individual documents — 4 seconds per retrieval.<br>2. File integrity is maintained since original records are out of the user's reach.<br>3. System can be interfaced with computer to select documents for viewing.<br>4. System files easily updated. | 1. Can store only about 100,000 documents.<br>2. Lack of remote viewing option necessitates duplication of data base for every terminal.<br>3. Since uses only microfilm, a suitable microfilm generating system is required. |
| Microfilm — System 410 (Mossler) | A system similar to the CARD System but with larger storage and remote viewing capacity. | $100,000 to $150,000. | 1. Same as CARD System above.<br>2. Stores about 20,000,000 8 1/2 in. by 11 in. documents with access time, 6 1/2 seconds.<br>3. Remote viewing eliminates need to duplicate data base for every terminal. | 1. Same as CARD disadvantage # 3.<br>2. Only 6 remote terminals can view simultaneously.<br>3. Once cards removed from system they must be manually returned to proper coded position. |
| TISAR System (Fotomen, Inc.) | A total information storage and retrieval system. It can be effectively used in Medical Records. | $125,000 for each data base module which stores 2,000,000 documents. $3,500 for each remote terminal. | 1. Offers access to data banks from any number of remote terminals.<br>2. Offers random access of documents.<br>3. Can store 25,000,000 documents.<br>4. Offers remote hard copies as an option.<br>5. Has a modular data base which allows easy expansion. | 1. Documents must be in the microfilm form — microfiche.<br>2. Same as CARD disadvantage # 3. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: COMMUNICATION**

**COMPONENT: MICROFILM**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Videofile (Ampex) | A storage-retrieval system with unique entry feature. TV camera photographs documents in 1/15 of a second for storage on video tape. | $300,000 to $750,000. | 1. Has high-density storage.<br>2. Storage capacity unlimited.<br>3. Makes updating files easy.<br>4. Provides hard copy printouts.<br>5. Each console has access to data base without disrupting operations of other remote consoles. | 1. Video tape may not be valid storage medium since it wears physically with each retrieval.<br>2. Remote consoles cannot interface with other TV systems within the hospital. |
| CRT Audio Tape/Keyboard/ Printer — Viatron System 21 (Viatron) | A system which can enter data via a keyboard, store data on Viatape cartridges, or communicate with a computer. | $39 per month. $4 for each Viatape cartridge. | 1. Has the greatest flexibility since it is a generalized terminal which can encompass all areas within the hospital. | 1. Only 80 of its total 320 characters can be used to enter data, limiting amount of information which can be displayed. |
| COM (Computer Output Microfilm) | A system which produces microfilm direct from a computer instead of paper copy. | Eastman Kodak KOM-90 - $117,000; typical system $50,000 to $150,000. | 1. No paper generated.<br>2. Faster than high speed printers. | 1. Costly - need high volume to justify.<br>2. May require purchase of different microfilm vendors. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: DATA MANAGEMENT**
**COMPONENT: MULTI-PURPOSE HOSPITAL INFORMATION NETWORKS**

| Name | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| REACH, National Data Communications Corp. | A time shared intra-hospital communication and data management system, with data input via a Raytheon CRT, a standard keyboard, and 20 selection buttons. The CRT has a special card reader system to identify the system user and provide system security. Two Honeywell 516 computers are located within the hospital for some batch processing and all real-time applications. The major accounting functions are performed on a Honeywell 1200 computer which also provides C-O-M for major reports and patient records. | Approx. $8.00 per bed per day. | 1. Completely computerizes patient records.<br>2. Reduces clerical workload for all staff members.<br>3. All patient charges or workload procedures captured when originally recorded.<br>4. Can schedule all ancillary services.<br>5. Very rapid response in CRT (less than .5 sec).<br>6. Data recording is concise and accurate.<br>7. Better cost control.<br>8. Patients records immediately available at all CRT locations. | 1. Input procedure through CRT is cumbersome.<br>2. Printer on nursing units noisy.<br>3. All entries for medications must be recorded on hard copy and later entered into the system.<br>4. Physician not happy with input methodology. |
| MISP, IBM Corp. | MISP is an executive software package that provides the communication network for the IBM-1050 terminals. The 1050 terminal complex inputs data from a multiple-keyboard, typewriter keyboard, or CRT terminal. MISP can operate under IBM DS or DOS on the IBM 360/30 computer or larger models. User application packages are available from IBM or from other user facilities including the IBM-SHAS program. | $3.00 per bed per day. | 1. Provides the message switching capability for intra-hospital communications.<br>2. Better patient scheduling.<br>3. More concise procedure and accurate reporting.<br>4. Better cost control. | 1. Desk space required for terminals.<br>2. More time required for recording data at source collection point.<br>3. Difficult to make corrections on erroneous entries.<br>4. No system security presently available.<br>5. Professional staff not freely accepting keyed input.<br>6. Highly trained staff must be available for system maintenance. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: DATA MANAGEMENT**
**COMPONENT: MULTI-PURPOSE HOSPITAL INFORMATION NETWORKS**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Medi-Data, Burroughs Corporation | The Medi-Data system is a centralized time shared system under development by four hospitals and Burroughs Corp. Each hospital has a B300 computer to handle all RO33's and sufficient CRT's on-time to the central CPU (three B5500) via high grade telephone lines. Source data which includes all patient admission service charges, and discharge summaries enter the system through the CRT by a special input clerk who keys in specific codes and narrative data. | Approx. $7.50 per patient day. | 1. Concise and accurate reporting format.<br>2. Data storage and retrieval is rapid.<br>3. Better cost control.<br>4. Patient accounting data immediately available. | 1. Special codes must be used with all data entry.<br>2. Special data input clerks must enter all data.<br>3. Scheduling of ancillary services not currently available.<br>4. System does not interface with purchasing and inventory control.<br>5. CRT response time slow (greater than 1 second). |
| Clini-Call, Sanders Associates | A total hospital information network which can extend to any hospital area, i.e., admissions, wards, surgery, pharmacy, dietary, laboratories, accounting, and administrative offices. Clini-Call can store, retrieve, route, sort, and check data and provides patient medical histories, current medical records, statistical summaries, and legal reports. Data input is via a light pen which selects data from a CRT screen. | $1,500,000 300-bed.<br>$3,000,000 600-bed. | 1. Schedules medical tests.<br>2. Maintains inventories of bids and supplies.<br>3. Show an indated status of mail orders and accounting. | 1. The computer and/or computer magnetic tape is its sole storage medium; memory requirements will skyrocket. Older medical records could be put on microfilm via (COM) techniques; however, microfilm is incompatible with Clini-Call's display concept. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: DATA MANAGEMENT**
**COMPONENT: MULTI-PURPOSE HOSPITAL INFORMATION NETWORKS**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| MIS-1, Lockheed | A time-shared multi-hospital system design to handle up to 2000 beds with limited outpatients. The primary input/output terminal consists of a computer communication, including T.V. terminals with special light-pen device and the A.B. Dick Co. inktronic printer. The system is designed as a communication vehicle for all patient lists and services. Charges are generated on a daily basis and batch processed. The hospitals are linked to the central computers (2 IBM 360/40) via separate high grade telephone lines. | \$2,000/mo. for 440 beds. | 1. Reduces clerical workload for recording test requests and results.<br>2. Full duplication of hardware decrease down-time.<br>3. Patient charges are all recorded when services are rendered.<br>4. Message composite on video terminal fast and easy.<br>5. Essential patient data immediately available. | 1. Central power failure at computer center knocks out all facilities.<br>2. System is not designed to handle all medical information.<br>3. No scheduling of services available.<br>4. No inventory control available. |
| Medelco T.H.I.S. | Medelco is a communications tool and not a mass data storage device. Data input is through punched coded cards and data output is displayed on a teletypewriter. Medelco interfaces with and communicates to all hospital operations. | \$350,000 to \$400,000 250-bed hospital.<br>\$450,000 to \$500,000 500-bed hospital.<br>\$550,000 to \$750,000 750-bed hospital.<br>Can be leased for: \$8-9,000/month 250-bed hospital.<br>\$11-12,000/month 500-bed hospital.<br>\$14-15,000/month 750-bed hospital. | 1. Can calculate patient charges and schedule beds as well as departments.<br>2. Will communicate among all hospital departments. | 1. Does not attempt to store department or patient medical records.<br>2. Use of cards for data input requires continued card updating.<br>3. Cards must be returned to proper location after use. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: DATA MANAGEMENT**
**COMPONENT: CLINICAL LABORATORY TEST DATA ANALYSIS**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Automated Clinical Laboratory System, DNA | A customized hardware/software package to monitor laboratory test equipment and print specimen labels, job task lists, floor reports, billing reports, and other statistical reports. Using a 4K 16 bit word Raytheon 703 computer, special programs are available for interface to most laboratory analog or digital output equipment and individualized lab work station terminals. The multiprogrammed system will retain patient laboratory results for up to seven days. | $170,000 for 250 beds or more. | 1. Customized data input terminal for each laboratory section.<br>2. Easily interfaced with central accounting systems. | 1. Terminals require counter space in laboratory.<br>2. Results are recorded twice - once on worksheet and again into terminal.<br>3. Limited maintenance available. |
| Clinidata Mark II, Berkley Scientific Laboratories BSL | To reduce clerical work associated with the clinical laboratory, BSL uses the Veridata 300 or 400 input consoles interfaced to a PDP computer. The lab technician enters data by keying in 7 digits for ID purposes, 3 for test ID, and 4 for specimen ID. Test results use up to 7 digits. Results enter the computer directly from the automated laboratory analysis device or are keyed in by the technician for manual test. Teletypewriters are used for generation of worksheets and patient reports. The central processor analyzes throughput of chart recorders including sensing peak readings, correcting for basic drift, detecting sample interaction, and calculating value concentrations. | Not available. | 1. Expanded throughput can be accomplished easily by adding consoles and controllers.<br>2. Results of test can be printed on ward or clinic within 15 seconds of completion of test.<br>3. Stat test can over-ride Bates procedures.<br>4. Summary sheet of patient data tabulated weekly.<br>5. System can schedule workload. | 1. Terminal space required in laboratory and on work cabinets.<br>2. Computer required in immediate area.<br>3. Maintenance of sophisticated equipment not readily available. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION:** DATA MANAGEMENT
**COMPONENT:** CLINICAL LABORATORY TEST DATA ANALYSIS

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| CLAS, Spear | A hardware/software package which handles analog or digital signals from all laboratory equipment. The package works in a time-shared mode to handle on-line testing equipment and prepares work sheets and other tasks simultaneously. It can handle video display and teletype terminals. | $80,000 for a 475-bed hospital. | 1. Fewer errors in laboratory results reported to physicians.<br>2. Test variance automatically checked to identify errors.<br>3. Testing equipment automatically calibrated. | 1. Additional space required for terminals in laboratory.<br>2. Not easily interfaced with other computers. |
| CRS Series, Infotronics | A modular laboratory software package offering display and printout of test results as well as paper tape output. Designed to handle up to 20 automatic analyzer channels. Specialized programs adapted to individual requirements are available. | Not available. | 1. Fewer errors in result reporting.<br>2. Data presented by patient identifier.<br>3. Modular software easily updated. | 1. Additional space required for terminals.<br>2. Limited maintenance available. |
| EAI -- "Pace III" | Pace III is a turnkey concept designed to analyze data from gas chromatographs, analytic analyzers, mass spectrometers, physical testing machines, and spectrophotometers. It is modular and can be expanded to handle various laboratory equipment configurations. It measures peak areas, retention times, overlapping peaks, applies response factors, and calculates component concentrations. Its operation is controlled by a model ASR33 teletype. Primarily designed for use in hospitals of 400 beds or more. | Not available. | 1. Turnkey operation.<br>2. Better instrument utilization.<br>3. Less human error. | 1. System appears to need a great amount of installation space. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: DATA MANAGEMENT
COMPONENT: CLINICAL LABORATORY TEST DATA ANALYSIS

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| DEC -- "Linc 8" | The Linc 8 monitors tests and data processing activities by interpreting and processing data simultaneously from 15 instruments. It stores quality control and diagnostic control tables and will print out warnings of improper test variances, and calibrates itself. Linc 8 maintains a patient file of all laboratory reports that can be summarized and printed at any time. At regular intervals the computer will forward billing information to the accounting department's computer. Primarily designed for use in hospitals of 400 beds or more. | Approx. $50,000. | 1. Accurate and prompt reporting.<br>2. Easy terminal interface.<br>3. Reasonable cost.<br>4. Interface with accounting computer. | 1. Computer and terminal space required. |
| Varian/Cary - Spectro System 100/200 | Designed to automate the clinical laboratory; offers on-line computer control option, a Varian 620/i general purpose computer, and an instrument-computer-user interface tailored to each analytical instrument. | Not available. | 1. Control of laboratory testing and charge procedures.<br>2. Modular system.<br>3. More accurate reports by control of human errors.<br>4. Expanded capability. | 1. Laboratory space required.<br>2. Software expertise appears necessary. |

IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: DATA MANAGEMENT
COMPONENT: COMPUTERIZED ACCOUNTING

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| SHAS, IBM Corporation | IBM Shared Hospital Accounting System operates in a batch mode on 360/30E or 360/25E hardware. The software package includes accounts receivable, billing, general ledger, ancillary statistics and cost report sub-systems. | $4,500 to $21,000 monthly for hardware and operating staff which will handle 100 to 1000 beds. | 1. Message switching enables data retrieval at various terminal locations.<br>2. Improves accuracy of cost accounting.<br>3. Provides timely and accurate management information.<br>4. Is independent of data collection method. | 1. Software must be modified to user needs.<br>2. Operates in batch mode only.<br>3. Customizing software to user requirements difficult.<br>4. Support staff must be assigned to development prcjects. |
| Burroughs BHAS | Burroughs Hospital Administrative software package for the B2500 or B3500 computer. Operates in serial batch environment and includes billings, accounts receivable, general ledger, MR reporting and payroll operations. | $13,000 to $38,000 monthly rental for hardware and operating staff to handle 500 to 2000 beds. | 1. More accurate and timely data reporting.<br>2. Improved control of paper work.<br>3. Software expansion capability.<br>4. Provide up-to-date management data in detail or summary format.<br>5. Can be interfaced with any data collection scheme. | 1. Operates in serial batch mode only.<br>2. Source data must be translated into machine readable form.<br>3. All services must be pre-priced for maximum effectiveness. |
| Honeywell HCSS | Honeywell's Hospital Computer Shared System is a modular stand-along or multiple user shared-system that operates on a time-shared basis. It uses a H200 or H1200 computer for all financial applications from paper tape input at remote terminals polled by the computer. | Up to $43,000 monthly for up to 4,000 beds. | 1. If time-shared, hardware does not require significant floor space.<br>2. Computer utilization time shared capability increase.<br>3. Established data collection methods not changed.<br>4. Provides timely financial data.<br>5. Data base quickly assessed for special data requirements. | 1. Early planning decision critical to use of time-shared system.<br>2. Time shared systems inflexible to individual user demands.<br>3. Adequate time-shared group required for favorable cost effectiveness. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: DATA MANAGEMENT
COMPONENT: PATIENT DATA INFORMATION NETWORK

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Standard Radio & Telefon AB, Patient Information System | The ITT concept uses a CRT keyboard terminal and data display. Operational since 1967, the ITT communicates patient data between intensive care, the operating feeder laboratories, nurses' office, head physician's office, and the X-ray consultation room. | Not available. | 1. Instantaneous availability of patient data at any remote location.<br>2. On line graph capability of body parameters.<br>3. Total terminal flexibility enables easy interface with other communications components such as closed circuit television, microfilm distribution, or digital computer readout devices. | 1. Power cable and environmental control devices must be planned.<br>2. Computer rooms with proper environmental controls must be available. |
| Edstan Coded Card Concept | The concept uses coded plastic cards and a series of indicator lights on a display panel to show patient bed status. The display panel, located in any hospital area, displays room condition by several classifications. | $14,000 200-bed.<br>$33,000 600-bed.<br>$44,000 800-bed. | 1. Panel lights indicate if a room is available for occupancy, if it is ready for occupancy and reserved, if the current patient has been discharged, whether a male or female patient is currently occupying a given room, and housekeeping work orders. | 1. Space requirements include a computer room, stations for the plastic cards, and the display panel at appropriate locations. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: DATA MANAGEMENT
COMPONENT: DIAGNOSTIC SUPPORT

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Medidata Sciences, Automated History | The Medidata concept is a comprehensive data base designed for patient history taking using display unit carrousel slides coupled to a PDP8 computer. The carrousel stores 80 slides with four groups of questions per slide, maintaining a total of 320 questions. The questioning program has 16 major branches with six major levels per branch. The PDP 8 computer with a 16K core and 131K disk can handle about 50 terminals. | $264,000 for 20 terminal system. | 1. Physician bias eliminated in history taking.<br>2. Data commission errors are eliminated.<br>3. Workload can be leveled for entire workday.<br>4. Questions can be displayed in several languages, reducing data input errors from misunderstanding.<br>5. Physician's time saved. | 1. Unable to capture emotional response to questions.<br>2. System requires on-line interface with a computer.<br>3. Examinee must be able to read and have average intelligence.<br>4. Limited to 6 levels of branching and 340 frames.<br>5. Medidata does not have extensive service facilities.<br>6. Program modifications are difficult. |
| Biomedical Computer, Inc. SADE | The SADE is a stand-alone history taking device using a 16 mm film system and a computer component to enable the user to sequence through multiple programs in logical order. The SADE is operated by 12 exterior function buttons, an on/off switch, focus control, and a lockout feature. The examinee pushes one of the 12 function buttons to select the correct response to the question presented in the frame. Branch to the next frame is approximately 4 seconds. Examinee responses are recorded on a standard paper-punched tape or sent directly to the computer. Film reels have up to 4,000 frames. | Assuming a volume of 25 SADE units and 160 tests per unit per month, a cost of $6-7 per test. | 1. Almost unlimited questioning and branching capability.<br>2. Consistent and logical questioning to every patient.<br>3. Physician time saved.<br>4. Computer interface not required. | 1. Slow in branching to next frame (4 sec).<br>2. Requires large volume of tests (at least 4000/month). |

Abrams, M. E., et al. "Computer-Based General Practice and Health Centre Information System." Journal of Royal College General Practitioners 16 (December 1968):415-27.

Adams, R. E. "How to Determine the Profit or Loss on Patient Television." Modern Hospital 111 (October 1968):96-8.

Adey, W. R. "National Objectives in Health and Medical Care." Research/Development 19 (December 1968):24-29.

Aerospace Medicine and Biology: A Continuing Bibliography with Indexes, March 1969. NASA, April 1969. N69-24822.

Aerospace Medicine and Biology: A Cumulative Index to the 1968 Issues of a Continuing Bibliography. NASA, January 1969. N69-24752.

Allen, R. An Annotated Bibliography of Biomedical Computer Applications. June 1969. PB-184 225.

Arena, V. M. Special Airborne Medical Care Unit. March 4, 1969. AD-689 403.

Armstrong, L. M., et al. A Study of a Circular Dental Clinic Employing Advanced Practice Methods. June 2, 1969. AD-689 788.

Bach-y-Rita, P., et al. "A Tactile Vision Substitution System." American Journal of Optometry 46 (February 1969):109-11.

Baevski, R. M., et al. Applications of Computer Technology in Medicine. May 21, 1969. JPRS - 48079.

Barr, R. "Now: A TV-Teaching Network that Really Delivers." Hospital Physician 5 (May 1969):62-68.

Beck, W. S. Automation for the Hospital of Tomorrow. April 1, 1968. AD-677 593.

Beck, W. S., and Creamer, R. A. Hospital Information Feasibility Study. August 1968. AD-676 005.

Ben-Porath, M.; Clayton, G. D.; and Kaplan, E. "Tape-Recording of Dual-Channel Energy-Modulated Color Scanning." Journal of Nuclear Medicine 10 (April 1969):155-9.

Bernstein, G. B. A Fifteen-Year Forecast of Information-Processing Technology. January 20, 1969. AD-681 752.

Bohnert, L. A. Retrieval of Technical Documents. November 1967. AS-664 596.

Borko, H., et al. Interactive Displays for Document Retrieval. August 4, 1966. AD-661 657.

"Business Bulletin: Briefs." Wall Street Journal (May 8, 1969):1.

"Can Technology Fill the Medical Personnel Gap?" Safety Maintenance 137 (April 1969):21 ff.

"Canada-Wide System Permits Expert ECG Analysis in Minutes." Canadian Doctor 35 (April 1969):36-9.

"Canadian Hospitals and Medical Schools on Network." Canadian Hospital 46 (April 1969):36.

Careleton, R. A. "Computer Program for Processing, Storage, and Reporting of Cardiac Catheterization Data." Medical Research Engineering 8 (March-April 1969):18 ff.

"Caring Together: Competing Hospitals in Many Cities Merge Amid Spiraling Costs." Wall Street Journal (January 2, 1969):1.

"CCTV Is Successfully Applied in Cobalt Eletherapy." Canadian Hospital 46 (April 1969):35.

"Children Are Able to Visit Parents via Closed-Circuit TV Visit-Vision." Public Relations Newsletter 18 (March 1969):2.

Chouinard, R. L. "Hospital Paging Systems." Canadian Hospital 46 (April 1969):55.

Codling, D. "Does CCTV Increase the Depth or Rate of Learning." Canadian Hospital 46 (April 1969):34.

__________. "Here's the Story on Video Recorders." Canadian Hospital 46 (April 1969):31 ff.

Colombo, D. S., and Rush, J. E. Use of Word Fragments in Computer-Based Retrieval Systems. February 1969. PB-184 104.

"Computers to Process Apollo Biomedical Data." Space World E12-60 (December 1968):47.

Creamer, R. A. The USAF Hospital System. August 1968. AD-674-593.

Creamer, R. A., and Fagan, G. A. An Evolutionary Plan for the Integrated USAF Medical Information System. September 1968. AD-679 544.

Creer, R. P. "Audiovisual Communications: Some Pro's and Con's." Nursing Outlook 17 (May 1969):61.

"Data for Doctors." Communications News (July 1969):6.

Dearden, D. M., and Anderson, L. D. "An Evaluation of Televised Instruction in Anatomy and Physiology with and without Follow-up Classes." Nursing Research 18 (March-April 1969):156-60.

Deland, E. C., et al. Computers and the Delivery of Medical Care. February 1969. AD-682 952.

"Development of Medical Electronics in the German Democratic Republic." Medical and Biological Engineering 6 (September 1968):559-60.

"Doctors Use TV to Improve Bedside Manners." Canadian Hospital 46 (April 1969):37.

Donaldson, P. Electronic Apparatus for Biological Research. New York: Academic Press, 1958.

Drinnan, A. J., and Green, G. W. "Continuing Education for Dentists Using Open Circuit Television." New York State Dental Journal 35 (April 1969):203-10.

"Electronic First-Aide for the Busy Doctor." Business Week (October 5, 1968):156-80.

Excerpta Medica Automated Storage and Retrieval Program of Biomedical Information. Excerpta Mark I System. Amsterdam: Excerpta Medica Foundation, 1969. PB-184 026.

Fallat, R., and Strom, R. L. "Basic Concepts in Computer Science for Laboratory Physicians." Minnesota Medicine 52 (May 1969):847-852.

Faraday, C. P. "Computer-Orientated Medical Records System." Medical Records 10 (February 1969):4-15.

FCC License Applications for Biotelemetry. Washington, D. C.: American Institute of Biological Sciences, 1968. AD-681 814.

Filosa, L. "New Information System Uses Less Staff, Provides More Data, More Dollars." Modern Hospital 112 (June 1969):87-9.

Foote, D. P. Charge - Controlled Storage Display Panel. May 1969. AD-687 308.

Gault, M. H., et al. "Kidney Transplants: Computer Display of Chemical and Laboratory Parameters." Canadian Medical Association Journal 100 February 22, 1969):359-62.

Geier, L. Ten Years with TV at Johns Hopkins. Baltimore: Johns Hopkins University Press, 1958.

Gelblat, M. Computerized Storage and Retrieval of Cardiac Catherterization and Pathology Data. June 1968. AD-671 912.

Genesky, S. M. Some Comments on a Closed Circuit TV System for the Visually Handicapped. December 1968. AD-679 526.

Goodman, R. M. Research in Life Sciences Instrumentation Pertinent to Studies in Space Biology: Quarterly Progress Report, July 1 - September 30, 1968. N 69-11291.

Gould, R. S. "Architectural Reorganization and Automation: The Answer to Rising Hospital Costs." Medical Times 97 (March 1969): 226-30.

Griffin, N. L. Electronics for Hospital Patient Care. Washington, D. C.: Government Printing Office, 1968. FS2.74/3:D-25.

Griffin, R. M. "Comparative Study of Automated Reporting." American J. Occupational Therapy 22 (July-August 1968):307-10.

Halme, A. J., and Hyvarinen, J. "Use of an Ordinary General Purpose Computer for Neuronal Impulse Interval Measurement." Medical and Biological Engineering 6 (September 1968): 563-5.

Hanley J., et al. Combined Telephone and Radiotelemetry of the EEG. August 13, 1968. AD-687 910.

__________. Some Applications of Biotelemetry. April 1968. AD-678 980.

Harkness, J. P.; Cadmus, R. R.; and Tillman, L. P. A Manpower Study of Technical Personnel in Hospital Clinical Laboratories. October 1968. PB-180 437.

Hattery, L. H. Information and Communication in Biological Science. Washington, D. C.: Center for Technology and Administration, American University, 1961.

Haynes, L. S. Video Communication Program. May 1967. PB-184 137.

Hedley, A. J. "Computer Assisted Follow-up Register." Methods of Information in Medicine 8 (April 1969):67-77.

Hofmann, P. B., et al. "Automated Patient Census Operation: Design, Development, Evaluation." Hospital Topics 47 (May 1969):39-41.

"Hospital Computers in the U.S.A." Biomedical Engineering 4 (1968): 78-9.

"Information-Retrieval System Being Offered by Mead, Paper Firm." Wall Street Journal, (March 21, 1969):15.

"Intercontinental Transmission of Computerized Medical Data." Candian Hospital 46 (May 1969):18.

Jackson, G. G. "Information Handling Costs in Hospitals." Datamation 15 (May 1969):56-9.

Jenkins, D. "Computer Helps Doctors Diagnose Patients' Ills." Product Engineering 39 (November 18, 1968):100-2.

"Jerrold ITFS System Ties Milwaukee Hospitals." Communications News (July 1969):1.

Jones, S. V. "EGG by Telephone." Science Digest 65 (May 1969):85.

Kidd, E. M.; Price, C. E.; and Yount, S. L. Study of the Data Central System for Information Retrieval Applied to NSA Data. February 26, 1969. PB-183 450.

Kiely, J. M., et al. A Computer-Based Medical Record: Entry of Data from the History and Physical Examination by the Physician. 1968. AD-679 772.

Knowles, L. G., and Yates, W. A. The Flexicon: An Approach to a Low Cost Medical Display for Computer Processed Data. February 1968. PB-178 065.

Korein, J. "Computer Processing of Clinical Medical Data." Bulletin of New York Academy of Medicine 45 (May 1969):489-490.

Kosty, E. W. "Centralizing Data Processing in a Two-Location Hospital." Management Services 5 (November-December 1968):51-4.

Kovner, A. R. "The Nursing Unit: A Technological Perspective." Ph.D. dissertation, University of Pittsburgh, December 1966.

Krasnoff, S. Computers in Medicine: A Primer for the Practicing Physician. Springfield, Ill.: C. C. Thomas, 1967.

Kubicek, W. G.; Patterson, R. P.; and Witsoe, D. A. Development and Evaluation of an Impedance Cardiographic System to Measure Cardiac Output and Other Cardiac Parameters, July 1, 1967 — June 30, 1968. June 1968. N69-16690.

Kuperman, A. S. "Computer Processing of Pulmonary Data." American Review of Respiratory Diseases 99 (April 1969):598-602.

Leo, Sister Mary, "A Study of Communications Activities of the Medical-Surgical Nurse Supervisor in Selected Hospitals." Master's thesis, University of Pittsburgh, August 1967.

Lewis, S. T. "Microfilming — One Solution to the Preservation of Medical Records." Master's thesis, University of Pittsburgh, June 1954.

Lindburg, D. A. The Computer and Medical Care. Springfield, Ill.: C. C. Thomas, 1968.

Logue, P. E.; Peterson, Lars; and Miller, C. "An Orientation Video Tape for Psychiatric Patients." Mental Hygiene 53 (April 1969):85.

Lusted, L., and Coffin, R. W. Prime: An Automated Information System for Hospitals and Biomedical Research Laboratories. Chicago: Year Book Medical Publ., 1967.

Mamontov, O. V., and Novikov, Yu A. New Techniques in Scientific Information Systems. May 2, 1969. JPRS - 47965.

"Many, Many Users of TV." Changing Times 23 (June 1969):31-3.

"Marketing Automated Monorail System for Hospitals." Wall Street Journal (January 18, 1968):12.

Marko, A. R. A Histogram Display System (BIO-TV) for Physiological Signal Monitoring. November 1968. AD-683 338.

Martin, W. B. Pattern Recognition of EEG to Determine Level of Alertness. June 1969. AD-689 536.

Mayne, J. G. "Experiences with the Use of Automation for Collecting Medical History Data." Methods of Information in Medicine 8 (April 1969):53-9.

McLaughlin, L. "Nursing in Telediagnosis." American Journal of Nursing (May 1969):1006-8.

Movtdman, J. E.; Niriforuk, P. N.; and Pickering, W. D. An Analogue Computer Study of the Human Cardiovascular Control System. 1968. N69-14825.

Murray, R. C. "Touch-Tone Phones Help Hospital Eliminate Lost and Late Charges." Southern Hospital 37 (March 1969):30-2.

Newhouse, J. P. Toward a Theory of Non-Profit Institutions: An Economic Model of a Hospital. January 1969. AD-682 499.

Niles, A. M. "Call NURSING DIAL ACCESS." American Journal of Nursing 69 (June 1969):1235-6.

"On-Line Computer System Is Memory for Patient Care Data." Modern Hospital 112 (July 1969):70.

Onder, J. J. "Use of Television in Psychiatric Treatment and Education." J. Soc. Motion Picture and Television Engineers 77 (October 1968):1034-7.

Oosterkamp, W. J., et al. "New Method for Television Display of Roentgenological Information in Black-and-White and in Color." J. Soc. Motion Picture and Television Engineers 77 (December 1968): 1290-91

Palmer, W. M. "Emergency Medical Consultation via Ham Radio." Electronics Digest 3 (July-August 1969):6-7.

Paplanus, S. H.; Shepard, R. H.; and Zvargulis, J. E. "A Computer-Based System for Autopsy Diagnosis Storage and Retrieval without Numerical Coding." Laboratory Investigation 20 (February 1969):139-46.

Payne, L. C. Medical Automation. Philadephia: Lippincott, 1966.

Procedural Guide for the Evaluation of Document Retrieval Systems. Westat Research Analysts, Inc. December 31, 1968. PB-182 711.

The Proceedings of the Conference on the Use of Computers in Radiology. Columbia, Missouri: Missouri University, April 1968. PB-183 750.

Pshenichnyi, V. P., and Timonin, V. M. Information Retrieval System for Medical Diagnostic Equipment, USSR. January 23, 1969. JPRS 47293.

Ramey, J. W. Television in Medical Teaching and Research. Washington, D. C.: U. S. Office of Education, 1966.

Reichertz, P. "Electronic Data Processing in Medicine." Landzart 43 (September 10, 1967):1201-7.

"Report on the Task Force on X-Ray Image Analysis." Public Relations Newsletter 18 (March 1969):2.

Roberto, E. A. "Case for the Computer in the Small Hospital." Hospital Topics 47 (May 1969):33-9.

"Rochester Hospitals Using Emergency Radio System." Hospital Forum 37 (April 1969):10.

Rosner, S. W., et al. "Telephone Transmission of Spirograms for Computer Analysis." Medical Research Engineering 8 (January-February 1969):18-21.

Rostow, E. V. Bibliography: President's Task Force on Communications Policy. June 1969. PB-184 424.

__________. Domestic Applications of Communications Satellite Technology. June 1969. PB-184 416.

__________. The Domestic Telecommunications Carrier Industry: Part I. June 1969. PB-184 418.

__________. The Domestic Telecommunications Carrier Industry: Part II. June 1969. PB-184 418.

__________. Future Opportunities for Television: Part I. June 1969. PB-184 419.

__________. Future Opportunities for Television: Part II. June 1969. PB-184 420.

__________. Organization to the U. S. International Communications Industry. June 1969. PB-184 414.

__________. President's Task Force on Communications Policy. August 14, 1967. PB-184 425.

__________. The Roles of the Federal Government in Telecommunications. June 1969. PB-184 423.

__________. A Survey of Telecommunications Technology: Part I. June 1969. PB-184 412.

__________. A Survey of Telecommunications: Part II. June 1969. PB-184 413.

__________. The Use and Management of the Electromagnetic Spectrum: Part I. June 1969. PB-184 421.

__________. The Use and Management of the Electromagnetic Spectrum: Part II. June 1969. PB-184 422.

St. Pierre, P.; Fasana, P. J.; and Shank, R. Elements of Information Systems. 1968. PB-182-226.

Scheffler, F. L., and Smith, R. B. Document Retrieval System Operations Including the Use of Microfiche and the Formulation of a Computer Aided Indexing System. December 1968. AD-686 804.

"Searle is Marketing Automated System to Examine Patients." Wall Street Journal (February 14, 1969):11.

"Short-Wave System for Emergency Alert at Barnes." American Hospital Professionals 5 (March 1969):14.

Singer, J. P. "Computer-Based Hospital Information Systems." Datamation 15 (May 1969):38-45.

Smith, J. C. "Intermediate Data Retrieval System for the Anatomic Pathologist." Archives of Pathology 87 (April 1969):432-8.

Smith, Robert M. "Better Patient Care Through Electronics." Management Services 5 (May - June 1968):52-7.

"Some Emphasis on the Role of the Community Hospital and on Continuing Education for Physicians." American Medical Association Journal 206 (September 30, 1968):105-16.

Spivey, B. E., et al. "Computer Input of Patient Examinations by Means of Optical Scanning." Archives of Opthalmology 81 (March 1969):407-20.

Springer, E. W. "Automated Medical Record Systems: Legal Aspects." Medical Record News 39 (February 1968):65-7; 39 (April 1968):30-1; 39 (June 1968):36-7; 39 (December 1968):53-4; 40 (February 1969): 49-50.

Syner, J. C. A Computer Based Biomedical Information System, I: Logic Foundation and Techniques. October 1968. AD-681 893.

Taylor, V. The Price of Hospital Care. May 1969. AD-687 615.

Teller, D. N., et al. "The Collection, Storage, and Retrieval of Clinical Psychoharmacological Data." Diseases of the Nervous System 30 (February 1969 Suppl.):60-4.

Telpitz, A. I. Microfilm and Information Retrieval. October 29, 1968. AD-680 111.

"Time-Sharing Seen for Hospitals." Communications News (July 1969):4.

"TV Enters the Radiology Classroom." American Hospital Professionals 5 (March 1969):9.

Ulett, G. A., and Sletten, I. W. "A Statewide Electronic Data-Processing System." Hospital and Community Psychiatry 20 (March 1969):74-7.

U. S. Public Health Service. General Standards of Construction and Equipment for Hospital and Medical Facilities. Rev.ed. Washington, D. C.: Government Printing Office, 1969. FS2. 74/3:A-7/2.

United Aircraft Corp. Medical and Biological Applications of Space Telemetry. Washington, D. C.: U. S. Government Printing Office, 1965.

Verrasto, N. T. "System Cuts Down Patient Calls, Registered MD's, Beds." American Hospital Professionals (May 5, 1969):14-15.

Vickers, H. E., and Jones, F. "Computer-Compatable Filing System for Biochemical and Haematological Laboratories." Hospital 65 (May 1969):157-160.

Welkouritz, W., et al. "A Portable Electronic-Pneumatic Ventricular Assist Driving System." IEEE Trans. Bio-Medical Engineering 16 (January 1969):58-63.

Wells, P. N. T., and Evans, K. T. "Immersion Scanner for Two-Dimensional Ultrasonic Examination of the Human Breast." Ultrasonics 6 (October 1968):220-28.

Westat Research Analysists, Inc. Evaluation of Document Retrieval Systems: Literature Perspective, Measurement, Techincal Papers. December 31, 1968. PB-182 710.

Whittenburg, and Schumacker, A. W. Guidlines for Planning a Task-Oriented Information System. March 1968. PB-182 833.

## BIBLIOGRAPHY- DATA MANAGEMENT


Allen, S. I., and Otten, M. "Telephone as a Computer I/O Terminal for Medical Information." Journal of the American Medical Association 208 (April 28, 1969).

Ann Arbor Computer Corporation. Digital Computer Systems. Promotional Brochure.

Automated Business Systems. Hospital Accounting and Analysis Systems. Promotional Brochure No. EBS 249, 1969.

"Automatic Data Processing in Hospitals." Hospitals, J.A.H.A. 38 (January 1, 1964).

Barnett, Octo G. "Computers in Patient Care." New England Journal of Medicine 279 (December 12, 1960):1321-327.

Barr, Richard R.; Dunn, Marvin A.; Larson, Doris. "Microfilmed ECGs." Hospitals, J. A. H. A. 44 (April 16, 1970): 61-3.

Barron, Bruce A. "Medical Applications of the Computer: Part II" Hospital Practice (December 1968):47-60.

Bennett, Walter L.; Stroebel, Charles F.; Glueck, Bernard C., Jr. "A Patient-Centered Hospital Information System." The Office (May 1969): 65-8.

Bergman, John H., and Steffey, David L. "Data Processing Improves Outpatient Management." Hospitals, J.A.H.A. 43 (January 1, 1969):49-51.

Biomedical Computer Services, Incorporated. The Computerized Physicians' Office. Promotional Brochure.

Biomedical Computer Services, Inc. The Sade: Stand-Alone Data Acquisition Unit. Promotional Brochure.

Black, Colin. "Computer Currents Warm Norseland." Electronic News (December 29, 1969):30.

"Blueprint for Shared Computer Drawn in Chicago Project." Hospitals, J.A.H.A. 43 (September 1, 1969):64-9.

Burnett, Knox R., Computer Applications in Electrocardiography. Thesis Moore School of Electrical Engineering, May 1968.

Burroughs. Burroughs Computer Output-to-Microfilm System. Promotional Brochure No. 1042702.

Burroughs. A New Approach to On-line Systems Design. Promotional Brochure No. 1032877.

"Closed-Circuit TV System Links Surgical Team to Pathology Lab." The Surgical Suite Digest 43 (August 16, 1969).

"COM Makes Pan Am's Going Great." Information and Records Management (June - July 1969):44-6.

Community Health Services "C. A. R. E. S. Projects." Mimeographed. Saskatoon, Saskatchewan, April 15, 1970.

"Computer Controlled Blood-Bank Inventory." Computerworld (October 22, 1969):20.

"Computer Medical Roles Are Explored at Tulane University." Industrial Medicine and Surgery (September 1966):747-8.

Computer Sciences Corporation. Pay Information Manual. El Segundo, California, December 1968.

"Computer Systems Spread to Patient Care." Modern Hospital (November 1969):84-107.

"Computers for House Calls in Offing?" Medical World News (March 13, 1970).

Cronkhite, Leonard W. "Patient Location Control as a First Step Toward a Total Information System." Hospitals, J.A.H.A. 41 (May 1, 1967): 107-12.

"Designing for the Medical Field." Electrotechnology (September 1969):33-6.

Dobriner, Ralph. "For the Consumer, It's Solid State." Electronic Design 1 (January 4, 1970):76-9.

Dunlap, Henry B. "They Write It Here, It Comes Out There." Modern Hospital 109 (July, 1967):100-01.

Durham, Robert C. "Using Computer Simulation Modeling to Reduce Hospital Waiting Lines." Hospital Topics (April 1970):47-52.

Edstan Company. Wireless Bed Status System. Promotional Brochure.

"'Filing' the Population." Medical World News (December 12, 1969):28.

Finley, P. et al. "EDP is a Private Hospital Laboratory." American Journal of Clinical Pathology (December 1967).

"A First Step in Computerized Patient Care." Hospital Physician (August 1968):46-51.

Freilrum, Richard B. "Loyola University Medical Center Information System." Modern Hospital (February 1969).

Gamut Systems, Inc. Hospital Data Processing. Promotional Brochure.

Garfield, Sidney R. "The Delivery of Medical Care." Scientific American 222 (April 1970):15-23.

Geisler, Robert. "The THOMIS Medical Information System." Datamation (June 1970):133-36.

General Electric. Automated Film and Records Filing Systems. Promotional Brochure No. 68-4182.

Glamson, Baldwin, et al. "A Hospital-Wide System for Medical Data Handling." Hospitals, J.A.H.A. (May 1, 1967).

Goldman, J.; Knappenberger, H. A.; Moore, E. W., Jr. "An Evaluation of Operating Room Scheduling Policies." Hospital Management (April 1969): 40-5.

Gross, Malvern J. "Analyses of the Cost of Information Handling in Hospitals." Report to the Hospital Information Systems Analyses Committee, September 21, 1964.

Hammon, Gary L. and Jacobs, Stanley E. "Shared Computer Systems: Part 1" Hospitals, J.A.H.A. 44 (May 1, 1970):50-3.

Hofmann, et al. "Computers in Hospitals." Modern Hospital (July 1968).

Honeywell Corporation. Hospital Computer Sharing System (HCSS). Promotional Brochure.

"Hospital Systems Planned by NDC from Two Pacts." Electronic News (November 24, 1969).

Housley, Nicholas G. "A System for the Management of Medical Records." Hospital Management (September 1969):36-42.

Howell, John P. "Data Processing." Hospitals, J.A.H.A. 44 (April 1, 1970): 60-5.

Hsieh, Richard K. C. "Evaluation of Formal Communication Systems in a Hospital." Health Services Research (Winter, 1966):222-234.

Isberg, R. A. "Someday the Kidney Will Talk to the Nurse." Modern Hospital 109 (July 1967):81.

Jackson, Geoffrey G. "Information Handling in Hospitals." Datamation (May 1969):56-9.

Josephers, Sister Mary, R.S.M. "How Mercy Planned its Communications." Modern Hospital 109 (July 1967):87-9.

Jydstrup, Ronald A. "Cost of Information Handling in Hospitals." Health Services Research (Winter 1966):235-71.

Kaiser Foundation. Kaiser Foundation Medical Care Program. Oakland, California, 1968.

Kanon, Dov and Bilsborough, Sister Carol. "Patient Information System Utilizes Central Dictation System." Hospitals, J.A.H.A. 43 (October 1, 1969):56-9.

Kasanof, David M. "There's a Computer in Your Future." Registered Nurse (April 1970):52-7.

Katz, Jesse H. "Simulation of Outpatient Appointment Systems." Communications of ACM (April 1969).

Kelsay, Ronald C. "Computerized HIS: A Control Mechanism." Hospitals, J.A.H.A. 222 (April 1970):42-6.

Kiely, Joseph M. et al. "A Computer-Based Medical Record." Journal of the American Medical Association 205 (August 19, 1968):571-76.

Laird, Onalee. "Medical Records." Hospitals, J.A.H.A. 43 (April 1, 1969): 153-55.

Ledley, Robert S. "Practical Problems in the Use of Computers in Medical Diagnosis." Proceedings of the IEEE 57 (November 1969):1900-18.

Lehigh Valley Electronics, Inc. Interact Computer Systems. Promotional Brochure No. CC-6908.

Lenoski, Edward F. "Computer Processing of Pediatric Emergency Room Data" Journal of the American Medical Association 204 (May 27, 1968): 797-804.

Levy, A. and Drachman, R. "Computer Program Simplifies Record Keeping at Hospital." Journal of the American Medical Association (February 1, 1965).

Lindberg, D. A. "Collection, Evaluation and Transmission of Hospital Lab Data." Methods of Information in Medicine (July 1967).

Maddox, Darrell. "These Are the Claims for Hospital Corporations: Capital, Talent, Size, Centralization." Modern Hospital (December 1969): 102-4.

"Magnetic Disks Go to Court." Business Week (January 17, 1970):88.

"Making Use of Ex-Medics." Medical World News (July 25, 1969):35.

McDermott, Jim. "The Computer and Its Growing Pains." Electronic Design 1 (January 4, 1970):80-3.

Miller, Dulcy B. "Poor Communications: How it Keeps Continuity of Care Beyond Reach." Hospitals, J.A.H.A. 43 (July 16, 1969):156.

Mitchell, Michael B. "Appointment Scheduling." Hospitals, J.A.H.A. 44 (June 1, 1970):58-9.

Mohawk Data Sciences Corporation. MDS 4400 Source Data Gathering System. Promotional Brochure No. M-702-69.

Moiseeva, N. I., and Usov, V. V. "Some Medical and Mathematical Aspects of Computer Diagnosis." Proceedings of the IEEE 57 (November 1969):1919-25.

Moon, Jame E. "Computerized Pharmacy System Solves Hospital's Drug Inventory Problems." Modern Hospital 109 (July 1967):118-24.

Morrow, George M. "Discussion: An Internist Assesses Future Computer Use." American Journal of Pschiatry 125 (January 1969):34-6.

Mosenkes, Robert and Nobel, Joel. "A Look at Hospital Paging Systems." Hospitals, J.A.H.A. 43 (October 16, 1969):89-97.

"New Mercy Hospital Has No Back Door." Modern Hospital 109 (July 1967): 82-6.

Oliver, John A. "Electronic Data Processing." Hospitals, J.A.H.A. 44 (June 1, 1970):73-7.

Olson, Stanley "Hospitals Haven't Taken the Part They Should in Regional Programs." Modern Hospital (December 1969):99-101.

Olsson, David E. "Automating Nurse's Notes." Hospitals, J. A. H. A. (June 16, 1967).

"On-line Computer System is Memory for Patient Care Data." Modern Hospital (July 1969):70-2.

Paxton, Harry T. "Now: Instant Progress Summaries by Computer." Hospital Physician (November 1969):66-74.

Pifer, Alan. "A New Climate." Journal of the American Medical Association 45 (February 1970):79-87.

Potter, Bob. "Doctor-Computer Dialogue Speeds Orders." Modern Hospital 109 (July 1967):102-4.

Pribov, Hugo C. "Small Computer Does Big Job in Hospital Lab." Modern Hospital (April 1968).

Reading, G. et al. "Computerization of a Department of Surgery." Surgery (July 1969).

Remington Rand. Randtriever System. Promotional Brochure No. LBV 1022, 1968.

Rettenmaier, G. "Electronic Data Processing in Routine Clinical Work." Electromedica (March 1969):73-7.

Reynolds, Walter E. "Instrumentation in a Time Shared Environment." Research/Development (April 1970):20-6.

Richart, Robert H. "Evaluation of a Medical Data System." Presented at a Conference on Medical Information Systems, Kaiser-Permanente Health Services Research Center, San Francisco, January 28-30, 1970.

Riezenman, Michael J. "Urgently Wanted: A Data Terminal." Electronic Design 1 (January 4, 1970):90-3.

Rodde, Herbert R. "Shared Computer Concepts." Hospital Progress (November 1966):74-9.

Rosenthal, Marcia. "The VA's New Automated Hospital." Hospitals, J. A. H. A. 40 (June 16, 1966):50-6.

Sanders Associates, Inc. Hospital Data Management System. Promotional Brochure No. 6HA8/69-3M, 1969.

Shapiro, P. A., et al. "Information in Natural Languages." Journal of the American Medical Association (May 17, 1969).

Shaw, David V. "How to Lower Telephone Service Costs." Modern Hospital 109 (July 1967):93-7.

Siekert, Robert G. "A Video Terminal-Light-Pen Device for Ordering Medical Tests." Journal of the American Medical Association 206 (October 7, 1968):351-56.

Silverstein, Martin Elliot. Information Systems as a Physician's Tool. Presented at the American Management Association's seminar on Computer-Based Hospital Information Systems, New York City, May 27, 1968.

Slack, Warner, et al. "Computer Based Medical History System." New England Journal of Medicine (January 27, 1966).

Smith, James L. "The Computer." Hospitals, J.A.H.A. 43 (September 16, 1969):61-5.

Smith, Lorraine "The REACH System is Here, and the Doctors Can Take It or Leave It." Modern Hospital (February 1970):94-8.

Speed, Eunice L. "Scan." American Journal of Nursing (January 1969):107-10.

Speer, Raymond D. "A Changing World with Microcircuits." Electronic Design 1 (January 4, 1970):84-9.

Stevens, J.A. and Millard, G. E. "Data Processing of Patient Medical Records." Journal of Industrial Engineering (July - August 1965):237-43.

Syska and Hennessy Inc. "Hospital Systems, Part III: Communications." Technical Letter 18 (September 1968).

Telecommunications for Enhanced Metropolitan Function and Form. Washington, D. C.: National Academy of Engineering, August 1969.

Terrel, T. "Go to Source for Communication Gears." Modern Hospital 109 (July 1967):76-8.

Thomas, E. L. "Future of Computers in Anaesthesia." Canadian Anaesthetist's Society Journal (November 1968).

Thompson, J. D., et al. "Predicting Requirements for Maternity Facilities." Hospitals, J. A. H. A. 37 (February 16, 1963):45-9.

U.S. Department of Commerce. "Analyses of Information Needs of Nursing Stations." Washington, D.C.: U.S. Government Printing Office, May 1969. PB 186 246.

Univac. Communicate...Computer...Control. Promotional Brochure No. U4637.

"Univac Comes in from the Cold." Business Week (November 22, 1969): 160-63.

"U. of I. Medical School Students Treat Computer Cases." Communication News (December 1969).

Vallbona, Carlos."Preparing Medical Record Data for Computer Processing." Hospitals, J. A. H. A. (May 1, 1967).

Van Brievingh, R. P. Van Wijk "Automation in Medicine." Electromedica (March 1969):69-72.

Volgyesi, Andrew S. "Computer Design of Hospitals - Toronto General - Software." Computer Decisions (September 1969):24-7.

Weed, Lawrence L. "Technology is a Link, Not a Barrier, for Doctor and Patient." Modern Hospital (February 1970):80-3.

Weid, G. L., et al. "Computer Assisted Identification of Cells from Uterine Adenocarcinoma." Acta Cytologica (September - October 1968).

Weishaar, J.; Rummel, W.; Reuss, A. "Initial Experience with Punch-Card Control of the Gammatron 3 in Radiotherapy." Electromedica (March 1969):78-8.

"What You Should Know about Radio Paging." Modern Hospital 109 (July 1967):90-1.

"Who's Who in Electronics." Electronics (November 24, 1969):8-16.

Williamolsson, Guran. "A Patient Data System on Trial." World Medical Electronics (September 1968):214-15.

Yoder, R. D. "Medical Record Data for Computer Processing." Hospitals, J. A. H. A. 40 (August 16, 1966).

# CONSTRUCTION

## INTRODUCTION

The construction state-of-the-art survey systematically identifies and documents present concepts and procedures for planning, designing, and constructing health care facilities, emphasizing the concepts and procedures most applicable to the "New Generation" of Military Hospital (NGMH). In addition, this survey evaluates and predicts the impact and availability of advanced technology which could influence health-care facilities built after 1972.

This survey focuses on construction concepts and procedures which can provide a basis for systems analysis. Specific construction materials or methods are not discussed since construction is heavily dependent upon local factors such as climate, aesthetics, manufacturing and building capabilities, materials and labor availability and building codes - all of which must be individually evaluated for each new or remodeled BLHC System.

## TECHNICAL APPROACH

Our survey was conducted in four (4) steps:

Step 1 - On-site visits to Beaufort, Andrews, Dix, Jacksonville, Long Beach, San Diego, Oakland, Eglin, Tyndal, March, and Lackland BLHC Systems, where Westinghouse interviewed military and civilian personnel familiar with the original construction program and its management, its costs, changes to the initial building and their costs, and the building's operating and maintenance costs. The interviews also explored construction methodology, legal and institutional constraints, progress review procedures, current criteria used to translate health-care requirements into facilities, and the design/construction process. Data on these CONUS health-care facilities, such as original size and cost, construction date and direction, and nature and timing of changes was obtained.

Step 2 - Further visits were made to civilian systems within the Veterans Administration and Public Health Service, university-related teaching, urban and suburban profit and non-profit, and Kaiser Foundation systems. Specific hardware, such as automatic materiel handling equipment, was examined in detail.

Step 3 - Two design team members visited health-care systems in England and Europe, evaluating their current construction procedures.

Step 4 - Literature relating to military and civilian health-care facilities construction was reviewed. Included were government reports, technical journals, and manufacturers' data. A bibliography is included at the end of this section which indicates the sources and depth of the search.

## STATE-OF-THE-ART

Improvement alternatives were studied which best fulfilled two primary objectives: improving the relationships and balance between initial, operating, and maintenance costs to enhance the systems' abilities to meet the present and future needs of the NGMH; and improving client-designer-contractor relationships to achieve optimally appropriate designs, material selections, and building procedures.

Interviews with concerned military and civilian health-care personnel made it apparent that least acquisition cost is the overriding parameter in most construction programs. This is the result of rapidly increasing construction costs over the past twenty years and the difficulty in obtaining bond and mortgage funding which must be amortized over the facility's life.

Health-care facilities are becoming more complex, with sophisticated mechanical and electrical services commonplace. Therefore, costs will likely continue their spiral, especially if a major industry realignment, perhaps catalyzed by the Federal Government, does not occur.

Westinghouse is convinced that initial costs should not be used as the only or primary criterion for evaluating construction. Far too often low initial cost leads to poorly planned or built facilities and to offsetting or overriding alterations costs. Consequently, the possibility of using slightly more expensive planning, design, and construction concepts should be evaluated against life-cycle benefits and sensitivities to growth and change.

Costs, however, are difficult to pinpoint because of the many interrelated variables associated with any construction project. Therefore, preliminary estimates of future costs must be based on fragmentary, often unrelated, historic costs.

Improvement in client-designer-contractor relationships and communications can significantly benefit any large project. Historically, the client has had difficulty in representing the nature of the system, its interrelated functions, and its sensitivity to growth and change to planning and design professionals. Consequently, systems which are adequate by today's planning and design criteria may still be inadequate in terms of true, life-cycle client needs.

Raising the level of understanding of the interdisciplinary team of clients, planners, designers and builders with respect to systems dynamics and operational environment is far more valuable than looking for a "miracle" hardware or "building system" solution.

## Design Concepts

There is considerable similarity in the design concepts used for most military and civilian health care facilities. Whatever the final building form, the architect usually begins by designing a tower in which wards are grouped around one major vertical shaft containing elevators and major utilities distribution risers. Tower size depends on the client's "bed" requirements and the extent to which wards can be grouped around the shaft in the configuration selected. Individual wards will vary in their design according to client preferences, architect abilities and preferences, and to some degree the institutional preferences of the funding agency, if any.

A major exception to design similarity is nursing unit layout where configurations range from circular to triangular. This diversity of shapes and their integral layout reflect the varied interpretations of the client's needs by the architect, plus minor input from health-care professionals and possibly from operations analysts.

The layouts reflect the client's organizational and manpower concepts, or, in extreme cases, are designed around a specific technological innovation such as automated materiel handling, making the entire system susceptible to the obsolescence of one sub-system component.

Typically, the nursing unit tower is located atop a symmetrical low-height base, which houses outpatient, ancillary and administrative activities. This low-height section carries the standard loads to grade.

Each observed layout was designed to accommodate a specific patient mix, and to minimize one or more of the following:

1. First Cost
2. Space/patient ratio
3. Periphery (outside building wall area)
4. Number of steps required by nurses (adjacency)
5. First cost using all private rooms, or some other static mix.

Present design concepts minimize the system's change and growth sensitivities, and the dynamics of changes in patient mix, organization, and technology level. Designs which minimize growth and change capabilities deny that medical practice is changing, that socio-economic developments are affecting patients' acceptance of health-care environments, that technology is constantly making hardware obsolete, and that the rate of change is accelerating.

The major innovations observed in design concepts were: the professional corridor, interstitial space, modularity, and changes in major elements.

## The Professional Corridor

With the professional corridor concept, patient rooms are usually on the periphery of the nursing unit, and the medical, administrative, and support facilities and staff are located in the center. This design allows maximum staffing and management flexibility and minimal staff movement inside the ward.

This design can also accommodate changes in patient mix, levels of care and patient support, and materiel distribution. Allied with major functions amenable to change, this concept incurs relatively low initial and life-eycle costs.

Interstitial Spaces

Because of the importance attached to change capabilities in health care facilities, a design concept has been developed which separates the major utility sources (HVAC, plumbing, electrical) from the primary space. All ducts, piping, conduit, etc., are installed in an intermediate floor (generally 6 feet to 8 feet high) above the primary space. Only the final connections to the primary space must be integrated into the original design, and only they will contribute to cost during alterations or expansion. These interstitial spaces may be obtained by the use of joists and trusses which can provide clear spans up to 80 feet.

Because of its extreme initial cost penalty (up to twice the cost of an equivalent conventional facility), interstitial space can be justified only in a system where fundamental physical changes will be required frequently but will be totally unpredictable in scope and character.

Modularity

In the construction industry, "modular" means that every space is designed as some multiple of a given dimension, allowing economics in design detailing, manufacturing, and installation.

Although complete modularity of all materials and equipment in the system can offer substantial economies in design detailing, manufacturing, and installation, manufacturers require a large market before they will start production.

Major Elements

Major elements of the BLHC System will be affected by local and regional factors and should utilize the overall system design criteria; these criteria should not be bent to accommodate any major element. Initial, operating and maintenance costs can be significantly affected by the design of major elements such as the structural frame, HVAC, and utilities.

1. Structural design has been affected by evolutionary developments in steel and concrete, resulting in lower costs for longer clear spans and lightweight short spans. Because manufacturers are increasing their roles in these developments, the time from concept to materials availability is usually very short.
2. New HVAC designs meet the need for a high-quality environment. Several trends include the greater use of high velocity air movement adaptable to individual space needs, terminal units with local exhausts to minimize or eliminate air returns to a central fan and its infection distribution dangers, heat reclamation and energy transfer to reduce operating cost, humidity control to improve patient comfort, and equipment "modules" for easy initial and replacement installations.
3. New concepts in plumbing and utilities design has resulted in: vacuum assisted sewage disposal to reduce first and life-cycle costs through use of smaller piping, and to reduce site layout constraints because gravity is not the entire motive force; easier, less costly rearrangement and additions; reduced water usage, reduced susceptability to clogging and other maintenance problems; simpler venting; and major revisions to concepts such as pipe sizing standards.

**Planning and Design**

Planning and contracting procedures typically follow a four step program:

Step 1 - The client engages an architect to design the facility within a budget constraint to meet the population's needs, depending on the architect to evaluate the system's interrelationships and management policies and procedures.

Step 2 - The client appoints one person to interface, guide, and control the architect, and to protect the client's interests. The architect's output is also periodically reviewed by a committee of health-care personnel, many of whom have never participated in a construction program, and who, therefore, are not deeply acquainted with the long term effects of early design decisions.

Step 3 - The architect selects structural, mechanical and electrical engineers, often on the basis of past relationships rather than on their experience with health-care facility design.

Step 4 - The architect and his engineers complete the plans and specifications and advertise for bids from general contractors. The contractor is usually selected on the basis of lowest bid price, interjecting the risk of contracting with a firm with little or no experience in health-care facility building.

Another planning approach is to use a consortium of professional and specialized planners, designers, and construction managers to define the health-care needs, the resources needed to fulfill those needs, and the organizational relationships within the facility. These professionals also complete the facilities design, manage the building work, and occasionally arrange financing. This procedure offers the advantage of an interdisciplinary approach in which any policy decision is rapidly evaluated against all other alternatives. The presence of a project manager with overall authority and exposure will ensure that all group members correctly interpret design concepts, and the entire planning phase will be accelerated.

A consortium group may also offer the option of integrating the construction phase into their effort, a common practice in the manufacturing and process industries. The group may also offer to own the facility and lease it back if this coincides with the client's capital structure.

A number of additional refinements are being introduced into the individual professional groups:

- Management tools, such as PERT networks, will be increasingly used to control and accelerate the various work phases through a better understanding of their interrelationships and their effects on deadlines.
- Computer based specification writing and detail drawing, coupled with improved data bases and retrieval systems, will shorten the design process and make the latest data on materials selection available.

- Computer based calculations of major design criteria and construction estimates will allow more accurate evaluations of options.

Building work is contracted under three basic types of contracts and with firms having varying levels of management and design abilities.

1. Use of a general contractor is the most prevalent method. The general contractor takes responsibility for the entire project, excluding planning and design, and is usually selected on the basis of his low bid for the work defined by the architect's drawings and specifications. They subcontract speciality work, such as HVAC, electrical, masonry, and roofing to qualified sub-contractors, thereby realizing savings through higher productivity. The general contractor undertakes project management, including coordination of sub-contractors; he typically performs excavation and installs the concrete and structural frame with his own forces; however, the percentage of in-house and sub-contracted work varies from firm to firm.

2. A designer-builder may assume responsibility for all design and building work under a single contract. The designer-builder manages the field work in the same way a general contractor does, but often sub-contracts, at his option, larger portions of the work in major specialty blocks.

The client awards a single contract and thereby concentrates responsibility with one firm. Contracts are typically negotiated, rather than competitively bid, and usually contain incentive clauses for reducing costs below a guaranteed maximum amount, and bonus/penalty clauses to reward or penalize the designer-builder for rapid or delayed completion.

Designers-builders have broader capabilities than a general contractor because of their in-house design and construction management capabilities. They can also advise the client of costs during preliminary planning, analyzing materials and methods alternatives to optimize selections.

3. The client can act as his own general contractor, sub-contracting all work directly to sub-contractors, thereby saving the general contractor's or designer-builder's markup.

This approach requires that the client have sufficient in-house management personnel to administer and control a large project. Without this management, savings are rarely realized, as the client is faced with the complex job of coordinating several, inter-related contracts. Coordination problems are further compounded if the separation of trades is not clearly defined by the design, and if the absence of a builder compromises coordination between the trades.

ADVANCED TECHNOLOGY

The objective of advanced technology is to produce hardware or design concepts which will result in a facility with adequate aesthetics and quality, at reduced initial and life-cycle costs. Several concepts have the potential to meet these objectives:

1. Cheaper, lighter, or stronger materials are being sought to substitute for existing materials or to fulfill several purposes (for example, pre-cast concrete slabs which are structural floors and which can also carry electrical and telephone conduct, plumbing, and HVAC pipes and ducts.)

2. Higher labor productivity at lower skill levels is a more efficient method of producing a construction element, using expensive capital equipment and a factory setting. In general, this process is designed to utilize lower paid industrial workers instead of skilled construction tradesmen. The benefits to be gained are claimed in at least three major areas: better working environment, tools, and supervision and will result in higher output/man; the results will be more uniform in quality; levels of skills and, therefore, the base rate/man will be lower.

3. Speeding up the construction process will lower costs if this speed is obtained by lowering the amount of field labor. This approach somewhat parallels number (2) above, because it generally implies factory pre-fabrication of parts shipped to the site for erection. However, it can also

include (1) above, where, for example, demountable walls (dry) are used instead of lath plaster walls (wet). Whatever method is used, the aim is always to reduce the time from initial planning to beneficial occupancy. One major cost item affected by this is the cost of financing.

The major barriers to the use of these advanced concepts in U. S. health care facilities are:

1. The Relative Fragmentation of the Market - Even though there are a large number of health-care facilities being built, there is not sufficient agreement among the various users concerning physical forms, equipment, finishes, and space requirements to warrant a full scale development and manufacturing program.

2. Distribution - Most building systems have originated in Europe where population density is far greater than in this country, and the distance between major population centers is smaller. Unlike the U. S., one large factory, with a high potential for cost economics, can serve several areas.

3. Governmental Subsidies - Most European governments devote considerable direct and indirect subsidies to system manufacturers because of the pressing need to rebuild their physical plants after World War II. The direct subsidies come in form of tax rebates; priority in obtaining raw materials; the development of national building codes; provision of loans; creation and long term maintenance of markets; etc. One of their most important indirect subsidies comes in the form of long range research into the performance requirements of the buildings under study (mainly housing) and the provision of roads, sewers, water, rapid transit, etc., which encourage the demographic patterns used in the decision process for entering into manufacturing.

4. Fear of Job Security - Many construction trade unions fear loss of jobs as a direct result of more systems building, and are further concerned by the inherent breaking down of long time jurisdictional barriers. Their efforts to date have been aimed at inhibiting the introduction of systems building by

demanding that field trade rates of pay apply to union supervisors in the factory.

5. Building Codes are numerous, local, and vary enough to require separate techniques and materials to satisfy them. Many codes give specific approval to a narrow band of materials and practices, excluding advanced materials and procedures and performance oriented specifications. While the NGMH's are on Federal property and therefore theoretically free from code restraints, the present code structure in reality inhibits development and use of advanced technology by inhibiting market growth.

Because of these constraints, construction economies at this time are limited to:

1. Materials substitutions which are allowed by codes or which are sufficiently tested to force code acceptance in most localities such as PVC pipe for cast iron and copper.

2. Prefabricated sections, or "modules", such as factory-piped and wired bathrooms, partitions, and slabs.

3. Improvements in planning, design and construction management.

4. Use of larger modules, such as factory-finished ICU/CCU rooms.

5. Adapting a system logic that minimizes construction cost for each discrete area. For example, mechanical design criteria might be different for a coronary care unit than for a light-care ward without jeopardizing the system's ability to adapt to change in patient mix.

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: CONSTRUCTION
COMPONENT: DESIGN CONCEPTS

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Interstitial Space | Intermediate space between primary use floors for mechanical, electrical, and plumbing services. Current concepts employ long span, deep truss, or space frame structures which allow clear vertical heights of 6 to 8 feet in these intermediate floors. | $35 million for 890,000 square feet at V. A. Hospital, San Diego, Calif., to be completed late 1972. | 1. Primary floors are left free of mechanical and structural constraints, and can be re-planned independently of other floors.<br>2. Initial construction time reduced since structural-mechanical grid can be built before primary floor plans are finalized.<br>3. Mechanical systems are completely accessible, simplifying maintenance, repair and alteration. | 1. Construction costs much higher than conventional.<br>2. Vertical distance between primary floors increased.<br>3. Planning uncertainties arise in determining extent of use of interstitial space. |
| Building Concept for Clinic Health Facilities, Erdmann and Assoc., Madison, Wisc. | This concept uses modularization (4 ft. module) and standardization of uniform building elements so that standard building items can be used. Elements are pre-assembled and stockpiled in a warehouse and used as needed. All manufactured items such as hardware, plumbing fixtures, and equipment are standardized and bought in bulk. | 20 to 30% savings claimed over a building of equal quality. | 1. Bulk buying results in lower initial construction costs.<br>2. Standardization cuts planning, design, and construction time resulting in lower costs and quicker occupancy. | 1. Standardization is not sensitive to changes in technology.<br>2. Stockpiling outmoded building elements can result.<br>3. Concept is geared to lower construction costs and time spans only and not to user requirements. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: CONSTRUCTION**
**COMPONENT: DESIGN CONCEPTS**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| McMasters University Health Science Center, Hamilton, Ontario | McMasters is a 420 bed teaching hospital incorporating the modular and interstitial space concept for maximum flexibility. The basic module, called "Servo-System," is an 85' x 80' steel frame, prefabricated from three basic pieces and site assembled on the ground. The modules are joined in a horizontal, 4-level scheme, with an 8' - 6" interstitial space between each level. Mechanical, electrical, and plumbing services, stairs, and elevators are housed in shafts that serve as corner columns. | $54 million for 1,600,000 sq. ft. (includes 300,000 sq. ft. garage). Est. cost: $70 million, with interstitial spaces included. | 1. Use of repetitive elements speed construction.<br>2. The "Servo System" module can be built before non-permanent design decisions (e.g. wall and floor covering, type of heating) are made.<br>3. 73 ft. 6 in. clear span allows complete freedom of internal arrangement. | 1. Spread out design may create flow problems.<br>2. Interstitial space adds to cost and may not be needed in less technical areas of hospital. |
| Harness Program (British Ministry of Health) | Harness is a hospital design program. Its intent is to standardize all hospital functional areas into modules available in a range of sizes, capable of being linked and stacked. All building elements are designed to respond to modular coordination, performance and industrialization to reduce on-site labor costs. The program sets rigid limits on functional content, building discipline, and flexibility. (e.g. no hospital may be more than four stories high, all sites must be flat, etc.) | Intended to reduce total hospital costs (including initial costs) 40% below current levels. | 1. Planning, standardization, modular coordination and spatial flexibility. Allows the hospital maximum freedom of internal rearrangement, with minimal disruption of services.<br>2. Standard subsystem design and manufacturing procedures can shorten planning and design tasks and total project duration.<br>3. Planning coordinated subsystems can reduce sensitivity to obsolescence and new technology. | 1. Rigid planning, design, and construction standards can never meet all the various user requirements for a completely responsive health care system.<br>2. Costs of attaining the level of construction sophistication comparable to the British for the BLHC System would be very high. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: CONSTRUCTION
COMPONENT: DESIGN CONCEPTS

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Greenwich District Hospital, London, England | A hospital rebuilding project permitting:<br>a. uninterrupted use of most hospital areas throughout the construction period;<br>b. horizontal movement of people and goods;<br>c. high capacity for change.<br>The design provides three floors of working space with service subfloors above and below each, linked by four service shafts. Main beams of composite reinforced concrete and steel span 64 feet and accommodate the service, subfloors within the 7 foot beam depth. | Not available. | 1. Flexibility within working span allows non-structural elements such as partitions, doors, and storage units to be removed, interchanged, or altered with minimum inconvenience.<br>2. Escalators leave primary elevators free to move non-ambulatory patients.<br>3. Program phasing ensures that at all stages the new building in use plus the residue of the old form a workable hospital. | 1. Since the program will not be finished until September, 1971, evaluation is incomplete.<br>2. Internal expansion capability appears limited by location of open courts.<br>3. To date, rapid patient turnover has not been achieved because of inadequate light care facilities. |
| Lorenz Bohler Cirbeits Unfall Krankenhaus, Vienna, Austria | An 8-story occupational accidents hospital, Lorenz uses Vierendel trusses to support all floors above the second. The main building (250 ft. x 35 ft.) and a connecting 3-story treatment wing (135 ft. x 60 ft.) were built as one unit, using H-section columns, double leaf vierendel trusses with double channel web members, and concrete floors over steel sheeting. | Not available. | 1. Prefabricated windows, interior wall and ceiling partitions, and other standard items cut over-all construction time by one-fifth.<br>2. Rectangular truss panels allow all duct work and utilities to be placed between floors avoiding added shaft and duct space.<br>3. Internal wall and ceiling panels are detachable for easy maintenance and modification. | 1. Vierendel trusses cost more than conventional trusses. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: CONSTRUCTION
COMPONENT: DESIGN CONCEPTS

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Greater Baltimore Medical Center Construction Techniques, RTKL Inc.; Christie, Miles and Andrews | A programmed 400-bed horizontal hospital providing a means for inexpensive expansion and rearrangement, and mechanical accessibility. Sixteen feet deep steel beams over and at right angles to twenty-one feet deep girders allow major mechanical feeder lifts to run between girders and then branch to points between beams. The entire interior is vinylfaced dry-wall. Construction walls are anchored to a floating ceiling rather than to concrete slabs used for floors and roof. | Total cost: $10 million. Approximate unit cost including group i equipment: $28/square feet. | 1. Over and under beams allow completion of 60% of the mechanical/electrical work before starting interior finishing.<br>2. New techniques reduce construction time by 40%.<br>3. Expensive cut-outs in framing members for mechanical times are eliminated.<br>4. Interior wall construction facilitates shifting partitions as required.<br>5. Starting construction at the roof allows work to begin earlier on other construction phases. | 1. Depth of structural system is greater than that of typical steel framing of similar span.<br>2. Stopping wall partitions at the ceiling creates acoustical control problems. |
| Computer Design System at Department of Architecture, West Sussex County Council at Chester, England | CDS is used to design all municipal buildings such as schools, libraries, and geriatric facilities. All building types are divided in 11 major components, for example site, structural support, and environmental control. Each component is sub-divided in modular shapes or volumes of space. The architect, with a computer terminal, is able to retrieve from the memory bank programmed-current information on each building subcomponent such as material, unit cost, quantity required, and total construction cost of that component. The computer rapidly evaluates them all for optimal design and prints hard-line drawing copies. The method controls and manages up to 85% of a building. | Not available. | 1. The use of a computer permits quick, accurate, optimal decisions, and thus speeds planning.<br>2. Construction costs can be more accurately determined in the planning stage.<br>3. Allows cost savings through time saved in planning stages. | 1. High costs associated with either buying or leasing computer equipment and developing master programs.<br>2. Program development is time consuming and must be continually updated to respond to current trends, etc. |

## IMPROV ENT ALTERNATIVE COMPARISON CHART

**FUNCTION: CONSTRUCTION**
**COMPONENT: PLANNING PROCEDURES**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Cubith Program (British Ministry of Health) | Part of a unified development program for district hospitals in England, Cubith is a computerized systems analysis program for managing and controlling all phases of the total country's hospital design and construction programs. System analysis compiles data format and flow and defines and uses procedures, products, and construction expertise to form comprehensive data banks. All project decisions, related activities and schedules for the entire process will be handled by computers. | Intended to reduce total hospital costs (including initial costs) by 40%. | 1. Increases decision making speed, efficiency and accuracy, thereby reducing costs.<br>2. Total, systematic organization and control of all phases can lower both initial and long range costs.<br>3. Comprehensive data coordination can improve predictions of future requirements. | 1. Cubith program is tried on a scale which would make any evaluation valid.<br>2. Cost would be very high to implement a program of this magnitude in the BLHC System.<br>3. Requires an authoritative national health board with complete control of all hospitals to be completely effective. |
| RTKL School Construction System Approach | A construction approach using conventional materials, RTKL concentrates on improving productivity of local labor by organizing the construction process to reduce labor error and to optimize building performance. RTKL stresses four principles: complete and enclose the protective shell as soon as possible; separate the work sequences of the various trades to avoid interference; separate high and low technical phases of construction; permit a wide margin of Werrman error so that the structure and appearance is not jeopardized. | Approx. $25/ sq. ft. for school construction. | 1. Speeds construction.<br>2. Avoids costly maintenance problems.<br>3. Allows for 60 ft. x 60 ft. open bays for planning flexibility.<br>4. Simplify and detail construction procedures to increase use of unskilled and semi-skilled labor. | 1. Developed for single-story school construction only.<br>2. System development involved a trial and error, feedback and systematic refinement approach. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: CONSTRUCTION**
**COMPONENT: PLANNING PROCEDURES**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| University Residential Building System | A systems approach to dormitory residence construction adaptable for hospitals developed around 5 subsystems:<br>a. structural-ceiling<br>b. heating, ventilating, and cooling<br>c. partitions<br>d. bathrooms<br>e. furnishings.<br>Performance requirements were set up by Building Systems Development, Inc. of San Francisco, sent to manufacturers for bids, and then tested to see if performance criteria were met. | 1968 bid prices for 2000 units: $8,995,274 with Triposite System; $10,375,000 with Duoplanar System; $11,591,000 with steel systems. | 1. See advantages for SCSD. | 1. Bids came in higher than anticipated, causing delays, rejection of the bathroom subsystem, and renegotiation of the furniture subsystem.<br>2. Program scope was reduced from 4,500 to 2,000 student unit minimum volume, although bids assumed the higher volume minimum. |
| School Construction System Development Project | A systems approach to school construction using performance specifications, market aggregation, and coordinated building subsystems, which can be modified for hospital use. The SCSD uses six subsystems:<br>a. structure and roof<br>b. HVAC<br>c. lighting/ceiling<br>d. partitions<br>e. cabinets and fixed laboratory furniture lockers.<br>Teams capable of producing and integrating all subsystems entered bids. One team was chosen which then built all schools in the program (link package). | For Oak Grove School: $19.14/ sq. ft. Total program had a committed market of $25 million of which industrial participants spent $10 million on development. Overall savings of 18% realized on installed components, which accounted for 45-50% of total building costs. Up to now, savings of $2.5 million reported. | 1. Building flexibility is increased because subsystems can be dimensionally coordinated.<br>2. Renovation or improvement of one subsystem does not impair the function of the others.<br>3. Each subsystem can be performance tested before installation.<br>4. Local cost variations eliminated, construction time reduced, scheduling more precise.<br>5. Process allows bulk purchasing at lower unit cost; reduction in field labor and construction costs.<br>6. Maintenance costs are known. | 1. Market volume must be large enough to attract manufacturers' R&D expenditures.<br>2. Time frame to develop the total approach may be prohibitive; SCSD required approximately 5 years.<br>3. May encounter building trade union resistance.<br>4. Performance criteria may not be able to satisfy all local code requirements. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: CONSTRUCTION**
**COMPONENT: PLANNING PROCEDURES**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Study of Educational Facilities | A systems approach similar to SCSD using the following subsystems:<br>a. structural<br>b. atmosphere<br>c. lighting/ceiling<br>d. interior space division<br>e. vertical skin<br>f. plumbing<br>g. electric-electronic<br>h. roofing<br>i. carpet.<br>The open approach was used, putting together the system by cost and performance characteristics after bidding rather than receiving prearranged sub-system packages. | Average for 4 sample schools, $19.38/sq. ft. (7.05% under budget figure for school construction). | 1. See advantages for SCSD.<br>2. Open system approach gives a wider range from which to choose a system than to the SCSD link system. | 1. See disadvantages for SCSD.<br>2. More difficult to achieve compatibility among variously manufactured subsystems. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: CONSTRUCTION**

**COMPONENT: CONSTRUCTION CONCEPTS**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Adaptable Building System | An internal space division subsystem for the inpatient area system with standardized, horizontally joined, interchangeable modules consisting of 5 basic elements: wall shell, hygiene shell, storage shell, floor with service line distribution, and ceiling with mechanical distribution. Can be used with an existing shell space or new structures to provide space for patient care and related medical activities. | Wall system: $30 per linear foot. Hygiene unit: $950. Patient service console: $1000. Ceiling: $60 per square foot. Storage unit: $200. Based on test installation at Dallas Presbyterian Hospital, not including installation costs, total cost estimated at 70% material, 30% labor. | 1. Uniform, dimensionally compatible modules can be interchanged to allow arrangement flexibility;<br>2. Maintenance simplified since parts are inter-changeable and can be stockpiled;<br>3. Factory production of modules allows cost accuracy and higher quality;<br>4. Construction and planning lead time can be reduced. | 1. Cannot incorporate new technological developments easily;<br>2. Possible building trade opposition to the use of factory-made units;<br>3. Concept lacks producers due to uncertainty of market;<br>4. Requires structural system and enclosure;<br>5. Deals with inpatient space subdivision only. |
| Manufactured Room — H. B. Zachry Company | Precast concrete factory manufactured room complete with plumbing, electrical fittings, finishes, furnishings, and ceiling-mounted air handling units. Rooms are structural elements and are stacked vertically, in combination with conventionally cast vertical and horizontal circulation, cores, and shear walls. Used in hotels and housing to date. | Costs for Palacio del Rio Hotel, San Antonio: $500,000 factory set up, $50 per square foot to produce and place rooms. | 1. Reduction in construction time; 40% labor savings on low rise; 20% for high rise;<br>2. Self supporting up to at least 20 stories - needs only a base to sit on;<br>3. Minimizes field labor site preparation;<br>4. Very good acoustic separation between rooms;<br>5. High quality and uniformity due to factory manufacture. | 1. Room size limited by crane capacity and transportation limits on width of load;<br>2. Site limited by transportation distance from factory;<br>3. Limits ability to change space utilization;<br>4. Initial number of rooms needed may not be large enough to justify setting up a production factory;<br>5. Completed building is very heavy due to major material redundancy. |

IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: CONSTRUCTION
COMPONENT: CONSTRUCTION CONCEPTS

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Electro Systems Incorporated-Modular Medical Structures | Selfcontained, preassembled, totally equipped specialized care facilities designed for permanent or semipermanent attachment to an existing hospital. Modules are available in three basic sizes (4, 6, or 8 beds) and can be used for coronary, medical and surgical intensive care, or adapted to other care requirements. | No cost figures are available; manufacturers claim cost is about 15% below comparable new construction. Can be leased for a minimum of $10 per bed per day. | 1. On-site construction is simple and quick. Only site preparation, utilities and structural connections to existing hospital are needed, minimizing interference with hospital activities;<br>2. High quality, since components are factory manufactured;<br>3. Lag time between determining needs and occupancy is reduced;<br>4. Difference between estimated and actual costs is eliminated since cost of module is known;<br>5. Electro Systems Company guarantees proper operation of the modules and will provide training assistance. | 1. Single story, ground level installation limits adjacency options.<br>2. Limited options are available for individual hospital needs. |
| Atomedic Hospital | Circular, preassembled, 22-bed hospital (expandable to 44 or 66 beds), available for purchase or lease, which provides all the facilities needed by a small hospital, including laboratory, surgery, treatment, dietetics, records and administration. | $19,000 per bed for 22- and 44-bed units (not including special equipment). | 1. Structural beams are hollow aluminum to provide for mechanical, plumbing, and electrical lines. Lightweight, 50 tons;<br>2. Wall panels, ceiling sections and doors are interchangeable;<br>3. Short construction time - 7 or 8 weeks;<br>4. Staff to patient ratio is only .7 for a fully equipped hospital;<br>5. Flexible environmental control methods allow adaptation to all climates. | 1. Since design is based on use of computer and elaborate electronic equipment, the cost per bed is high;<br>2. Possible patient dissatisfaction over lack of windows;<br>3. Possible building trade union opposition to prefabrication;<br>4. Expansion capabilities limited; multi-story growth not possible. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: CONSTRUCTION**
**COMPONENT: CONSTRUCTION CONCEPTS**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Electro System "Multi-Wall" | Prefabricated facia mounted at the head of the patient's bed providing fully integrated mechanical and electrical subsystems. Multi-wall can rapidly update existing or planned hospital facilities for general patient rooms. Variations are available for single or multi-bed rooms, and for general in-patient rooms and coronary care areas. | $400 to $[illegible] for 2-bed unit depending upon equipment specified. | 1. Utilizes existing wall outlets, eliminating need to cut holes in walls, plaster, etc; 2. Reduces noise and interruption of hospital routines normally associated with remodeling. | 1. High cost. |
| Spectra System | A system of interrelated, interchangeable horizontally butting components for internal space division of inpatient areas. Intended for use both in renovation of old nursing units and in new construction. a. horizontal enclosure b. hygiene unit c. patient services center d. accessible ceilings e. accessories. | Not available. | 1. See advantage for Adaptable Building System. | 1. See disadvantage for adaptable Building System. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: CONSTRUCTION**
**COMPONENT: CONSTRUCTION CONCEPTS**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Tripoolite Concrete | A structural concept developed around a 20-in. planning module which uses precast stairs, columns, shear walls and spanning members tied as a monolithic structure by cast-in-place-beams, floor slabs, and shear-wall connections. A series of 8 in. x 10 in. [illegible] holes in the stems of the double spanning members and cast-in-place beams provides space for services to move through the 14 in. x 30 in. plenum created between the precast spanning member and cast-in-place top slab. | Not available. | 1. Economy is enhanced by installation ease. Mechanical services on top of the precast spanning members eliminate overhead work on scaffolding and ladders;<br>2. Allows wide range of exterior cladding;<br>3. Compatibility with moveable partitions on a 2 in. planning module allows complete architectural design freedom. | 1. Limited access to services. Once in place, the precast concrete access panels placed on spanning members are difficult to remove. |
| Modular Operating Theater Systems, Honeywell Limited | A factory produced, octagonal operating room module, available in 10 sizes from 250 sq. ft. to 465 sq. ft. complete with wall mounted equipment, theater lighting, and air conditioning. Although designed primarily for installation in new hospitals, it may be used in older hospitals if sufficient space exists. | Not available. | 1. Factory production ensures quality control.<br>2. Equipment is wall mounted to provide maximum free space and reduce maintenance costs. | 1. Octagonal shape makes space utilization and expansion difficult. |

FUNCTION: CONSTRUCTION
COMPONENT: CONSTRUCTION CONCEPTS

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Duotek Structure Cladding System | A composite building system of precast columns, prestressed beams, and prestressed tee slabs tied together by cast-in-place connections between primary beams and columns and a 2 1/2 in. cast-in-place concrete topping. Openings through beams and stems of tees are provided at 5 ft. intervals to accommodate services. | Not available. None built to date. | 1. Highly flexible, with bay sizes in 5-ft. increments up to 30 ft. x 65 ft; 2. Precast elements reduce construction time and dependency on weather conditions; 3. Can be adapted for use with other building systems; 4. Cladding panels are cast with a layer of insulation so that the inner structural segment is within a temperature controlled environment receptive to a variety of finishes; 5. May be used with or without suspended ceiling, with no fireproofing necessary. | 1. Limited to 5 stories; 2. Limited access to utilities through floor openings up to 4 ft. wide; 3. Requires 4 ft. between floors. |
| Transportable Building System | A building concept using coordinated structural boxes 4 ft. deep, 8 ft. wide, and 8 1/2 ft. high. The boxes are designed of light weight sandwich panel construction. A number of permanent fixtures are integrated into each structural frame e.g. airconditioning, lighting, piping, and wiring depending upon its use in relation to other boxes. Different basic units can be combined and arranged in various ways to create simple functional spaces or complex structures. | None available. None constructed to date. | 1. Moveable equipment, supplies, etc., can be packed inside the units for easy transporation and on-site assembly. Units are designed for compact transportability: 100 to 150% space increase of the assembled units from transport conditions to operational condition; 2. Permits almost unlimited expansion by adding modules as required; 3. Units can be grouped to fit the dimensions and shape of a particular site, allowing various configurations; 4. Adjustable jacks for foundations allow placement on rough terrain. | 1. Offers only a semi-permanent solution to overcoming acute health facility needs; 2. No means to evaluate units since none have been built; 3. Concept does not allow for multi-story design. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: CONSTRUCTION
COMPONENT: CONSTRUCTION CONCEPTS

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| The Alexander System (Non-hospital system) | A British building construction technique which vertically stacks 20 feet square, story-high, pre-cast concrete "tables" to form a building. Ducts are provided by leaving 3-foot spaces between the table tops (top of slab). Precision precasting allows placement by crane. | $3,053,568 for 156,350 square feet (includes furniture) for a research center at Birmingham University, England. | 1. High mechanical flexibility through open gridwork;<br>2. Repetitious building elements simplify fabrication and structural assembly. | 1. Slabs weight 17 tons each, requiring sophisticated erection techniques;<br>2. Columns are 23 feet on center restricting internal flexibility. |
| RECC Building (Perforated Waffle Slab) (Non-hospital system) | A perforated waffle slab floor-ceiling which allows passage of HVAC and electrical lines through holes in the web. Unused holes remain sealed with styro-foam plugs inserted prior to pouring the waffle slab. | Not available. | 1. Minimized depth of floor ceiling slab;<br>2. Eliminates noise associated with metal duct vibration;<br>3. Air flow for HVAC, handled without duct work, can be changed merely by knocking out different web plugs. | 1. Requires placing styrofoam plugs around each web of the waffle grid, and careful vibration of concrete during placement to eliminate honeycombing. |
| Bison Preferred Dimension Frame (Non-hospital system) | A British developed space frame of precast concrete beams and columns, notched at bearing points of perimeter and spine beams to allow services to pass through. The frame is dimensionally standardized on a 12 inch module. Floors are prestressed concrete. Load bearing cladding is available to replace the perimeter columns and edge beams. They can be produced with window openings and insulation installed. | Not available. | 1. Use of sophisticated steel molds ensures high finishes and consistency;<br>2. Frames are factory made under strict control, independent of weather;<br>3. Exterior cladding is in place at the frame's completion, allowing all internal work to proceed regardless of weather. | 1. Building site must be reasonably close to production factory;<br>2. Accessibility to service nodes is limited to indentation points in beams and columns at the building's perimeter. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: CONSTRUCTION
COMPONENT: CONSTRUCTION CONCEPTS

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| British Lift Slab (Non-hospital system) | A construction method which casts floor slabs at grade around previously erected reinforced concrete columns, lifted to their correct position with hydraulic jacks, and then permanently connected to the columns. The slab acts as the horizontal framing component eliminating beams, or structural elements other than the columns. | Not available. | 1. Building height is reduced since beams are eliminated, allowing maximum space for horizontal services distribution;<br>2. Form costs are minimal. | 1. Requires sophisticated erection equipment;<br>2. Technique is limited for high rise structure;<br>3. Column spacing must be uniform and not over 25 ft. center to center. |
| Terrapin Pack Building Units (Mark 36 Series) Terrapin Ltd., London, England (Non-hospital system) | Wood box frame units, folded packs are shaped to the site. Four "folded packs," comprising a site floor area of 800 sq. ft. can be transported on any standard truck. Exterior panels, doors, windows, etc. make up the folded packs. Mechanical equipment is also factory placed. | 95% of the cost of the unit is factory produced, 5% is site work. Unit price is $1800, or $9/sq. ft. | 1. Minimum on-site labor required. Off-site unit production increase efficiency and quality;<br>2. Units can be relocated without depreciating their quality since units are never reduced to component parts;<br>3. Fast, efficient erection. Three men can erect a 40 place classroom complete with mechanical and electrical services in a single day. | 1. Maximum widths are 25 ft. and heights, 10 ft. Plan flexibility is low;<br>2. Units need flat site. They can be erected on a sloping site;<br>3. Units are not manufactured in U.S.A. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: CONSTRUCTION
COMPONENT: CONSTRUCTION CONCEPTS

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Arbigrill (Redpath Dorman Long, Engineers) (Non-hospital system) | A British construction technique employing composite steel beam and concrete construction. A grid of precast panels resting on stool beams with holes at 2 ft. centers for services is topped with 2 inches of cast-in-place concrete flooring. The gridwork forms 1 ft. 6 in. sq. clear spaces for vertical services adjacent to beams, and 1 ft., 6 in. by 6 ft. 8 in. elsewhere. A 3/4 in. diameter gridwork is placed in the floor to suspend ceilings, service pipes and ducts. | Not available. | 1. Composite construction results in minimal beam depth and overall height;<br>2. The structural grid early in the planning period enables designers to lay outduct and service runs with confidence;<br>3. Reduced construction time. | 1. Holes in beams cannot accommodate large ducts;<br>2. Double beams might be needed at beam line if holes for services along the beam line are necessary. |
| Sectra System (Non-hospital system) | A system developed in France for the industrialized production of fire-proof, multi-story, load-bearing concrete structures. Load-bearing floors, walls, and roof slabs are monolithically cast on inverted U-shaped heated steel forms in a 24-hour production schedule, on-site, in place. | Cost savings estimated at 14% to 25% under conventional building costs. | 1. Meet ACI codes;<br>2. No special labor skills required; does not depend on a factory for production;<br>3. Time savings of up to 50% of conventional building with year-round production and maximum use of industrialized subsystems;<br>4. Good for high rise structures. | 1. Not readily available in the U.S.A.;<br>2. Requires large crane;<br>3. Good only for floor plans with transversal bearing cross walls; limited flexibility;<br>4. Very inflexible internal space divisions available and limited change capability. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: CONSTRUCTION
COMPONENT: CONSTRUCTION CONCEPTS

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Balency System (Non-hospital system) | A French-Italian structural system using precast wall slabs and special functional castings with poured-in-place floor slabs. Electrical wiring, radiant heat tubing, and complete plumbing trees are cast in, ready to receive fixtures, as are precast fabricated toilet compartments. | For apartment dwelling units, reportedly $13,000 per unit, (at Poughkeepsie luxury high-rise apartments). | 1. Considerable construction time saved; 2. Construction is largely independent of weather. | 1. Requires specially designed trailers to bring components from factory to site; 2. The size of the project must be large enough to cost justify building a production facility; 3. Extremely limited initial space arrangements; almost no change capability; 4. Long spans not obtainable. |

# BIBLIOGRAPHY - CONSTRUCTION


Adaptable Building System for Progressive Patient Care. College Station, Texas: Texas A&M University, December 1967.

Agron, George. Systems Analysis and Hospital Programming. Speech presented at American Hospital Association's Institute on Hospital Design, El Paso, Texas, 1970.

AMSCO. Spectra. Promotional brochure prepared for American Hospital Association Convention, 1969.

"Assembly Line for that Dream House." New York Times (February 1, 1970):E-3.

Barnett, Jonathan. "The Computer Revolution: How Does It Affect Architecture ... and How Can Architects Best Exploit Its Powerful Potential?" Architectural Record (July 1966):168-70.

Bèthlehem Steel. Greater Baltimore Medical Center. Promotional Brochure No. 2451.

"Bison (Concrete Limited)." Hospital Building and Engineering (September 1969):33.

Boice, John R. ed. Building Systems Information Clearinghouse Newsletter 1 (Spring 1969).

"British Lift Slab." Hospital Building and Engineering (September 1969):30.

British Steel Corporation. Design in Steel: Speeding Hospital Construction. Promotional Brochure.

"British Transplant Hospital." Progressive Architecture (September 1968):116-23.

Canada Department of Industry. Industrialized Building. Lectures and Proceedings to a National Conference on a Systems Approach to Building, April 29-30, 1968. Ottowa: Queen's Printer and Controller of Stationery, 1968.

Canada Department of Industry. Modular Coordination. Proceedings of Conference on Modular Construction, Ottowa, October 17 — November 1, 1967. Ottowa: Queen's Printer and Controller of Stationery, 1967.

_____. Report of the Canadian Technical Mission on Prefabricated Concrete Components in Industrialized Building in Europe. Ottowa: Queen's Printer and Controller of Stationery, 1966.

_____. Report of the Canadian Technical Mission on the Use of Prefabricated Steel Components in Industrialized Building in Europe. Ottowa: Queen's Printer and Controller of Stationery, 1967.

Construction Systems, Inc. The Perforated Joint System. Promotional Brochure, 1969.

Coreale, William. "Building Codes and Industrialized Building." Speech presented at Industrialized Building Technology Seminar, sponsored by Technical Forum Association, October 14-15, 1969.

Crane, David A. Technologies Study: The Application of Technological Innovation in the Development of a New Community. Washington, D. C., 1968.

Department of Education and Science. Building Bulletin 42: The Coordination of Components. London: Her Majesty's Stationary Office, 1968.

Dietz, Albert G. H. "Building Technology: Potential and Problems." Speech presented at Industrialized Building Technology, sponsored by Technical Form Association, October 14-15, 1969.

Electro Systems, Inc. Multi-Wall: A New Tool for Hospital Room Modernization. A.I.A. 22A. Promotional Brochure, Richmond, California, 1969.

Fischer, Robert E. "Systems Building: What it Really Means." Architectural Record (January 1969):147-54.

Fischer, Robert E., and Walsh, F. J. "What the Systems Approach Means to Air Conditioning: Part 1." Architectural Record (April 1969): 197-204.

_____. "What The Systems Approach Means to Air Conditioning: Part 2." Architectural Record (August 1969):151-8.

*Florida Schools Magazine*. (December - January 1967-1968).

"Gardiner Building Systems." *Hospital Building and Engineering* (September 1969):39.

Hardless, Trenor, ed. *Europrefab Systems Handbook.* London: Interbuild Prefabrication Publications Ltd., 1969.

"Health Care." *Progressive Architecture* (February 1969):94-140.

"High-rise Hotel Construction Speeded by Prefabbing Concrete Boxes Off-site." *Architectural Record* (January 1968):163-6.

Honeywell Ltd. *Modular Operating Theatre Systems.* Promotional Brochure No. SAH1.

*Hospital Literature Index.* Vols. 24, 25. Chicago: American Hospital Association, 1968.

"Industrialized Systems Building Can Curb the Rising Cost of Our Hospitals and Health-Care Facilities." *Texas Hospitals* (December 1968).

"Integrating Ducts With Concrete Floor Structures." *Architectural Record* (May 1969).

*Introduction to the First SEF Building System.* Toronto: Metropolitan Toronto School Board, n.d.

Jacques, Richard G. "Performance Criteria." *Architectural Record* (May 1966):191-5.

"Long Spans Support Double Floor Construction." *Hospitals, J.A.H.A.* (April 1, 1967):36.

MacGuire, Hugh C. "Atomedics: New Name for Space Age Medicine." *Canadian Doctor.*

Mann, George J. "Corporations and the Evolving Building Process." *Michigan Business Review* 21 (July 1969):13-17.

_____. "Future Hospitals Will Go Where The People Are." *Modern Hospital* (June 1968).

Mann, George J., and Patterson, James. "Design Project Aims at Bringing New Flexibility to Hospital Interiors." Hospitals, J.A.H.A. 41 (August 1, 1967):51-6.

Mann, George J. and Schmitz, Gunter. Prototype Ward Building System for Texas Department of Mental Health and Retardation. Mimeographed. College Station, Texas: Texas A&M University, 1969.

Ministry of Health. Development Project No. 3: Greenwich District Hospital. London: Her Majesty's Stationary Office, February 1968.

______. Health Service Design Note No. 20: Standardization in Hospital Building. London: Her Majesty's Stationary Office, October 1968.

______. Hospital Design Note No. 1: Dimensional Coordination and Industrialized Building. London: Her Majesty's Stationary Office, February 1964.

______. Hospital Design Note 2: Protection Against Fire. London: Her Majesty's Stationary Office, September 1965.

Ministry of Public Buildings. Bibliography on the Application of Computers in the Construction Industry 1962-1967. London: Her Majesty's Stationary Office, 1968.

Ministry of Public Building and Works. Dimensional Co-ordination for Building. London: Her Majesty's Stationary Office, 1968.

______. Going Metric in the Construction Industry. London: Her Majesty's Stationary Office, 1968.

______. Industrialized Building: Four Case Studies of the Selection of a Main Contractor. London: Her Majesty's Stationary Office, 1966.

______. Sound Insulation and New Forms of Construction. London: Her Majesty's Stationary Office, August 1968.

National Academy of Engineering. Costs of Health Care Facilities. Washington, D. C.: National Academy of Sciences, 1968.

"Nottingham Teaching Hospital." Hospital Building and Engineering 2 (November 1969):4-7.

Page, Clinton A. "SEF: First Open System for Schools." Architectural and Engineering News (May 1969):41-2.

Parslow, Robert, and Paulden, Sydney. "Design and Costing by Computer Graphics." Hospital Building and Engineering (September 1969):5-8.

Patterson, James. Adaptable Building System: Progressive Patient Care. College Station, Texas: Texas A&M University, 1968.

Portland Cement Association. Duotek Promotional Brochure No. PA0008.01 (01), 1969.

Portland Cement Association. Triposite. Promotional Brochure No. XS56843.

"Redpath Dorman Long." Hospital Building and Engineering (September 1969):42.

Relocatable Multiphasic Health Screening Two Systems. College Station, Texas: Texas A&M University, July 1969.

Rothenstein, G. "System Building Can Cut Hospital Construction Costs." Modern Hospital (August 1967):147.

"RX for Hospital Construction." Industrial Design (July-August 1969):30-7.

"Sanders and Forster" Hospital Building and Engineering (September 1969):45.

Sane, Dean N. "Victoria Union Hospital Complex at Prince Albert Gets Total Energy Installation." Canadian Hospital 45 (September 1968): 54-67.

Schmitz, Gunter. "Industrialized Components for Health Facilities." Paper presented at AIA/ACSA Teacher's Seminar, Montreal, 1968.

Schoolhouse Systems Project, Third Report. Tallahassee, Florida: State Department of Education, September 1968.

SCSD: The Project and the Schools. New York: Educational Facilities Laboratories, 1967.

Spurgeon, David. "McMaster Project: A Radical Departure from Presently Known Teaching Hospitals" Canadian Hospital (September 1968): 68-9.

"Staggering Trims Weight." Engineering News Record (March 1969):51.

"Structural Sandwich for VA Hospital." Architectural and Engineering News (May 1969):88-9.

"Structure Delivers Air and Controls Light." Architectural Record (July 1964):180-4.

"Trent Concrete." Hospital Building and Engineering (September 1969):46.

University of California. Contract Documents and Performance Specifications. Berkeley, California: URBS Publication (1), June 1967.

_____. Performance Specification Illustrative Information. Berkeley, California: URBS Publication, March 31, 1967.

_____. Storage Study. Berkeley, California: URBS Publication (4), October 1967.

_____. Student Housing Cost Study. Berkeley, California: URBS Publication (3), October 1967.

_____. User Requirements. Berkeley, California: URBS Publication (5), April 1969.

U. S. Public Health Service. Publications of the Health Facilities Planning and Construction Service. Washington, D. C.: U. S. Government Printing Office, 1968.

_____. Representative Construction Costs of Hill-Burton Hospitals and Related Health Facilities. Washington, D. C.: U. S. Government Printing Office, January - June 1969.

"Vierendeels Aid Hospital Support." Engineering News Record (August 29, 1968):40.

"Walls Move When Hospital Grows." Engineering News-Record (October 10, 1968):37-8.

"Zwei Universitatskliniken." Deutsche Bauzeitung Die Bauzeitung. (November 1969):716-24.

# DENTISTRY

## INTRODUCTION

Dentistry in 1970 is searching for methods of providing more individuals with improved health care at a cost which is within their means. To accomplish this, dentistry must devise techniques whereby the dentist can provide more services in the same amount of time. The development of high speed cutting instruments in recent years has been a giant step in this direction and has stimulated much of the new exploration in the field of dental practice.

The present imbalance between the population's dental needs and the number of available dentists constitutes a national problem. A literature review has shown that it is unlikely that there will ever be enough dentists to fill those needs. Currently, there are 90,000 practitioners in the U.S. Based on projected population increases, this figure would need to be more than doubled in the next ten years just to maintain the status quo.

It is estimated that over 90 percent of the population have dental caries, over half the adult population suffers from peridontal disease, and more than 20,000,000 people in the U.S. have lost all their natural teeth. Moreover, of the total reported cases of cancer, five to ten percent are found in the mouth. One prescription for the nation's dental ills is periodic dental inspection to detect deviations and treat them before extensive damage occurs. Yet only 20 percent of the population receive regular and adequate dental care, and only 40 percent receive any care at all. One reason for this situation is that the ratio of people qualified to perform dental care is one to every 1900 people who need it.

Clearly, the problem of increased productivity is the greatest single challenge faced by modern dental medicine. Meeting this challenge will involve revision of traditional concepts in the areas of dental methodology;

of utilization and training of ancillaries; of design and function of equipment, instrumentation, and operatory space. Innovations must be evaluated in terms of their effect upon treatment capability, with maximum dentist efficiency the ultimate goal.

## TECHNICAL APPROACH

In surveying the state of the art in dentistry, we first conducted a literature search including periodicals such as the Journal of the American Dental Association and the Journal of Canadian Dentistry, proceedings of dental conferences, and reports generated by the Public Health Service, the U. S. Navy, and the U. S. Air Force. (A bibliography is included at the end of this section.)

On March 26, 1970, we visited the Health Center at the University of Alabama in Birmingham, Alabama. Under the direction of Dr. Arthur H. Wuehrmann and Dr. Glenn E. Robinson, this school has pioneered new designs in equipment and its arrangement in the dental operatory. It was among the first to do extensive experimentation with four-handed dentistry concepts and to introduce them to others. Moreover, it is recognized for its leadership in demonstrating how auxiliaries can be used most effectively and in defining the expanded duties that may be assigned to them.

The Dental Health Center of the Public Health Service in Louisville, Kentucky was visited on March 27, 1970. For the past three years the health center has been conducting dental studies on subjects such as the ratio of the number of operatories to dentists and to auxiliaries, what procedures auxiliary personnel should perform, and how auxiliaries should be trained.

On April 9, 1970, a meeting was held in Washington, D. C., with representatives of the Army, Air Force, and Navy dental corps. In attendance were:

Colonel James E. Cassidy, Chief, Professional Branch Office,
Assistant for Dental Services, Office of the Surgeon General,
U.S. Army, Washington, D. C.

Colonel Robert C. Walters, Dental Research and Clinical
Requirements Office, Assistant Surgeon General for Dental Services,
U.S. Army, Washington, D. C.

Captain E. F. Sobieski, Planning and Logistic Branch Office,
Assistant Chief for Dentistry, Bureau of Medicine and Surgery,
U.S. Navy, Washington, D. C.

Other persons contacted for discussion or information include:

Dr. Charles O. Cramford, Acting Chief, Manpower Development Branch,
Division of Dental Health, Bethesda, Maryland

Dr. Richard Ribisli, Manpower Development Branch,
Division of Dental Health, Bethesda, Maryland

Dr. Stanley Lotzkar, Associate Director,
Education and Manpower Training,
Bureau of the Health Professions,
Divison of Dental Health, Bethesda, Maryland

Dr. Frank Burdick, Chief of Dental Services,
Veterans Administration Hospital,
Pittsburgh, Pennsylvania

Dr. Daniel Meadows, Chief of Dental Service,
Veterans Administration Hospital,
Birmingham, Alabama

Dr. Keith Marcroft, Staff Prosthodontist
Veterans Administration Hospital,
Birmingham, Alabama

Dr. Jame Austin, Staff Dentist
Veterans Administration Hospital,
Birmingham, Alabama

## STATE OF THE ART

The general trends in dentistry are:

1. To treat the patient from a seated rather than a standing position.
2. To practice four-handed dentistry in the treatment of the supine patient.
3. To redesign equipment to meet the needs of four-handed dentistry.

4. To increase productivity through effective utilization of auxiliary personnel.
5. To design effective multiple operatories.
6. To improve dental radiography.
7. To improve operatory illumination.
8. To improve dental sterilization.
9. In the military to provide comprehensive dental care to service personnel and their dependents.
10. To establish preventive dental care facilities.

Sit-down Dentistry

The traditional posture for performance of dental procedures requires the dentist to stand while the patient sits in a slightly reclining position. The dental chair is constructed so that adjustments to the back and headrest are frequently needed to make the patient comfortable and to improve the visual approach of the operator. Other pieces of equipment are bolted to the floor in such positions that auxiliary personnel cannot be utilized effectively. In addition, dental assistants and other personnel, not having been trained to work efficiently, in most instances represent only a combination of a part-time chairside assistant, receptionist, bookkeeper, and janitor.

Investigators, both individually and in groups, have studied the strengths and weaknesses of conventional dentistry methods. Their findings and field reports, which show that most dentists are anxious to abandon the conventional stand-up method, are largely responsible for the trend toward sit-down dentistry. This trend is likely to accelerate in the 1970's since dental students are being trained in this approach.

The new posture overcomes the chief drawback of the old -- fatigue and the concomitant erosion of performance efficiency. Although some older dentists have difficulty working while seated and a few patients resist the supine position, the major roadblock to widespread utilization of the sit-down method has been the unsuitability of most standard dental equipment. It has proved to be both inconvenient for the dentist and uncomfortable for the patient. The solution to this problem lies in the redesign of equipment and the implementation of four-handed dentistry.

In two-handed dentistry the dentist works alone. Although he may employ an assistant, the assistance given is indirect, consisting of seating the patient, positioning equipment, mixing amalgam, and performing other extra-oral tasks.

Conversion to sit-down dentistry changes this picture. The mouth of the supine patient is now accessible to a second pair of hands. The dental assistant works directly in or near the oral cavity, relieving the dentist of routine treatment tasks. The assistant also relays instruments, equipment, and materials as the need arises so that the seated dentist need not leave the immediate area of the patient's mouth to complete the operation.

At the present time dental schools have federally supported programs to teach four-handed sit-down dentistry, and complementary programs for dental ancillaries are developing in junior colleges. Some high schools now offer dental assistant programs in conjunction with the 11th and 12th grade academic course and have produced trainees with excellent potentials. It may be possible for these students to attend a junior college or dental school program with advanced standing. High schools are also considering the possibility of adding a post-high school year for additional training. At this time, students completing high school programs are not certified by the Council for Dental Education of the American Dental Association. But as these programs develop, it is likely that requirements for certification will be reviewed.

The practice of four-handed dentistry is complicated at present by the limitations of state dental regulations. Most state codes are prohibitively restrictive, and only a few are broad enough to permit expanded duties by a dental assistant. An example of enlightened dental regulation is the 1967 revision of the Rules and Regulations of the Pennsylvania law:

> A legally licensed and registered dentist may delegate to competent dental auxiliary personnel those procedures for which the dentist exercises direct supervision and full responsibility except as follows:
>
> (1) Those procedures which require professional judgment and skill such as diagnosis and treatment planning and the cutting of hard and/or soft tissues or any intra-oral procedure which would lead to the fabrication of an appliance which, when worn by the patient, would come in direct contact with hard or soft tissue and which could result in tissue irritation or injury.
>
> (2) Those procedures allocated by the Dental Law to Registered Dental Hygienists.

Nation-wide enactment of similar changes will enable auxiliary personnel to assume the additional responsibilities required in four-handed dentistry.

Adaptation of Equipment

The efficiency of sit-down four-handed dentistry depends, to a large extent, upon the functional compatibility of the dental equipment.

New designs for the standard dental chair reduce the thick head rest and increase the degree of recline. With the chair lowered to a completely horizonal position, the seated dentist and his seated assistant can work in comfort with unimpaired visibility.

Streamlined cabinetry design places the work surface over the chairside assistant's lap at elbow height. All restorative materials and essential equipment are readily accessible so that the assistant need not leave the operating area, reach excessively, or open special compartments. The cabinet is mobile and no larger than necessary to accommodate the usual instruments and materials for one or more types of operation.

The problem of developing equipment to meet the needs of sit-down four-handed dentistry has received a great deal of attention in dental schools across the country. The University of Pittsburgh School of Dental Medicine was the first to achieve a large-scale breakthrough in this area. Although a number of mobile dental units had previously been designed and sold on a limited basis, it was in 1964 that the faculty of the Pittsburgh School along with the S.S. White Dental Manufacturing Company developed a mobile unit that was both functional in design and educational in purpose. Two hundred and eighty six operatories were equipped with this unit which is connected to the floor by a umbilical cord arrangement for utilities that enables the unit to be easily moved within the operatory. The College of the Pacific in California has developed a unit similar to it, with the exception that it is larger and contains additional compartments. These units contain retractable hoses which limit their range of operation. The use of non-retractable hoses would permit a reduction in the size of the unit and provide more flexibility in the utilization of the instruments. The University of Alabama is a leader in the field of equipment experimentation. New designs initiated there include a mobile dental cabinet, a stainless steel preset tray, and the "Dentassist" chairarm equipment attachment.

Research on dental equipment is continuing. New designs with built in flexibility will continue to appear on the market to meet individual needs, such as those of the ever increasing number of practitioners who are left-handed.

Utilization of Auxiliary Personnel

There is a growing awareness of the fact that the skills of auxiliary personnel constitute an insufficiently-tapped resource for augmenting productivity. Support personnel such as the receptionist, the clerk, the sterilizing aide, and the "roving" assistant who seats and drapes the patient and cleans up the operatory, can relieve the dentist of time-consuming chores. The hygienist, the assistant, and the technician, have valuable skills that can be utilized to significantly increase the dentist's treatment capacity. Creation of a new category of auxiliary personnel termed by some a "dental therapist" is presently under consideration. Also under consideration is the professional dental administrator whose function would be similar to that of the hospital administrator in areas such as staffing and administration of areas other than those involving professional judgments.

The practice of four-handed dentistry represents an advancement in the utilization of auxiliary personnel. This takes the form of intensified auxiliary involvement in the treatment process and is the basis of what is called the "team" approach to dentistry. It is achieved by expanding the duties of qualified assistants to include certain routine treatment procedures usually performed by the dentist, such as pumice prophylaxis, exposure of X-ray film, rubber dam application, suture removal, cavity toilet, adaptation of the matrix and the placement of restorative materials.

The dental team can be used for either stand-up or sit-down dentistry and is flexible both in composition and in function. Experiments have been conducted using two, three, or four assistants per dentist, serving in various roles at from one to four chairs. All combinations showed an increase in productivity in ratios up to 120 per cent, although some four-chair tests proved overtaxing to the dentist. Studies by the Navy and the Public Health Service indicate that the most efficient team consists of one dentist, three assistants, and one roving assistant serving three operators. It should be noted that efforts to evaluate patient objections failed because none of the patients expressed any objections.

Dental schools now have Dental Auxiliary Utilization Programs which introduce students to the team concept and teach them how to function effectively within its framework. In these programs dental students work with auxiliaries in treatment situations. Assistants may be trained auxiliaries, of which there is a severe shortage, if the school is one of the few that offers a training program for dental assistants or they may be fellow students. It is expected that this team training will have a significant impact on the practice of dentistry within five years. More accurate projections cannot be made until the legal aspects of para-dental assistance are clarified.

Operatory Design

Optimum utilization of space is a corollary of optimum utilization of auxiliary personnel. The productivity potential of the dental team can best be realized in a multiple operatory facility arranged in one of three basic patterns. The circular arrangement in essence provides a centralized supply area for servicing multiple operatories with a minimum expenditure of time and effort (Figure 1). To be most effective the dentist is stationed at the outside of the wheel where there is the greatest amount of space and where he can move easily to each operatory. The rectangular layout (Figure 2) uses parallel operatories separated by dividers. Special dental areas, such as oral surgery, perodontics, and endontics may be allocated separate rooms. A private office type of arrangement could be useful for a small facility, but somewhat limiting on a large scale because of the difficulty involved in communicating between offices and the service area.

There is a division of opinion concerning the optimum height of the operatory divider. It may extend to the ceiling for the privacy of the patient or stop at about the four-foot level so the dentist can supervise the delegated procedures being performed in each operatory by the assistants. Patients treated sitting in an upright position can easily see over the top of a four-foot divider. But with the patient in a supine position and with both the dentist and assistant sitting, the four-foot height provides adequate seclusion.

Dental Radiography

Traditionally, dental schools did not offer comprehensive training in dental radiography. Such training was usually limited to the 65 kilovolt, 10 milliampere X-ray technique with some instruction in the potential benefits of higher kv techniques and the basic principles of photochemistry.

Now the trend is toward 90 kv X-ray equipment. This trend is reflected by the fact that all X-ray machines currently produced are capable

FIGURE 1. Circular Multiple-Operatory Design.

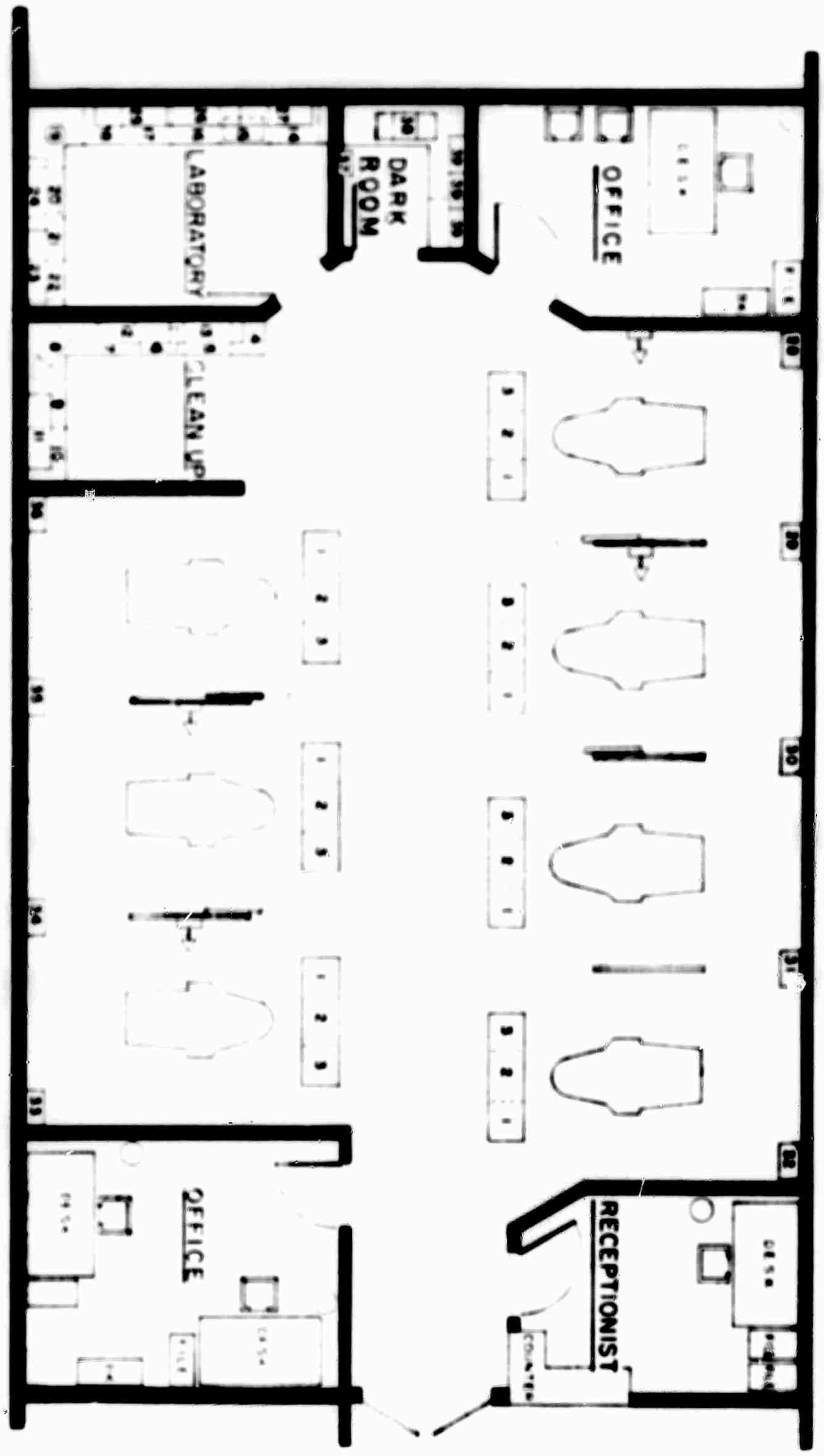


Figure 2. Rectangular Multiple Operatory Design

of 90 kv. With higher kv capacity, there is better resolution, less distortion, lower radiation levels through shorter exposure time, and a broader gray scale that shows a more distinct contrast between bone and tissue.

X-ray film developing is being simplified. Automatic film processors which give more consistent results in less time are gaining greater acceptance. Since these devices minimize processing defects arising from poor darkroom control, they all but obviate the need for retakes and unnecessary patient irradiation. The fact that the films produced can be used immediately for diagnosis aids in treatment and reduces the number of patient visits.

Another trend and the most significant innovation in dental radiography is the use of panoral X-ray machines for comprehensive oral diagnosis from one minimal exposure. The panoral X-ray machine is currently used by five to ten percent of practicing dentists. It is standard equipment for the Veterans Administration, Armed Forces, and the Public Health Department, and most major dental schools now teach their students how to use it.

The move toward simplicity of operation is also exemplified in machines, now available, which feature preadjusted voltages and currents and pushbutton compensation for film and cone variables.

## Illumination in Dentistry

Proper illumination reduces eyestrain and nervousness, and promotes higher quality and more efficient work. Because of the visual detail in dentistry, it is important to meet the following lighting criteria: (1) a minimum illumination of 1,000 foot-candles on the patient's chin; (2) a contract ratio of from 6:1 to 10:1 between the oral cavity and the surrounding light; (3) a color balance of the artificial light which approximates natural light, to make it easier to match the color of fillings to the teeth; and (4) light sources that can be easily moved from one position to another.

It is desirable, in addition, to have some ultraviolet radiation, to minimize the amount of heat which is emanated from a light source, and to use long lasting bulbs which show little or no change in light intensity and color balance with age.

Some dental lights on the market, such as the auratron tubes, fulfill many of the above requirements. An auxiliary point light for intraoral use would be useful, but its development has been hampered because most available light sources are too large and give off too much heat.

Fiber optical light sources are cool and compact. However, they are not yet fully accepted by the dental community, perhaps because they produce a diminutive bright spot of light which can cause visual discomfort, they require additional and more expensive specialized handpieces and increased bulk in handpiece size.

Sterilization in Dentistry

There is an ever-present danger in dentistry of cross-infection between patients and dentist if dental instruments are not sterilized properly. Methods of sterilization now in use include high temperature steam, dry heat, boiling water, alcohol vapor, and ethylene oxide. However, there is no agreement on which method or combination of methods is most reliable. Autoclaving, or sterilization through high temperature steam, is effective. Dry heat, which takes longer, is also an effective sterilizer; however, faulty temperature control mechanisms are common in commercial dry heat sterilizers which, of course, decreases their reliability. Boiling instruments in water at atmospheric pressure does not accomplish sterilization because some spores, as well as the hepatitis virus, survive long periods of boiling. The alcohol vapor sterilizer is preferred by some dentists because it does not corrode carbon steel cutting instruments. Although the sporicidal ability of the alcohol vapor sterilizer has been questioned by some research microbiologists both here and abroad, there is formidable evidence attesting to its effectiveness.

Ethylene oxide sterilizers, complete with vacuum pumps and humidity controls, are considerably more expensive. But since their sterilizing effectiveness is unquestioned, many prefer to use them. The low sterilization temperatures of these machines make it possible to sterilize handpieces without any deleterious effects on their intricate parts. The main drawback is the time it takes to sterilize -- from eight to ten hours.

Sterilized tray set-ups for each procedure provide both convenience and uniformity, as well as eliminate the large cabinets that are now used in most operatories. Prepared instrument trays are assembled in the central support area and stored in cabinetry accessible to the dental operatory. Cabinets located between the operatory and the support area with openings on both sides are most functional.

The use of disposable instruments is increasing and warrants further investigation. With such single-use instruments the problem of sterilization is automatically solved.

## Military Dental Care

Although the military ratio of dentists to patients is more favorable than the civilian ratio, a constant turnover of personnel makes it possible to provide only a small portion of the treatment required. In 1962 it was estimated that the dental treatment deficit in the Army exceeded 8,000,000 hours and currently it is almost double that amount. With a Dental Corps of 2800 officers which equals about 4,000,000 professional hours for treatment, it is possible to meet only 20 to 25 percent of the need for dental treatment. Actually, the oral health of men entering active duty is so poor that the initial treatment requirement they represent each year exceeds total treatment capability.

Since the need for dental care so greatly exceeds the capability for providing it, the Army Dental Corps Policy Committee set up the following order of priority for patient treatment:

1. Emergency care for all patients as quickly as possible.

2. Treatment of patients whose conditions have a high probability of interfering with duty performance or of patients with skills critically important to high priority military missions.

3. Mandatory preventive care for all personnel under 26 years old and for all patients receiving clinical treatment. Preventive care would be available for others on a voluntary basis.

4. Comprehensive, definitive care for career military personnel to be encouraged and, if results from prototype programs are favorable, to be required on an annual basis.

5. Definitive care for other military personnel to the extent resources permit.

6. Definitive care for other authorized personnel to the extent resources permit.

Utilization of auxiliary personnel, particularly those qualified to perform expanded duties, could equalize this unbalanced care/need situation. At present, however, the number of auxiliaries available is inadequate to fulfill the need. Predictions are that this shortage will continue for at least five years. Although the rate of training is improving, there is little hope that it will produce the number of required dentists unless the military establishment institutes its own training programs. If the training of auxiliary personnel becomes a major project for the military, then additional professional personnel must be provided for teaching purposes.

The fact that military dental care is in a critical condition becomes even more apparent when the status of military dependents is considered. These people have not, as yet, been incorporated into the military dental care program. Dental care is authorized only for dependents overseas or in remote areas and in emergency cases.

During hearings before the Senate Subcommittee on Health Benefits Legislation during the 89th Congress, Second Session, it was brought out that the military services consider the lack of a dental care program one of the major morale problems of the serviceman and his family. A survey taken by the Air Force in 1962 showed that 36 percent of the officers and 50 percent of the enlisted personnel questioned said that the provision of dependents' dental care would affect their decision as to extending their periods of service. According to the Surgeon General, "many military families have had to turn to relief sources for assistance in paying their dental bills."

On the other hand it is obvious that the uniformed dental services are just barely managing to care for active duty personnel. To triple their workload would be to cripple them severely in relation to the accomplishment of this primary mission. To solve the problem of dental care for dependents it may be necessary to make extensive use of civilian dentists, with split shift schedules for military dentists as a possible adjunct or alternative.

Legislative proposals to institute comprehensive dental care for military dependents is now under consideration. Action has been deferred pending the completion of studies on manpower and cost requirements.

## Preventive Dentistry

One of the most vital principles of dental medicine is preventive care. Preventive programs would include dental prophylaxis, topical fluoride application, and educational instructions, including audiovisual aids, relative to the prevention of dental disorders. Very little dental supervision would be needed because Registered Dental Hygienists are licensed to provide such services. For efficient operation and maximum utilization of the skills of the hygienist, support duties could be delegated to dental assistants. The cost of operating such a preventive care facility of this type would be minimal -- the benefits, maximal. A recent development of pit and fissure sealants should significantly increase preventive care capabilities. This procedure could well be included as a duty of an auxiliary.

There is agreement within the health professions that preventive dentistry facilities are needed, but authorities differ on the question of locale. Integration of each preventive care unit with a dental treatment facility would permit daily professional communications and offer patients a single facility for everything related to dentistry. If such were the situation, it would also be possible to include, as part of the preventive activity, radiology examinations, diagnosis, and treatment planning. Here there would be a facility that could be operated almost totally by auxiliary personnel with a minimum number of dentists to supervise, diagnose and plan.

From another standpoint preventive facilities lose more than they gain in affiliating with diagnostic or treatment areas. The reasoning is that patients should visit the preventive facility and come to regard it as a familiar place unconnected with treatment. To the patient, treatment frequently means anxiety or pain, and these associations should be avoided if possible. With negative associations removed, the patient will come to the preventive facilities more frequently and will be motivated to take a more active part in the program.

A third possibility involves the coordination of all health preventive care programs in one comprehensive facility. Since all such programs are closely related, the development of a total preventive health care program would be entirely feasible.

# BIBLIOGRAPHY — DENTISTRY


Abramovitz, J. "Expanded Functions for Dental Assistants: A Preliminary Study." Journal of the American Dental Association 72 (February 1966):386.

American Dental Association. Proceedings of Conferences on Utilization and Training of Dental Assistants, September 13-15, 1960.

Baird, K. M.; Purdy, E. C.; Protheroe, D. H. "Pilot Study on the Advanced Training and Employment of Auxiliary Dental Personnel in the Royal Canadian Dental Corps: Final Report." Journal of Canadian Dentistry (December 1963):778-87.

Baird, K. M.; Shillington, G. B.; Protheroe, D. H. "Pilot Study on the Advanced Training and Employment of Auxiliary Dental Personnel in the Royal Canadian Dental Corps.: Preliminary Report." Journal of Canadian Dentistry (October 1962):627-38.

The Business of Dental Practice. Stamford, Conn.: Professional Publishing Corporation, January 1969.

Cassidy, J. E. "Present Status of Dental Care in the U.S. Army." Personal Communication, April 1970.

Dental Clinics of North America. Practice Administration. Philadelphia: W. B. Saunders, 1967.

Dental Law of Pennsylvania, Rules and Regulations as Revised 1967.

Ehrlich, A. B. and Ehrlich, S. F. Dental Practice Management. Philadelphia: W. B. Saunders, 1969.

Frank, J. E., et al. "School Dental Care in a Community with Controlled Fluoridation." Public Health Report 79 (February 1964):113-24.

Hollinshead, B. S. Survey of Dentistry in the United States: Final Report. American Council on Education, 1961.

Kilpatrick, H. C. High Speed and Ultra High Speed in Dentistry. Philadelphia: W. B. Saunders, 1959.

Kilpatrick, H. C. Work Simplification in Dental Practice. Philadelphia: W. B. Saunders, 1969.

Klein, Henry. "Civilian Dentistry in War-time." Journal of the American Dental Association 31 (May 1944):648-61.

Knoll, O. J. Clinical Investigation #186 Dental: Final Progress Report. United States Air Force, November 1968.

Law, F. E.; Johnson, C. E.; and Knutsen, J. W. "Studies on Dental Care Services for School Children: First and Second Treatment Series, Woonsocket, Rhode Island." Public Health Report 68 (December 1953): 1192-8.

__________. "Studies on Dental Care Services for School Children: Third and Fourth Treatment Series, Woonsocket, Rhode Island." Public Health Report 70 (April 1955):402-9.

Ludwick, W. E.; Schnoebelin, E. O.; Knoedler, D. J. Greater Utilization of Dental Technicians, I: Report of Training. United States Navy, August 1963.

__________. Greater Utilization of Dental Technicians, II: Report of Clinical Tests. United States Navy, May 1964.

McCallum, C. A., Jr. "New Decade - New Decisions." Presidential Address, American Convention of Dental Schools, March 20, 1970.

Nelsen, R. J.; Pilander, C. E.; and Kumpula, J. W. "Hydraulic Turbine Contra-Angle Handpiece." Journal of the American Dental Association 47 (1953):324-9.

Perkins, J. J. "Principles and Methods of Sterilization." Directory of Research. American Sterilizer Company, 1956.

Report of the National Advisory Committee on Health Manpower. Vol. 1. Washington, D. C.: U.S. Government Printing Office, November 1967.

Robinson, G. E., et al. "Four-handed Dentistry: The Whys and Wherefores." Journal of the American Dental Association 77 (September 1968).

Sinnett, G. M., et al. "Four-handed Dentistry: A New Mobile Dental Cabinet Design." Journal of the American Dental Association 78 (February 1969).

Soricelli, D. A. "A System of Quality Control for Dental Care." Paper read at 21st National Dental Health Conference, May 7-9, 1970, Chicago, Illinois.

Stinaff, Robert K. Dental Practice Administration. St. Louis: C. V. Mosby, 1968.

Survey of Dental Practice, 1968. Journal American Dental Association 79 (November 1969):1202.

U. S., Congress, House, Subcommittee on Military Dental Care. Dental Care Needs of Military Dependents. Nineteenth Congress, July 25-26, 1967.

Waterman, G. E. "Effective Use of Dental Assistants." Public Health Report 67 (April 1952):390-4.

Waterman, G. E., and Knutson, J. W. "Studies on Dental Care Services for School Children: Third and Fourth Treatment Series, Richmond, Indiana." Public Health Report 69 (March 1954):247-54.

## DIETARY

### INTRODUCTION

Dietary service is a fundamental part of the Base Level Health Care System. It not only fills the ordinary nutritional needs of hospital patients and personnel but also assists in therapy by providing special diet meals tailored to individual patients and by educating patients to cope with restricted diets once they leave the hospital. The hospital food service system, moreover, may also influence patient morale and the hospital's overall public relations program.

The general objectives of the dietary system are to provide a high quality meal at minimum cost and to effect efficient meal delivery. To achieve these goals the following considerations should be taken into account:

1. Is the meal nutritionally balanced, flavorful, and aesthetically pleasing?
2. Is the food free of harmful bacteria?
3. Is the regular patient offered a sufficient variety of foods?
4. Do dietitians regularly consult with patients on restricted diets and with their physicians to develop specialized menus that offer tasty food in sufficient variety?
5. When the patient receives his meal, is it as palatable as it was when first cooked, or has it lost flavor due to freezing or prolonged warming?
6. Do heated foods arrive at patient rooms at a sufficiently high temperature, and do refrigerated foods arrive cold?
7. Can individual meals be efficiently prepared and served at times other than regular meal times?
8. Are kitchen personnel and equipment utilized for maximum efficiency?

9. Is the food preparation workload distributed throughout the day to ease peak or crisis periods?
10. Is the meal being produced at lowest cost?

## TECHNICAL APPROACH

We initiated our state-of-the-art survey of hospital food service by commissioning Thomas E. Terrill of the University of Pittsburgh to prepare a brief description of current hospital food service operations. To supplement this information we made an extensive review of current trade and professional journals. Pertinent articles are listed in the bibliography at the end of this section.

To directly observe innovative food service operations, on-site visits were made to the following locations:

| Location | Food Concept |
|---|---|
| Greenville Hospital System<br>Greenville, South Carolina | Shared hospital commissary; convenience foods |
| Rahway Hospital<br>Rahway, New Jersey | Total convenience food; all disposable ware |
| Mercy Hospital<br>Buffalo, New York | Total convenience food; outside food service management; automated distribution; and disposable ware |
| Kaiser Hospitals<br>Redwood City, California<br>Oakland, California<br>Panorama City, California | Total convenience foods |
| Tulane University<br>New Orleans, Louisiana | Computer assisted menu planning |
| Heinz Manufacturing Company<br>Pittsburgh, Pennsylvania | Freeze dried food products |

| | |
|---|---|
| AMSCO Systems Company<br>Erie, Pennsylvania | Abbreviated kitchen for convenience foods |

Requests for product and service information were made to the following firms:

| Manufacturers | Product or Service |
|---|---|
| American Retailers of America<br>Philadelphia, Pennsylvania | Food vending and management |
| Champion Dishwashing Machine Company<br>Division of AMSCO<br>Winston-Salem, North Carolina | Scullery equipment |
| Hospital Dietetics, Inc.<br>Division of Interstate United Corp.<br>Chicago, Illinois | Dietary management |
| Hospital Dietary Service, Inc.<br>Chicago, Illinois | Food management services |
| Market Forge<br>Everetts, Massachusetts | Food processing equipment |
| Marriott Corporation<br>Washington, D. C. | Food management and catering service |
| Hobart Manufacturing Company<br>Troy, Ohio | Food processing equipment |
| Institute Magazine<br>Chicago, Illinois | Studies in food service operating characteristics |
| Continental Metal Products<br>Waburn, Massachusetts | Microwave ovens |
| Westinghouse Major Appliance Division<br>Mansfield, Ohio | Microwave ovens |

| | |
|---|---|
| Better Built Company<br>Saddle Brook, New Jersey | Rack Washers |
| United Service Equipment Company<br>Murfreesboro, Tennessee | Wheeled equipment |
| Campbell Soup Company<br>Camden, North Carolina | Food products |
| Disposable Association<br>New York, New York | Disposable dinnerware and flatware |
| Lily Tulip<br>Toledo, Ohio | Disposable dinnerware and flatware |

## STATE OF THE ART

A hospital dietary department by its very nature has an unpredictable number of patients and visitors to serve and a fluctuating number of restricted diet meals to prepare each day. The introduction of the selective menu which accommodates patient preferences makes it even more difficult to forecast food demands. Such a forecast is necessary because food preparation requires a significant amount of time and both over- and under-production are costly miscalculations. Increasing wage rates and decreasing availability of skilled dietary workers presents yet another problem. Consequently, hospitals are being forced to examine both the logic of using convenience foods that can be heated quickly when exact demands are determined and the possibility of passing the onus of labor on to a food manufacturer. The general trend in dietary is, then, to reduce hospital time spent in food processing by one or more of the following alternatives:

1. Purchase bulk food pre-prepared in some measure.
2. Cook food in double or triple quantities and freeze for future use.

3. Use pre-prepared, pre-cooked food purchased from an outside supplier or from a hosp'tal-sponsored commissary kitchen.
4. Hire a caterer to provide total food services.
5. Use speed cooking equipment, such as convection and microwave ovens.
6. Use disposable ware to eliminate part or all of the ware washing and sanitizing processes.
7. In a systems approach use computers to control all aspects of food production.

No single food service alternative or combination of alternatives is optimal for all hospitals. The selection of one or more of the above dietary measures depends on the location and size of the hospital, the availability and cost of labor and land, the location and number of surrounding health care facilities, the availability of qualified convenience food suppliers or caterers, and the state of existing kitchen facilities.

1. Purchase of Pre-prepared Raw Food

The purchase of pre-prepared raw food represents only a small step towards a convenience food system. These foods are generally purchased by hospitals devoted to conventional cooking but which are willing to pay a food cost premium to save hospital personnel time and food preparation kitchen space. Of course, pre-prepared raw foods have been used for many years, e.g., canned or frozen raw vegetables, but their use is being expanded to include such things as peeled potatoes, pared apples, and oven-ready meats and poultry.

2. Cooking Large Quantities and Freezing for Future Use

Cooking entrees in double or triple quantities is another means of conserving hospital personnel time. One portion is served directly to the patients, and the other portions are preserved for future use. Food costs are reduced because some bulk purchasing is possible, and labor savings result from an elimination of repetitious preparation tasks.

### 3. Convenience Foods from an Outside Supplier or Commissary Kitchen

The trend toward bulk food production with its resultant labor and food cost savings is maximized in a total convenience food system. Such a system is seldom found in its pure form -- where every food item, even salads and special dietary foods, are purchased in a ready-to-serve state. At the present, most of the hospitals using this plan have adopted some variations of the system, for example, using pre-prepared entrees only or using convenience food only for regular diets and providing a small kitchen for special diet meal preparation. There are, however, several Kaiser Foundation hospitals in California that have totally adopted the system from their inception and were built without any major kitchen facilities.

In a total convenience food system, food may be processed by an outside supplier or by a hospital-sponsored commissary kitchen (a food processing center funded by several participating hospitals). In either case, convenience food preparation generally takes the following form: food items are prepared; they are either conventionally cooked and then packaged, or packaged and then cooked in a water bath; the items are quickly cooled and then refrigerated or blast frozen. The food is delivered to participating hospitals in refrigerated trucks or packed in crushed ice in unrefrigerated trucks. The food is then heated in electronic ovens or water baths either in the central kitchen or in decentralized nursing unit kitchens. The hospitals thus serviced are no longer in the restaurant business, and hospital dietary functions are reduced to food heating and nutritional control of patients' food.

The convenience food system offers savings in labor, food costs (due to bulk purchasing), and kitchen space and equipment. Over- or under-production is eliminated, for only required food is heated, and there is little food waste. Flexibility is ensured, for a large increase in the number of patients can be easily handled; moreover, single meals can be served with little difficulty at times other than regular meal times.

If an outside proprietary supplier is used, food costs, of course, will be higher and food quality control is more difficult. A commissary kitchen, on the other hand, is a non-profit business and can offer satellite hospitals lower food costs and more direct quality control.

If the hospital commissary kitchen concept is adopted, two alternatives are feasible. The kitchen of one hospital can be expanded to accommodate the additional equipment and personnel necessary for bulk food production, or separate kitchen facilities can be built that will be easily accessible to all participating hospitals. A separate commissary kitchen is less expensive to build than a conventional hospital kitchen; however, if any readily adaptable facilities exist, a kitchen conversion could be a less-cost alternative. The feasibility of a remotely located commissary kitchen also depends on such variables as the location of the satellite hospitals, the availability of land, and the location of raw food suppliers.

4. Catering

Using a catering service is another possible solution to the shortage of skilled food service personnel. Because a caterer services multiple contracts, he can experience a savings in the various food preparation activities which may be passed on to the hospital, and improved management may also trim costs. Moreover, being relieved of at least regular meal supervision, the dietitian can devote more time to planning restricted diets (diabetic, low-calorie, low chloresterol) and hospital bookkeeping becomes simplified.

5. High-speed Cooking Equipment

Concomitant with the development of convenience foods is the use of quick heating methods, viz., microwave, infrared, and convection ovens.

Although infrared and convection ovens are generally located in the central kitchen, microwave ovens are often situated at each nursing station in order to make hot reconstituted food immediately available to the patient.

6. Disposable Ware

As convenience foods reduce hospital participation in food preparation, disposable ware (dishes and utensils) is beginning to reduce the amount of necessary dish washing and sanitizing. Disposable utensils, plates, bowls, cups, and trays are available in a variety of colors and in such materials as paper, plastic, and styrofoam. Their primary benefit, of course, is long-range savings resulting from conservation of labor and reduction of maintenance, electricity, detergent, dish ware replacement, and equipment costs. Not to be forgotten, though, is the health benefit. Disposables are not only sanitized and packaged to prevent contamination but, since they are used only once, there is no possibility of cross infection from one patient to the next. Presently, few hospitals have totally converted to dietary disposables. Rather, many use a combination of disposables and reusables, for example, disposable dishes but reusable trays and flatware.

Disposables should be evaluated according to whether they improve the quality of health care, as well as cut operating costs. The results of such a study will, of course, vary in each hospital, depending on local rates, hospital size, operating methods, and overhead.

Other factors to consider in judging the benefits of disposables are:

1. Does the disposable satisfy the function of the reusable item it would replace?
2. If any increased costs result, can they be offset by such benefits as sterility, increased infection control, and convenience?
3. What is the present cost of food service ware processing,

including employee salaries, ware collecting, washing, sanitizing, stacking, equipment, electricity, and detergent?

4. Are disposables acceptable to the workers, patients, or personnel who will use them?

7. Computerization

A final trend is a systems approach to the dietary department, using the computer for inventory control, ordering and purchasing, cost accounting, forecasting production demand, menu planning, nutrient control, and ingredient assembly. Although computerization in most of the above areas is still in the experimental stage, electronic data processing equipment is currently being used to adjust recipe ingredient amounts to yield very specific quantities, thus eliminating human calculating errors and ensuring uniform recipe results regardless of quantity.

ADVANCED TECHNOLOGY

Food service improvement alternatives that are currently under investigation but which will be available for implementation only after 1972 are discussed below.

1. Advances in food preparation will take the following direction:
   - Bulk cooking using microwave principle
   - Dehydrated pre-cooked soups and entrees which will be reconstituted at bedside or nursing unit
   - Dual purpose freezer-ovens for each ward
   - A multipurpose food cooking and heating device to efficiently prepare all frozen foods.
2. Computer programs will be developed to control all aspects of food service from the meal request to food consumption, including nutritional calculation according to patient condition and

disease; calculation of menus and recipes; inventory and requisition of food products; and preparation and delivery to the patient.

3. Dietary systems should reduce or eliminate staff involvement in food distribution, for example, by improving methods of reconstituting meals at nursing stations. Automatically controlled conveyors could move food from a central location, reconstitute enroute, and assemble patient trays at decentralized locations throughout the hospital. The action could be initiated by the patient with programmed over-ride to take care of special diet problems.
4. Nutritional values and food portions must be standardized, and results should be made available to vendors of convenience foods.

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: DIETARY**
**COMPONENT: FOOD PREPARATION**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| NACKA System | Food entrees are prepared in a central commissary-type kitchen and distributed to 20 satellite hospitals. Cooked entrees are stored in plastic film, heated for three minutes in 212°F water, chilled, and stored at 37°F. Vegetables and special diet items are prepared locally. | | 1. Participating hospitals need only minimal kitchen facilities; less space, equipment, electricity, heating, and water are needed.<br>2. Mass production reduces labor costs.<br>3. Continuous food preparation eliminates peak and slack labor periods.<br>4. Food portion control is facilitated, and food yield increased.<br>5. Over- or under-production is averted, and a large increase in the number of patients can be easily handled.<br>6. Food cost savings result from bulk buying and purchase control.<br>7. Patient meal scheduling is more flexible.<br>8. Commissary kitchens are less costly to construct than in-hospital kitchens.<br>9. Food retains more flavor and nutritive value than frozen items, and the need for thaw is eliminated. | 1. Several participating health centers must be available.<br>2. Both water baths and micro-waving are often needed to reconstitute food.<br>3. Food shelf-life is limited to two to three weeks.<br>4. Storage temperature of 37°F may not fully inhibit bacteria growth.<br>5. Maximum cost savings are not realized, since vegetables and special diets are prepared locally. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: DIETARY**
**COMPONENT: FOOD PREPARATION**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| AGS System | Entrees, vegetables, and special diet items are prepared in central hospital kitchen for distribution to satellite hospitals. Food items are sealed in plastic film, cooked in a water bath to an internal temperature of 180°F, immersed in ice water to reduce food temperature to 32°F, and stored at 28° to 32°F. | $1.10/meal | 1. See advantages 1-9 of the NACKA System<br>2. Food may be stored up to six months, although the rotation time is 60 days.<br>3. Vegetables and special diet items are available, as well as entrees. | 1. See disadvantages 1-2 of NACKA System.<br>2. Strict bacteriological control practices must be used. Food must be properly heat treated; reheating temperatures must be high enough for safety but low enough for flavor preservation. |
| Darenth Park System | In a commissary-type kitchen, food is prepared, carried on a conveyor belt through a humid air cooker, packaged, blast frozen, stored at -5°F, and distributed to satellite hospitals. | | 1. See advantages 1-8 of the NACKA System.<br>2. Bacteriological counts show that blast-frozen food has a consistently lower count than conventionally prepared foods. | 1. See disadvantage 1 of NACKA System.<br>2. Extensive new cooking equipment is needed: humid air automatic cooker, conveyor lines, labeling and heat sealing machines, blast freezers, cold room equipment and air circulating ovens.<br>3. Food flavor is often damaged by freezing, and food must be thawed before being reconstituted. |
| Southwest Methodist Hospital System | Bulk food is conventionally cooked and stored under refrigeration for up to 72 hours. Food are portioned on patient trays and reconstituted at nursing stations. | | 1. See advantages 3 and 7 of NACKA System.<br>2. Food quality may be directly controlled by hospital staff.<br>3. Bulk cooking produces some savings in space, equipment, labor, and food costs. | 1. Additional refrigerators and microwave ovens are required.<br>2. Labor and food cost savings are not as substantial as those of a large caterer or satellite system. |

# IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: DIETARY**
**COMPONENT: FOOD PREPARATION**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Catering | Food is prepared and delivered by an external organization. | $1,000 to $1,200 per year, per bed. | 1. No capital investment required by hospital.<br>2. Hospital bookkeeping is simplified. | 1. Qualified caterer must be locally available.<br>2. Hospital does not have direct quality control.<br>3. Caterer may not supply special diet items, so a small in-hospital kitchen is required.<br>4. Increased food costs. |
| Total Convenience Food System | All foods are purchased, preprepared or precooked, from outside suppliers and placed in freezers, refrigerators, or dry storage. As needed, foods are assembled on trays and reconstituted in microwave ovens. | $4.01 per patient, per day.<br>$1.30 to $1.40 per meal. | 1. See advantages 3, 5, and 7 of NACKA System.<br>2. Substantially fewer in-hospital workers are required.<br>3. Less equipment, food preparation, and storage space are needed.<br>4. Handling of cold, rather than hot, food allows perfect portion control.<br>5. Less training is required for in-hospital food service workers. | 1. Qualified suppliers may be unavailable, particularly in rural areas.<br>2. Special diet items may be unavailable.<br>3. Direct food costs are higher.<br>4. Additional freezer space is needed.<br>5. Food quality may be reduced by freezing and temperature fluctuations in distribution channels.<br>6. Direct quality control is difficult. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: DIETARY**
**COMPONENT: RECONSTITUTION OF CONVENIENCE FOODS**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Decentralized Reconstitution | Assembled food trays are transported to nursing units, heated in microwave ovens, and served directly to patients. | | 1. Trays may be delivered to wards during low traffic periods.<br>2. Food is served hot immediately after it is removed from ward ovens.<br>3. Less food deterioration than with hot cart method.<br>4. Subkitchens convenient for between-meal nourishments and late meals.<br>5. Nursing staff can closely monitor food intake. | 1. Subkitchens require additional ward space.<br>2. Microwave ovens and refrigeration are required on each floor.<br>3. Dietitian has less control over total food system.<br>4. Several transfers of food may increase danger of contamination. |
| Centralized Reconstitution | Food trays are assembled and heated in the central kitchen and delivered to patients via heated cart. | | 1. Lower overall operating costs.<br>2. Less nursing time is devoted to food service.<br>3. Ward space is not occupied by subkitchens, and food odors and noise are reduced on nursing units.<br>4. Greater variety of food possible, since water baths and convection ovens may be used in addition to microwave ovens. | 1. Food temperature may be reduced during transportation.<br>2. Traffic flow problems are more frequent since foods must be delivered at strictly regulated times.<br>3. Serving late meals or between-meal nourishments is inconvenient.<br>4. Peak and slack labor periods are not reduced. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: DIETARY**
**COMPONENT: RECONSTITUTION OF CONVENIENCE FOODS**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Microwave Ovens | Single or double magnetron tube emits high frequency radio microwaves at 2450 megacycles. Resistance of food molecules to microwaves creates heat. | $400 to $1000 | 1. Cooking time greatly reduced.<br>2. Food reheated by microwave has no "leftover" taste.<br>3. Most non-metallic utensils -- glass, paper, and most plastic -- are safe for oven use. | 1. Not all foods can be microwaved successfully, for example, eggs, frozen baked potatoes, breaded foods, and steaks.<br>2. Large food quantities are difficult to microwave.<br>3. Frozen foods must first be defrosted.<br>4. Food dries out quickly during reheating.<br>5. Aluminum containers may not be used. |
| Convection Ovens | Air heated by gas or electric power is continuously circulated around the food. | Variable with size: estimated $50 to $1,000. | 1. Large-capacity ovens can accommodate high volume food production.<br>2. All types of convenience foods may be heated. | 1. Food moisture is quickly removed.<br>2. Heating takes longer than in microwave or infrared units. |
| Infrared Ovens | Infrared rays are transmitted through quartz plates to heat food. Infrared radiation may be combined with refrigeration of ambient air to prevent scorching. | | 1. Quick reconstitution.<br>2. Color and flavor of deep fried or breaded foods are enhanced. | 1. For even heat distribution, food must have uniform thickness.<br>2. Food scorching is common. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: DIETARY**

**COMPONENT: RECONSTITUTION OF CONVENIENCE FOODS**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Water Immersion Heaters | Precooked food stored in water-proof pouches are brought to serving temperatures of 165°F by immersion in water bath at 180° to 212°F. | | 1. Existing equipment can be used.<br>2. Capital outlay for total system is minimal. | 1. Applications limited to small operations.<br>2. Limited number of foods adaptable to pouch storage.<br>3. Not readily adaptable to decentralized reconstitution. |

**COMPONENT: USE OF COMPUTERS**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Computerized Ingredient Control and Menu Planning | Computers are used to adjust recipes to produce specific yields and to plan menus. | | 1. Food preparation time is reduced.<br>2. Nutrient requirements can be met without tying up a great amount of the dietitian's time.<br>3. Recipes can be accurately and quickly adjusted to patient load.<br>4. A greater variety of menus for patients on restricted diets may result. | 1. Data base is limited and parameters for computer menu planning have not been adequately defined.<br>2. No dollar savings in total dietary system. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTIONAL: DIETARY**
**COMPONENT: FOOD PREPARATION**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| **COMPONENT: DISPOSABLES** | | | | |
| Disposable Ware | Disposable dishes, trays, and utensils, made of paper, plastic, or styrofoam. | $.10 - .[illegible] per meal | 1. Better sanitation.<br>2. Time and labor saved as dish retrieval-scraping-washing cycle becomes obsolete.<br>3. Less dish storage space needed.<br>4. Savings in electricity, detergent, dishwasher maintenance, and ware replacement.<br>5. Kitchen inventory is simplified, since paper-ware comes in "sleeves" of a standard count.<br>6. Based on an average of 174 patients, annual savings of $630 to $11,500 were reported. | 1. Suppliers must be easily accessible.<br>2. Special materials handling procedures and equipment for waste disposal are needed.<br>3. Additional storage space may be needed to accommodate bulk purchasing.<br>4. Disposables are not currently acceptable for heavy meats and juicy entrees.<br>5. Kitchen employees may feel their jobs are being threatened. |

American Hospital Association. Cycle Menus for Small Hospitals and Nursing Homes. Chicago, 1964.

_____. Guidelines for Selecting a Consultant in Food Service Equipment and Layout for Hospitals and Related Health Care Institutions. Chicago, 1967.

_____. Guidelines for Therapeutic Dietitians on Recording in Patients' Medical Records. Chicago, 1966.

Amsco Systems Company. "Introducing 'Integrated' Dietary Systems." Systemsense No. 1 (1969).

Andrews, Janet. "Estimating Food Costs by Computer." Hospitals, J.A.H.A. 43 (October 16, 1969):107-8.

_____. "Inventory Control in the Dietary Department." Hospitals, J.A.H.A. 43 (October 1, 1969):96-9.

Andrews, Janet T., and Tuthill, Byrdine H. "Computer-based Management of Dietary Departments." Hospitals, J.A.H.A. 42 (July 16, 1968):117-23.

Balsley, Marie. "Perspectives on Five New Food Service Systems." Hospitals, J.A.H.A. 40 (December 1, 1966):89-95.

Barton, Jane. "Microwaves Take Cooking Out of the Kitchen." Modern Hospital (November 1962):134-42.

Berkman, Jerome, and Moehn, Charlotte. "Convenience Foods: How to Save Money by Paying More for Food." Modern Hospital (February 1968):92-4.

Boehrer, J.M.; Ray, H.J., Jr.; Bates, A.W., Jr. Medical Food Service Computerization Study. Brooks Air Force Base, Texas: USAF School of Aerospace Medicine, February 1969.

Brisbane, Helen M. "Building a Computer-assisted Nutrient File." Hospitals, J.A.H.A. 43 (November 16, 1969):92-3.

Brown, Robin M. "Computer-assisted Cost Accounting in the Dietary Department." Hospitals, J.A.H.A. 43 (October 1, 1969):99-102.

______. "Estimating Dietary Labor by Use of Work Modules." Hospitals, J.A.H.A. 43 (October 16, 1969):103-6.

Decareau, Robert V. "The Microwave Oven in Hospital Food Service." Microwave Energy Applications Newsletter 2 (January-February 1969).

Donovan, Anne Claire, and Meyer, Burton. "How to Plan Progressive Patient Food Service." Modern Hospital 95 (December 1960).

Doyon, Paul R. "Automated Food Delivery Systems." Hospitals, J.A.H.A. 44 (February 1, 1970):109-16.

Flynn, Helen W. "Food Delivered Cold, Served Hot from Nurses' Stations." Hospitals, J.A.H.A. 37 (December 16, 1963):98-102.

Friesen, Gordon A., and Neibert, Wid O. "Monorail: Hot Idea for Hot Food Service." Modern Hospital 108 (June 1967):120-2.

Grove, William A. "Necessity Is the Mother of Convenience Food." Modern Hospital 112 (June 1969):102-3.

Gue, Ronald L. "An Introduction to the Systems Approach in the Dietary Department." Hospitals, J.A.H.A. 43 (September 1, 1969): 100-1.

______. "Mathematical Basis for Computer-planned Nonselective Menus." Hospitals, J.A.H.A. 43 (November 1, 1969):102-4.

Gue, R. L., and Liggett, J.C. "Mathematical Programming Models for Hospital Menu Planning." Journal of Industrial Engineering (August 1966).

Hartman, Jane. "CCTV and Tape Recorders Help Extend the Dietitian's 'Reach.'" Modern Hospital (April 1968):139.

Irwin, Eleanor, and Keller, Frances N. "A Meal Pattern System Coordinated for Different Institutions." Hospitals, J.A.H.A. 43 (November 1, 1969):104-7.

Ivanicky, Mary C.; Mason, Helmi A.; Vierow, Susan C. "Food Preparation: Labor Time versus Production Quantity." Hospitals, J.A.H.A. 43 (October 16, 1969):99-102.

Jernigan, Anna Katherine. "Designing a New Kitchen." Hospitals, J.A.H.A. 42 (May 1, 1969):88-9.

_____. "Selecting a Tray Conveyor." Hospitals, J.A.H.A. 42 (September 16, 1969):87-8.

Konnersman, Paul M. "The Dietary Department as a Logistics System." Hospitals, J.A.H.A. 43 (September 1, 1969):102-9.

_____. "Forecasting Production Demand in the Dietary Department." Hospitals, J.A.H.A. 43 (September 16, 1969):85-7.

Koval, Barbara. "Frozen Food 'Factory' Manufactures Savings for British Hospital Group." Modern Hospital 112 (June 1969):94-6.

"The Lankenau Study." Institutions Magazine (August 1966):91-9.

Letourneau, C.U.; Hamrick, W.A.; Sorenson, B.D. "The Use of the Microwave Oven in Food Service." Hospital Management 98 (October 1964):35-8.

Levin, Francee. "AGS: A Great System." Southern Hospitals (November 1969):5-8.

Maddox, Darnell. "Kaiser Kitchens Eliminate Most Cooking." Modern Hospital (June 1967).

Mumma, William R. "Four Meals a Day." Hospitals, J.A.H.A. 44 (April 16, 1970):77-81.

Muller, Ella. "Patients Like Disposables, Elmhurst Study Finds." Modern Hospital 112 (June 1969):97-9.

Nicolaus, Norbert. "Automated Food Preparation and Service." Hospitals, J.A.H.A. 44 (March 16, 1970):108-14.

Ostenso, Grace L. "Evaluation of Computer-assisted Management of the Dietary Department." Hospitals, J.A.H.A. 43 (November 16, 1969):94-6.

Peters, David A. "Foods of Tomorrow." Hospital Progress (February 1968):80-96.

Pharayil, P. "Patients Learn How to Calculate Special Diets in Hospital Classes." Modern Hospital 112 (June 1969):100-1.

"Reconstituted Foods and Disposables Characterize Rahway's Food Service." Modern Hospital (June 1968):112-4.

"Rising Costs Still Head List of Food Service Problems for Hospitals." Modern Hospital 112 (June 1969):104-8.

Sager, Jane F. "Recipe and Ingredient Control by Computer." Hospitals, J.A.H.A. 43 (September 16, 1969):87-90.

Skarupa, Jack A. "Four Hospitals Have Food Prepared in a Central Commissary-type Kitchen." Modern Hospital 112 (June 1969):90-3.

Stanford University. "Dietary System." Clinical Teaching and Health Care Systems: Models and Evaluation. Stanford, California: Stanford University School of Medicine, June 1969.

Terrell, Margaret E. "Analysis of Food Trends and Policies: Prelude to Dietary Department Design." Hospitals, J.A.H.A. 40 (October 16, 1966):142-6.

Thomas, Edward J. "A Great Leap Forward Falls on Its Face." Modern Hospital 108 (June 1967):113-5.

Treadway, R.H. "New Food Products and Processes: Implications for Hospital Food Service." Hospitals, J.A.H.A. 39 (August 16, 1965):94-9.

U.S. Public Health Service. Hospital Dietary Services. Washington, D.C.: U.S. Government Printing Office, 1966. No. 930-C-11.

Westgate, Robert. "U.S. Lights Fire Under Microwave Ovens." Electronics (October 13, 1969):123-7.

# EDUCATION AND TRAINING

## INTRODUCTION

Education and training are essential functions of the military Base Level Health Care System. As in civilian teaching hospitals, improving the knowledge, skills, and judgmental capabilities of health care personnel is a primary responsibility. Educational activities designed to achieve such increased competency benefit the individual instructed, the hospital he serves, and the patient to whose care he contributes, and may also help to alleviate the critical manpower situation in the field of health care delivery.

The BLHC System provides two basic types of training for professional, technical, and support personnel. In-service programs include:

- Orientation of new personnel
- On-the-job training
- Continuing education for physicians, nurses, corpsmen, and support personnel.

Programs constructed along more formal lines include:

- Internship and residency programs for physicians, dentists, and administrators
- General military training for officers and enlisted personnel
- Classroom instruction and correspondence courses for high school credit
- Formal training programs for support personnel such as surgical technicians, radiology technicians, and clinical laboratory technicians.

Another type of base level training is conducted for the immediate benefit of patients and their families. In view of the growing emphasis on preventive health care, patient- and community-oriented programs are likely to become increasingly important components of hospital-based instruction.

Education and training in the BLHC System have several unique characteristics. Expense, for instance, is a major factor since the high turnover rate of military personnel makes the cost of orientation, on-the-job training, and continuing education extremely high. Teaching time is also very important. In a hospital, time spent in teaching skills to others could more profitably be spent in administering patient care. A third factor is that the intelligence and comprehension levels of the various hospital personnel are variable in the extreme.

The technique of individualized instruction is one means of satisfying the unique educational demands of the military BLHC System. This method, which emphasizes the individual learner and his specific needs, can be economically feasible and can relieve instructors of many routine teaching and recordkeeping chores via communication media.

There are three basic aspects to the individualization of instruction. The first is the strategy of allowing each learner to enter the instructional system and begin his learning at a point commensurate with his background and previous knowledge, i.e., variable entry based upon entry level capabilities. Second is the strategy of self-pacing which allows each learner to proceed through specified learning experiences at his own best pace. Third, each learner is matched with those methods and materials which best suit his own particular characteristics and needs, subject, that is, to the limitations of time and resource availability.

When students are allowed to proceed at their own pace through a carefully organized sequence of learning experiences, the time taken to achieve the learning objectives will vary by a factor of three or four. Since group-oriented instruction is normally geared to the pace of the slower learner, there is much to be gained by providing study alternatives which encourage faster learners to proceed at an accelerated pace. If half the trainees in a given program can complete the prescribed course of instruction in one half the normal time, very significant savings in terms of resources devoted to training can be realized.

This is not to suggest that all instruction can or should be individualized, but rather that any training system should provide maximum flexibility within which individual learners can avail themselves of materials that meet their needs.

In the following discussion of education and training we have not included well known and commonly available audio-visual aids. Moreover, we do not discuss the informational content of various educational programs, since a wide variety of software developed specifically for use in education and training programs for health care personnel are available on the commercial market. A list of training films and filmstrips is included in Appendix A.

Each of the three services has an unrivaled capacity to produce appropriate learning materials for all types and levels of health care personnel. Our primary concern is to identify the most appropriate means of extending this capability and making existing resources more accessible to personnel at Base Level Health Care facilities.

## TECHNICAL APPROACH

In surveying the state of the art of the hospital education and training functions, we first conducted a literature search including periodicals such as Hospitals, J.A.H.A., the Journal of Medical Education, Training in Business and Industry, and the Journal of Dental Education. Also helpful was a 1968 Westinghouse survey of 25 civilian hospitals on the East coast and a subsequent study at Children's Hospital in Pittsburgh, which investigated methods of instruction for nursing and ancillary support personnel and surveyed the instructional materials developed for closed circuit television. A study conducted by the Westinghouse Learning Corporation for the Air Force in which more than 20 varieties of instructional media were analyzed provided additional data. A selected bibliography is included at the end of this section.

On-site visits to the following hospitals constituted a first-hand review of present methods of education and training:

1. Navy Hospital and Training School, San Diego, California
2. March Composite Medical Facility, March Air Force Base, California
3. Oakland Navy Hospital, California
4. School of Aerospace Medicine, Brooks Air Force Base, Texas
5. Air Force Medical Service Training School, Sheppard Air Force Base, Texas
6. Army Medical Field Service School, Fort Sam Houston, Texas.

The following conferences were attended in order to keep abreast of the latest developments in hospital education and training:

1. Second National Conference on Coronary Care Units, American College of Cardiology, June 18-20, 1969, Denver, Colorado
2. Westinghouse Multidisciplinary Continuing Education Conference,June 4, 1969, Pittsburgh, Pennsylvania
3. National Regional Medical Conference, Workshop on Instructional Media, May 19-23, 1969, Denver, Colorado
4. The 11th Annual Meeting of the Council on Medical Television, April 24-26, 1969, Kansas City, Missouri
5. The 12th Annual Meeting of the Council on Medical Television, April 27-29, 1970, Philadelphia, Pennsylvania
6. Department of Audio Visual Instruction Conference, April 29-30, 1970, Detroit, Michigan.

In addition to the above information sources, we drew on the extensive experience of the Westinghouse Health Systems Department which is currently involved in an independent state-of-the-art survey of medical and paramedical education and training. The expertise of the Westinghouse Learning Corporation in the area of educational technology also provided valuable assistance.

## STATE OF THE ART

The general trends in education and training revolve around the concept of individualized instruction. This concept has been approached in a variety of ways, but all of them utilize communications media.

Several instructional media systems presently available have significant potential for quality improvement of education. No less important is their time-sharing capability which frees critical human resources for the delivery of patient care and support services. These systems have been evaluated for flexibility, accessibility, reliability, ease of operation and maintenance, and adapability to the variety of types and levels of instruction that must be provided. In the context, then, of the BLHC System, the trends in training media are:

- To program instruction
- To televise instruction materials
- To store and retrieve information using dial access systems
- To computerize educational programs.

### Programmed Instruction

Programmed instruction is normally implemented via a text-workbook or an automated teaching machine. The subject matter is presented in small units called frames, typically consisting of a few sentences or a short paragraph. Frames usually present factual information and then elicit a response from the learner to determine if he can proceed. In effect, the learner is tested at frequent intervals. This reinforces key points and makes him an active participant in the learning process rather than merely a passive recipient of information.

Whether the instruction is structured in the form of a text using a sliding mask, presented by an electrically operated machine, or checked and fed back to the learner by a computer, the basic system remains the same: the sequential use of carefully controlled stimuli to elicit predetermined responses.

Programmed instruction can be further distinguished as linear or branching according to the programming sequence utilized. In a linear program the instructional material is arranged in a single ordered sequence. Every student proceeds in a straight line from beginning to end through the same sequence of instruction. Test stimuli are presented at regular intervals, of course, to insure that the information being presented is indeed being learned.

In a branching program multiple paths are arranged through the material. Information is presented, questions are asked, and the learner responds as in a multiple choice test. Wrong answers lead to additional sources of information or to remedial instruction designed to re-teach the basis for the correct response.

Analytical and experimental research studies indicate that procedural skills can be learned effectively from programmed teaching machines fitted with audio-visual aids. Instruction along these same lines is common in medical, dental, and nursing education, as well as in training courses for technical and support personnel. The Armed Forces have been leaders in the development of this method, and they are presently using a variety of such materials in training programs at their medical field service schools. Considerable experience and substantial expertise in instruction programming thus already exists. Selective extension of this capability to BLHC facilities is a logical next step. Barring the use of elaborate electronically-controlled programs, few special facilities are needed. Work productivity need not be decreased since learners can usually study programs independently and on their own time.

Unfortunately, the costs for materials development and validation for programmed instruction are relatively high, since extensive research is required. The specific response pattern desired must be identified, and the validity and reliability of the program must be established for a wide variety of learners.

## Learner Centered Audio-Visual Devices

Conventional audio-visual devices are currrently being used to supplement BLHC educational programs. These include 35 mm motion picture films, single concept sound filmstrips, sound on slide presentations, and even audio recordings. Most of these devices contain both audio or visual stimuli; the audio portion commonly substitutes for the teacher's commentary on the material presented. Recent technological advances in miniaturization of integrated aural-visual components, coupled with simplification of the operation process, have resulted in the increased utilization of this method by learners with little direct assistance from an instructor.

A rear screen projector permits viewing in a lighted room. Combined with an audio headset, it produces an effective device for use in problem locations where disturbance to or from adjacent activities is undesirable. The software can be circulated and stored as easily as a textbook and much of the hardware is portable.

In regard to the audio-visual media as a whole, however, the picture is somewhat different. The number of types and levels of instruction demanded by a facility as complex as a BLHC System, require consideration of potential drawbacks. One such, the proliferation of incompatible software formats, would be disastrous. Similarly, the storage, retrieval, and scheduling of both learning materials and equipment could become serious problems.

## Instructional Television

Television combines more methods of presenting information than any other single communications media. Operating at full potential -- with sound, print, picture, motion, and the immediacy of live transmission -- a television system can be used for any telecommunication purpose. On the other hand, it adapts readily to the partial mode -- audio only, still pictures only, or simple transmission to distribute and display data.

Instructional television, like all television, is the electronic transmission of images, usually accompanied by synchronous sound, from a single point of origin to a receiver. Multiple TV receivers can accommodate large audiences and thereby cut instructor man hours by a significant factor. The medium also permits large numbers of students to share learning resources of the highest quality. Expensive and delicate laboratory equipment and complex demonstrations in specialized environments suddenly become community property. By offering the best, TV succeeds in standardizing the content and quality of instruction at that level. If presentations are recorded on videotape, duplicated using Electronic Video Recording (EVR), or otherwise reproduced, they can be used again and again for as many audiences as necessary.

Broadcast and cable television without two-way communication is essentially a presentational rather than an interactive instructional medium. It has no "real time" direct learner feedback; it is incapable of immediate learner response evaluation.

For maximum effectiveness, television systems require a sizable support subsystem: technically trained personnel; film projection, videotape recording, and projection equipment to relay live, taped, and filmed presentations; cameras; reception units. The extra cost of such personnel, equipment, and facilities can be considerable.

## Dial Access Information Retrieval Systems

Dial access information retrieval systems effectively resolve the biggest problem of the media, -- the storage and distribution of software such as audio recordings, video recordings, filmstrips, slide presentations, motion picture sequences. In such a data retrieval system a wide range of taped, filmed instructional materials is permanently stored at the end of a telephone line. The remoteness of the location is of little significance. By dialing an assigned telephone number for the program desired these materials become immediately accessible. Such systems combine economy, simplicity, and the capacity to accommodate not only instructional materials, but medical and administrative data as well.

## Computer Assisted Instruction

The emergence of computer technology and sophisticated data storage, reduction, and manipulation suggest exciting possibilities for the management and control of large hospital-based instructional systems. The years immediately ahead may see the development and utilization of totally automated education.

Computer Assisted Instruction (CAI) has been defined as direct two-way interaction between a student and a computerized instructional program. This computerized material can be presented in teaching sequences carefully organized to maximize the chances for efficient learning. Methods of responding to the presented material are available, and the computer monitors responses and programs accordingly. As a result the student becomes an active participant in the learning process and is constantly aware of how well he is doing.

Programs and modes of operation differ. A diagnostic mode, for instance, is effective for testing performance. A drill and practice mode teaches facts and procedural steps; a tutorial mode, concepts and principles; a simulation mode, problem-solving, reasoning, and decision-making skills.

Although research studies have found CAI to be more effective than conventional instruction with the expenditure of less instruction time, the cost of operational CAI is prohibitive at present. It will continue to be so until further development of practical operational aspects and appropriate instructional materials results in an economical and utilitarian breakthrough.

"A.A.O. Audio-Visual Library Listing, 1966." American Journal of Orthodontics 52 (September 1966):687-92.

Adams, Robert E. "Hospital's Learning Center Uses Multimedia Approach." Hospitals, J.A.H.A. 43 (March 19, 1969):52-6.

"Aides Learn to Adapt Basic Nursing Skills to Care of Geriatric Patients." Modern Nursing Home 22 (January-February 1968):73-5.

Baden, E. M. "An In-service Training Program for Dietary Employees." American Dietetic Association Journal 50 (March 1967):216-17.

Bennett, A. C. "Can Hospitals Afford Not to Have a Training Program?" Hospitals, J.A.H.A. 41 (December 16, 1967):59-62.

______. "Can Our Hospitals Manage the Training Crisis?" Training in Business and Industry (April 1968):24.

Benschoter, R. A. "Multi-Purpose Televesion." Annals of the New York Academy of Sciences 142 (1967):471-78.

Berman, H. M. "The Printed Image." Annals of the New York Academy of Sciences 142 (1967):437-39.

Broadbent, D. "Audio-Visual Techniques in Professional Medical Education." Medical Journal of Australia 2 (July 22, 1967):174-76.

Brodman, E. "The Challenge in Medical School Libraries." Journal of Medical Education 40 (January 1965):1-19.

Brudner, H. J. "Computer-Managed Instruction." Science 162 (November 29, 1968):970-76.

Bumstead, R. A. "LPN Training: It's Worth the Struggle." Training in Business and Industry (April, 1968):30-3.

Cameron, J. S. "Broadcast Television for Doctors: A First Evaluation." British Medical Journal 1 (April 9, 1966):911-14.

Catania, J. J. "Closed-Circuit TV Helps Patients Understand and Adjust to Environment." Modern Hospital (July 1967):66-7.

"CCTV Gives this Hospital New Eyes." Modern Hospital 106 (June 1966):86-7.

Churchill, E. A. "What is Hospital's Place in Continuing Medical Education?" Journal of the American Medical Association 184 (May 11, 1963):44-5.

Ciancio, S. G. "Closed Circuit Television in the Teaching of Pharmacology." Journal of Dental Education 31 (1967):468-70.

Collins, E. M. "Programmed-group Instruction in Dental Education." Journal of Dental Education 31 (1967):511-16.

"Components of Housekeeping Costs." Hospitals, J.A.H.A. 42 (March 16, 1968).

"Computers in Medicine." British Medical Journal 4 (1967):250-51.

Currie, D. J., and Smialowski, A. "Teaching and Audio-Visual Aids." Journal of the Biological Photographic Association 33 (November 1965):137-46.

Davidson, R. J. "Education and Hospitals." Hospitals, J.A.H.A. 43 (April 1, 1969):79-82.

Douglas, C. P. "To Teach This Art: Some Thoughts on Medical Education for the 21st Century." Scottish Medical Journal 12 (August 12, 1967):269-76.

"Education on Wheels." American Journal of Nursing 67 (1967):2554.

"Eleven Hospitals in Two-Way Hookup with OSU Medical Programs." Ohio State Medical Journal 58 (1962):1180.

Fisher, B. "Dynamic Training Program Aims at Reducing Turnover." Hospitals, J.A.H.A. 41 (November 16, 1967):89.

Flint, C. "Motion Picture and Television Film Clips." Journal of the Association of Medical Illustrators 18 (1967):7-8.

Frye, L. B. "An On-Duty Inservice Experiment Aids." Nursing Outlook 13 (August 1965).

Furlong, T. E., and McTernan, E. J. "Inservice Training Builds Know-How and Morale." Hospitals, J.A.H.A. 41 (June 1. 1967): 49-52.

Gasking, J. D., et al. "Closed Circuit TV and Videoscope Recording in Teaching Pharmacology." British Journal of Medical Education 1 (1967):216-20.

Gates, K. H. "Let's Solve the Paramedical Problem." Medical Record of Nursing 36 (October 1965):272-301.

Gjersvik, T. "Graphic Arts as Part of Medical Illustrations." Journal of the Biological Photographic Association 34 (February 1966):19-21.

Goulet, C. R. "Education and Training." Hospitals, J.A.H.A. 40 (April 1, 1966):47-50.

______. "On The Way: More and Better Trained Ancillaries." Registered Nurse 28 (June 1965):55-63.

Graves, et al., "Audio-Visual Methods in Continuing Education." Journal of the College of General Practioners 11 (1966):231-4.

Green, A. C., and Millard, W. L. "Facilities for Communications Systems in Medical Education." Journal of Medical Education 38 (April 1963):282-91.

Green, J. H., and Thomson, J. P. S. "Use of Videotape Recording and Live Closed-Circuit Television in Teaching Medical Students." British Journal of Medical Education 1 (1967):135-43.

Greenberg, H. R. "Television-Induced 'Psychosis.'" New York State Journal of Medicine (May 1, 1967).

Greenspan, R. "RN Refresher: A Return of Confidence." Training in Business and Industry (April 1968):27-9.

Hale, T. "To Mend Staffing Crisis." Modern Hospital (February 1968):82-7.

Harshbarger, J. H. Development of a High Resolution Research Television System (December 1965), AD 630 941.

Hedman, L. L., and Mansfield, E. "Hospital to Hospital via TV." American Journal of Nursing 67 (April 1967):808-10.

Heldrich, F. J. "Medic: A Cooperative Venture in Continuing Medical Education." Maryland State Medical Journal 16 (March 1967):90-5.

Hill, K. R., and Fletcher, R. "The Impact of Television on Medicine." Proceedings of the Royal Society of Medicine 61 (1968):149-55.

Hill, L. A. "The Continuing Education of Hospital Personnel." Hospital Forum 8 (March 1966):21.

Hood, J. H. "An Audio-Visual Teaching Unit for Radiology." British Journal of Radiology 41 (February 1968):150-51.

Hosie, W. A., and Mayer, B. "Which Audio-Visual Aid for Which Situation?" Public Relations Journal 19 (December 19, 1963):4-6.

"Hospital Indicators." Hospitals, J.A.H.A. 42 (January 16, 1968):27-9.

Hunter, A. T. "The Use of Broadcast Television in Continuing Medical Education." Candian Medical Association Journal 98 (January 16, 1968):34-9.

Ingmire, A. E. "Inservice Seminars Help Nurses Improve Patient Relationships." Hospitals, J.A.H.A. 41 (August 1, 1967):68-75.

"It all Depends on Their Training and Supervision." Modern Nursing Home 22 (1968):4.

Jernigan, A. K. "Inservice Training: A Necessity for Increasing Productivity." Hospitals, J.A.H.A. 41 (October 1, 1967):115-17.

Judge, R. D., and Romano, M. R., editors. Health Science Television: A Review. Ann Arbor, Michigan: Edward Brothers, Inc., 1966.

Kundel, H. L., et al. "Evaluation of a Television Image Processing System." Investigative Radiology 3 (January-February 1968):44-50.

Lawrence, L. G. "TV Systems for Teacher Education." Electronics World (January 1969):42-4.

Lazarus, H. R. and Beinlein, D. K. "Soap Opera Therapy." International Group Psycotherapy 17 (1967):252-56.

Lennon, B. "The Glasglow Postgraduate Medical Television Series: Production Problems on the Medical Side." Postgraduate Medical Journal 41 (1965):220-22.

Lent, R. H., and Scott R. "Knowledge, Numbers and Values: Medical Education since 1950." Canadian Medical Association Journal 97 (December 2, 1967):1418-27.

Lewis, A. J. "The Value and the Limitations of Medical Educational Television." Medical Biology Illustrated 18 (1968):268-72.

Lieberman, J. "The Public Health Service Audio-Visual Facility." Annals of the New York Academy Sciences 142 (1967):513-21.

Light, F. W. "Microscopic Telecommunication by Closed Circuit Television." Military Medicine 132 (January 1967):28-33.

Littlemeyer, M. H. "Annotated Bibliography on Current Changes in Medical Education." Journal of Medical Education 43 (January 1968):14-28.

Love, B. F. "Teaching Laboratory Techniques with Closed-circuit Television." American Journal of Medical Technology 33 (May-June 1967):253-57.

_____. "Refresher Programs for Medical Technologists." American Journal of Medical Technology 33 (September-October 1967):408-16.

Lubetkin, M. "Closed Circuit Television and the Script Writer." Training and Development Journal 22 (February 1968):57-61.

McDonald, G. W., and Kaufman, M. B. "Teaching Machines for Patients with Diabetes." Journal of the American Dietetic Association 42 (March 1963):209-13.

McGuinness, A. C., et al. "The Medical Television Audience of the New York Academy of Medicine after Four Years." Bulletin of the New York Academy of Medicine 44 (March 1968):332-45.

McLean, J. C. "How to Use Audiovisual Communications." Modern Hospital 106 (February 1966):97-100.

Manning, P. R., et al. "Comparison of Four Teaching Techniques: Programmed Text, Textbook, Lecture-Demonstration and Lecture-Workshop." Journal of Medical Education 43 (1968):356-59.

Meighan, S. S. "Continuing Medical Education through Television." Journal of the American Medical Association 200 (May 29, 1967):102-06.

Metzger, N. "Personnel Administration." Hospitals, J.A.H.A. 42 (April 1, 1968):121-26.

Meyer, T. C., et al. "Report on an Experiment in the Use of Telelectures for the Continuing Educations of Physicians and Allied Health Personnel." Journal of Medical Education 43 (January 1968):73-7.

Middleton, R., and Konz, S. A. "Slides plus Recorded Commentary Instruct Food Service Workers." Hospitals, J.A.H.A. 39 (October 16, 1935):91-5.

"Most Administrators Favor Certification of Aides and Training before Employment." Modern Nursing Home (March-April 1968):4-5.

Neal, Alan S. "Viewing Conditions for Classroom TV: an Objective Study." Audiovisual Instruction (September 1968):707-09.

Nelson, R. A. "The Hospital and Education." Hospitals, J.A.H.A. 36 (August 16, 1962):48-50.

Pender, J. L. "Dietician Teaches Patients Via CCTV." Hospital Topics 44 (February 1966):46-7.

"Planning Programs Get AHA Support at November Council-Board Meeting." Hospitals, J.A.H.A. 42 (January 16, 1968):71.

Polony, L. J. "Programmed Instruction and Automated Education for Hospital and Other Medical Personnel." Hospital Progress 46 (February 1965):83-7.

Ramey, J. W. "Television: Growing Pains of a New Teaching Medium." Journal of Medical Education 39 (December 1964):1107-113.

______. Television in Medical Teaching and Research. Washington, D. C.: U. S. Department of Health, Education, and Welfare, Office of Documents, 1965.

______. "Teaching Medical Students by Videotape Simulation." Journal of Medical Education 43 (January 1968):55-9.

Riley, W. B. "Getting More Mileage from Computers." Electronics 20 (January 1969):117-20.

Rivera, J. C. "History of Training in Submarine Medicine." Military Medicine 132 (March 1967):176-85.

Romano, M. T., and Bennett, I. C. "Concepts and Activities of Medical Center Television at the University of Kentucky." Journal of Medical Education 42 (September 1967):841-48.

______. "Video Tape Recording--Versatile Resource in Health Care." Hospitals, J.A.H.A. 42 (May 16, 1968):60-4.

Ross, Carmen F. "Inservice Education for the LPN." Bedside Nurse 1 (January-February 1968):19-22.

Russell, J. K. "Sound and Visual Teaching Aids in Obstetrics and Gynecology." Medical and Biological Illustrators 16 (October 1966):218-22.

Ryan, R. F. "Programmed Instruction in Plastic Surgery." Plastic and Reconstructive Surgery 40 (October 1967):392-97.

Smith, G., et al. "Further Studies on the Use of CCTV in Teaching Surgery to Undergraduate Students." British Journal of Medical Education 1 (1966):40-2.

Starkweather, J. A. "Computer-Assisted Learning in Medical Education." Canadian Medical Association Journal 97 (September 16. 1967):733-38.

Stoller, F. H. "Group Psychotherapy on Television: An Innovation with Hospitalized Patients." American Psychologist 22 (1967):158-62.

Tampas, J. P., and Soule, A. B. "Experience with Two-Way Television in a Teaching Hospital Complex." Journal of the American Medical Association 204 (June 24, 1968):83-5.

Thorm, G. W. "A Department of Medicine in 1963-1973." New England Journal of Medicine 270 (February 6, 1964):281-86.

"TV Teaching: How It Helps Nursing Students and RN's" Registered Nurse (March 1969):28-33.

"University of Illinois Medical Students Treat Computer Cases." Communications News (December 1969).

"Videotape: New Healing and Teaching Aid." Modern Hospitals 109 (July 1967):98-9.

Wagner, H. N. "Videotape in Teaching of Medical History Taking." Journal of Medical Education 42 (November 1967):1055-58.

Wedlick, L. T. "An Experiment in Paramedical Education." Medical Journal of Australia (April 22, 1967):830.

Wilmer, H. A. "Innovative Uses of Videotape on a Psychiatric Ward." Journal of the American Psychiatric Association 19 (May 1968):129-33.

Wilmer, H. A. "Practical and Theoretical Aspects of Videotape Supervision in Psychiatry." Journal of Nervous and Mental Disease 145 (1967):123-30.

______. "The Role of the Psychiatrist in Consultation and Some Observations on Video Tape Learning." Psychosomatics 8 (July-August 1967):193-95.

______. "Television as Participant Recorder." American Journal of Psychiatry 124 (1968):43-9.

______. "Television: Technical and Artistic Aspects of Videotape in Psychiatric Teaching." Journal of Nervous and Mental Disease 144 (1967):207-23.

## MAINTENANCE AND HOUSEKEEPING

### INTRODUCTION

The maintenance function is upkeep and repair of the BLHC Systems' equipment and buildings. When properly managed and controlled, an effective maintenance program will enable medical and paramedical personnel to rely on their diagnostic and treatment equipment and administrators to rely on their cost data and on hospital mechanical services and utilities. Housekeeping, on the other hand, must provide an aesthetically pleasing, bacteria-controlled environment to prevent the transferral of infectious organisms and to generate a positive psychological impact on patients and the general public.

In preparing this maintenance and housekeeping state-of-the-art report, the following factors were considered:

1. Because labor is the biggest cost item, how can labor needs be decreased and effectiveness increased?

2. Should maintenance and/or housekeeping be done by hospital-employed personnel or should an outside contracting service be used? If hospital employees are used, how should they be administratively organized?

3. Should hospital-owned equipment be used for maintenance and/or housekeeping or should an outside contractor supply his own equipment?

   Maintenance can be classified as one of three types on the basis of who invests in tools and other equipment:

   a. Capital, when outside contractor uses his own tools.
   b. Management, when outside contractor uses hospital-owned tools.

c. Self-contained, when trained hospital personnel use hospital-owned equipment.

4. How can the sources or causes of maintenance and housekeeping problems be best identified?

5. How can inventory costs be reduced?

6. How can equipment life and failure rate be accurately predicted and how can this information be used to evaluate purchasing decisions? How do equipment failure risks relate to health care delivery, and how can cost/risk relationships be established?

7. What housekeeping processes and procedures can be automated to reduce the labor force required?

8. How can maintenance and housekeeping record-keeping be reduced, but still be more effective?

The following state-of-the-art section discusses the general trends in maintenance and housekeeping and then treats in-house versus outside contractor methods as they apply to both housekeeping and buildings and equipment maintenance.

## TECHNICAL APPROACH

To determine the state-of-the-art of hospital maintenance and housekeeping, the Westinghouse study team first reviewed pertinent literature ranging from the American Hospital Association's Housekeeping Manual for Health Care Facilities and Manual of Hospital Maintenance to periodicals such as the Journal of the American Medical Association and Applied Microbiology to reprints on dust-free rooms using the laminar flow principle. A selected bibliography is included at the end of this section.

An initial report on hospital maintenance and housekeeping was prepared by Thomas E. Terrill of the Graduate School of Public Health, University of Pittsburgh. To reinforce or perhaps supplement this study, we contacted the following equipment manufacturers:

Lamson Corporation, Syracuse, New York

Wilt-Gateway Maintenance Supply Company, Pittsburgh, Pennsylvania

WASCON, Subsidiary of Robbins and Myers, Inc., Hatboro, Pennsylvania

Von Schrader Manufacturing Company, Racine, Wisconsin

Powers Regulator Company, Colorado

Harry A. Stroh Associates, Princeton, New Jersey

Bigelow-Sanford Corporation, New York, New York

Advance Floor Machine Company, Spring Park, Minnesota

ARA Environmental Services, Philadelphia, Pennsylvania

To generate data for the discussion of in-house versus contract maintenance and housekeeping, we made on-site visits to the following hospitals:

| | |
|---|---|
| Walson Army Hospital<br>Fort Dix, New Jersey | In-house maintenance; outside contractor for housekeeping |
| Malcolm Grow Hospital<br>Andrews Air Force Base<br>Maryland | In-house maintenance; in-house and outside contractor for housekeeping |
| Beaufort Naval Hospital<br>Beaufort, South Carolina | "Post Maintenance" which is done by an outside contractor; in-house housekeeping |
| Jacksonville Naval Hospital<br>Jacksonville, Florida | Original "Post Maintenance" superseded by in-house maintenance; in-house housekeeping |

## STATE OF THE ART

### Buildings and Equipment Maintenance

Hospital maintenance costs, mostly labor, have recently been estimated at $550.00 to $950.00 per year per bed -- approximately six percent of total hospital operating cost. Moreover, the following important factors are raising maintenance costs far more rapidly than the general cost of living:

1. Spiraling labor costs, especially for skilled personnel.
2. More complicated and expensive clinical and communications equipment demanding highly skilled maintenance personnel. Maintenance costs for this complex equipment are 13 to 15 percent of initial costs per year, twice that for conventional equipment.
3. Demand for better health care requiring additional, more varied, complex, and flexible equipment.
4. High capital interest charges making it more expensive to maintain inventories of repair tools and spare parts.

To reduce maintenance costs and provide better service, the general trends are to implement a computerized maintenance information network, to use preventive maintenance methods, and to consider the effects of hospital planning and construction on maintenance costs.

### Computerized Maintenance Information Networks

Computerized maintenance information networks minimize "crisis" management and place maintenance procedures on reasonably established schedules, significantly reducing costs. Information networks will:

1. Increase labor effectiveness through careful planning of tasks and the labor necessary to complete them.

2. Increase utilization of expensive repair tools through complete task scheduling.

3. Identify the causes of maintenance problems and delays, what equipment is causing more problems than anticipated, and why.

4. Keep an accurate history of repair costs and procedures for each piece of equipment so that preventive maintenance procedures and spare parts inventories can be adjusted accordingly.

5. Help make repair-or-replace decisions based on realistic equipment life expectancies and failure rates.

6. Evaluate the effectiveness of purchasing procedures by pointing out equipment which has not performed according to manufacturers' specifications.

Preventive Maintenance

Upkeep of most hospital buildings and equipment can be worked into a preventive maintenance network. For example, changing light bulbs on a schedule based on expected bulb life has been proven less expensive than changing bulbs only when defective. In addition, scheduled maintenance checks of electrical, heating, ventilation, and air conditioning equipment should be made to keep the equipment functioning optimally and prevent untimely failures.

Preventive maintenance which may be assisted by computer planning, is really the most important function of any maintenance department. To facilitate this type of upkeep, attempts should be made to standardize all equipment and, whenever new equipment is received, personnel should schedule regular maintenance checks.

Hospital Planning and Construction

Building design, construction, and materials selection can greatly affect the extent and complexity of building maintenance. Design concepts such as interstitial space can reduce maintenance costs, sometimes at a slight and justifiable increase in capital cost. Design errors, such as undersized foundations and structure, or inadequate HVAC equipment, can also result in expensive building maintenance and repair problems.

Construction methods can affect future building maintenance, especially if design criteria are not followed closely. Minor construction procedures such as earth compaction, structural steel bolting, and concrete quality control must be carefully supervised.

Materials selection must be made on a cost/benefit basis with careful analysis of investment and maintenance costs spread over the life cycle of the material. A good example of a material selection problem is building skin. While brick has been the traditional facade for military hospitals, it requires periodic pointing and has a lower insulating value than some newer wall material, such as insulated metal panels. Therefore, when choosing a skin material, we must consider initial and maintenance costs, aesthetics, speed of erection, availability, climate, and the effect of the skin material on other building services such as HVAC.

Design, construction, and materials selection are discussed under construction in this report.

Housekeeping

Although housekeeping is only three to five percent of the hospital's total budget, it is an essential part of the BLHC System and is now recognized as a scientific and professional service. Housekeeping's responsibilities include upkeep of areas used by the general public, as well as professional and patient rooms (preparing vacant room for new patient.) Some general trends in housekeeping are discussed below.

1. Because ninety to ninety-five percent of the housekeeping budget is generally devoted to personnel salaries, the trend is to utilize new methods, supplies, or equipment to provide long-term labor savings. "Team" cleaning and multiple-purpose machines are being introduced. For example, automatic floor maintenance machines which dispense a detergent germicide solution, scrub, vacuum up the solution, and damp-dry the floor in one operation are available, as well as a one-step technique in which a germicidal/detergent solution is sprayed on the floor which is then buffed with a 15 to 20 inch pad. A plethora of new cleansers have been developed but their selection is generally dictated by the preferences of the individual executive housekeeper.

2. The use of carpeting in hospitals is becoming more prevalent since fire-resistant, vermin-proof, and easy-to-clean fibers have been developed. Carpets are being installed in corridors, offices, lobbies, and patient rooms to minimize noise; reduce heating and air conditioning costs as a result of their insulating properties; cushion accidental falls, thus reducing the possibility of injuries and resulting lawsuits; and lessen or eliminate china breakage. A major advantage of carpeting is, of course, its aesthetically pleasing appearance. Problems, however, are encountered when moving beds and other portable equipment which do not have large enough wheels.

With regard to the financial feasibility of carpeting, though, the Wharton study, "A Summary: The Economics of Carpeting and Resilient Flooring" (1966), came to the conclusion that "resilient flooring is at all times more economical than carpet. The group found no case based on pure economic considerations where the total cost for carpet was less than the total cost for resilient flooring." The annual carpet cost, based on initial cost and service life, was between twenty-three percent and one hundred seventy percent more than the annual vinyl-asbestos cost. Cost, of course, is not the only element to consider in choosing a flooring material. Aesthetics and public relations also have significant importance.

3. Hospital housekeeping, if defined as maintaining a bacteria-free environment for patients and staff, includes providing sterile surroundings in such areas as operating and emergency rooms. The trend is to reduce air borne bacteria by various means, including laminar flow systems using high efficiency particular air (HEPA) filters. This does not preclude, however, the necessity for traditional cleaning of surfaces with a bactericide or disinfectant.

In-house versus Outside Contractor Maintenance and Housekeeping

When considering in-house and outside contractor services, cost, service and control must be evaluated as they relate to hospital size and location.

1. Cost

Large hospitals, regardless of location, can often justify in-house maintenance and housekeeping staffs; a large or small rural hospital may be forced to have extensive in-house staffs, but the small rural hospital's maintenance costs/unit will be significantly higher. If an outside contractor is used, costs may be cut considerably through sharing of overhead and through storage of materials, tools, equipment, and records outside of the BLHC System.

A shared outside contractor maintenance service can often reduce costs, especially for smaller hospitals, through better utilization of tools and parts inventories. One example of shared maintenance might be a regional equipment maintenance division serving all three branches of the service, with specialized maintenance personnel flown when required. Such a division could be the responsibility of private contractors or military service units. In the latter case, extended tours of duty in the unit or career personnel would be absolute necessities.

2. Service

A properly trained in-house maintenance force always supplies faster service because it is locally available. Whether the increased speed is cost-justified or not depends on hospital size and location and availability of labor and outside contractors.

An outside contractor, on the other hand, can buy in quantity, provide specialized skills, and use expensive labor-saving equipment that a single, small hospital may be unable to purchase. The contractor service, moreover, is devoted solely to maintenance and is therefore more knowledgeable of new technological developments. Often an outside or shared maintenance service can attract a trained personnel pool which can be efficiently spread over several hospitals, increasing service effectiveness and reducing costs with only a slight decrease in speed and increase in equipment down-time.

3. Control

An in-house maintenance force is more easily controlled than an outside contractor. Moreover, in-hospital services foster employee loyalty, interdepartmental cooperation, scheduling flexibility, and reduced security risks. Hospital location, availability of reliable outside contracting services, and the extent of control needed and desirable must be considered during the hospital planning stages.

Building and building services maintenance can be done by in-house personnel, outside contractors, or a combination of both. Most BLHC Systems will use a combination of methods: the routine work, such as changing light bulbs, plastering, painting and minor mechanical repairs to HVAC equipment will be done in-house; larger jobs, such as repairing a cracked floor or replacing a boiler will be done by outside contractors.

Outside contracting of large maintenance tasks is being used more often because:

1. Often only the manufacturer and dealer is staffed and equipped to offer maintenance services for the new and complex clinical and communications equipment increasingly being used. Smaller hospitals, especially, cannot attract specialized and skilled maintenance personnel; they also cannot absorb the costs of a total in-house maintenance staff, or the training costs and programs necessary to repair complex equipment. Outside contracting services, however, can efficiently use trained personnel by sharing them with several hospitals and thereby offer more interesting, higher-paying jobs.

2. The high cost of repair or calibration equipment needed for more complex instruments requires maximum utilization of that equipment. This can best be achieved by a central maintenance service distributing the investment cost among several hospitals.

3. Hospital space is in short supply and should be devoted to health care, not maintenance. Also, hospital space is expensive relative to space needed for maintenance operations, often making it uneconomical to house maintenance in the hospital.

## BIBLIOGRAPHY - MAINTENANCE AND HOUSEKEEPING


American Hospital Association. Hospital Administrative Services Handbook. Chicago, 1967.

_____. Housekeeping Manual for Health Care Facilities. Chicago, 1966.

_____. Infection Control in the Hospital. Chicago.

_____. Manual of Hospital Maintenance. Chicago.

Coriell, Lewis L. "Laminar Flow Systems for Sterile Work." National Cancer Institute Monograph No. 29

Coriell, Lewis L.; Blakemore, William S.; and McGarrity, Gerard J. "Medical Applications of Dust-Free Rooms." Journal of the American Medical Association 203 (March 18, 1968): 1038-46.

Coriell, Lewis L., and McGarrity, Gerard J. "Biohazard Hood to Prevent Infection during Microbiological Procedures." Applied Microbiology 16 (December 1968): 1895-1900.

_____. "Elimination of Airborne Bacteria in The Laboratory and Operating Room." Bulletin of the Parenteral Drug Association 21 (March-April 1967): 46-54.

Coriell, Lewis L.; McGarrity, Gerard; and Blakemore, William S. "Studies of Hepa Filtered Vertical Flow Air in the Microbiological Laboratory and Operating Room." Journal of the American Association for Contamination Control (1968).

Coriell, Lewis L.; McGarrity, Gerard J.; and Horneff, James. "Medical Applications of Dust-Free Rooms, I: Elimination of Airborne Bacteria in a Research Laboratory." American Journal of Public Health 57 (October 1967): 1824-36.

Hedrick, R.B. Evaluation of and Requirements for Automated Cleaning Equipment. Bloomington, Ind.: Indiana University, Aerospace Research Applications Center.

Kemp, James. Design, Maintenance and Operation. London: Her Majesty's Stationary Office, 1966.

Letourneau, Charles U., ed. Hospital Floor Sanitation Techniques. Spring Park, Minn.: Advance Flow Machine Company, Inc., 1965.

MacEacheon, Malcom T. Hospital Organization and Management. Chicago: Physicians' Record Company, 1957.

McGibony, John. Principles of Hospital Administration. New York: G. P. Putnam's Sons.

McGuinness. "Pulping Improves Waste Disposal." Progressive Architecture (February 1968).

Moody, N. F. "The Role of the Biomedical Engineer in The Modern Hospital." Canadian Medical Association Journal 93 (July - December 1965): 171.

O'Donovan, Thomas R. "Contract Service: Some Pros & Cons." Hospital Progress (February 1967): 70-2

O'Hallaron, Richard D. "Preventive Maintenance by Computer." Hospital Progress 48 (July - December 1967): 108-13.

Parks, George M. A Summary: The Economics of Carpeting and Resilient Flooring. Philadelphia: University of Pennsylvania, 1966.

"Problem and Solution: Waste Disposal at Pan Am." Kitchen Planning 5 (1968)

Sharits, J. W. Hospital Contract Maintenance Study. Pittsburgh: Westinghouse Research Laboratories.

Top, Franklin H. Control of Infectious Diseases in General Hospitals. New York: American Public Health Association.

U.S. Department of Health, Education and Welfare. Environmental Aspects of the Hospital, Volume I: Infection Control. Washington, D.C.: U. S. Government Printing Office.

______. Environmental Aspects of the Hospital, Volume II: Supportive Departments. Washington, D.C.: U.S. Government Printing Office.

Wheeler, E. Todd. Hospital Design and Function. New York: McGraw-Hill Book Co.

Zervins, A., and Spicher, J. L. Microbial Contamination of Hospital Environment, Activities Contributing to Contamination and Control Techniques. Westinghouse Research Laboratory Report No. 68-1D2-Clean-R1.

## MATERIEL HANDLING

### INTRODUCTION

Reliable, efficient, and economical management of materiel and supplies is essential to the mission of the Base Level Health Care (BLHC) System. The hospital distribution function, defined as the organized movement of bulk materiel and supplies, is handled by specifically assigned personnel and/or regular hospital employees. Distribution, moreover, may be on a regularly scheduled or random basis. The variety and extent of the task is indicated by following tabulation:

- Food and food supplies.
- Pharmaceuticals.
- Medical instruments, sterile packs, and trays.
- Therapeutic and life support equipment, incubators, and wheelchairs.
- Nursing supplies, I.V. solutions, and specimen samples.
- Housekeeping supplies and equipment.
- Office supplies and furniture.
- Records and general correspondence.
- Laundry, clean and soiled.
- Trash and waste products.

To generate increased profits, industry long ago incorporated automated materiel handling to reduce labor cost, improve reliability, and speed materiel flow. Private and military hospitals, however, have had an abundance of low cost labor and have been reluctant to employ automated distribution concepts.

Recently, though, the labor situation has changed — unskilled labor has become scarcer, mostly because of retraining, and has become more expensive. As a result, an increasing number of hospitals, both Government and private, have begun to investigate and invest in automated materiel distribution installations.

The Westinghouse state-of-the-art survey focuses on medical facilities and manufacturers using electronically controlled mechanical devices for materiel movement. Specifically we discuss automated carts, conveyors, dumbwaiters, and pneumatic tubes, linen chutes, and trash chutes.

## TECHNICAL APPROACH

In our survey of the state of the art in materiel handling, we concentrated on systems currently employed in the health care environment and on those that move materiel on an interdepartmental basis. The major effort was directed at automated bulk handling systems manufactured by four companies: AMSCO Systems, Columbus-McKinnon Corporation, Sybron Corporation, and Mosler Safe Company.

To inaugurate our study we first conducted a library search for recent periodical articles describing the hospital distribution function.(A bibliography is included at the end of this section.) We then solicited systems characteristics and cost/performance data from the following manufacturers:

Aerojet-General Corporation, Elmonte, California

American Chain and Cable Company, Bridgeport, Connecticut
Louden Machinery Company, Fairfield, Iowa
Olsen Division, Franklin Park, Illinois

American Sterilizer Company, AMSCO Systems Company, Erie, Pennsylvania

Barrett/Barrett-Cravens Company, Barret Electronic Corporation, Worthbrook, Illinois

Brewer Manufacturing Company, Upper Darby, Pennsylvania

Columbus-McKinnon Corporation, Conveyor Division, New York, New York

Diebold, Inc., Canton, Ohio
Lamson Division, Syracuse, New York

Eastern Cyclone Industries, Inc., Clifton, New Jersey

Eaton, Yale, and Town, Inc., American Monorail Division, Cleveland, Ohio

Ecology Industries, Inc., South Plainfield, New Jersey

Footlik and Associates, Skokie, Illinois

The Hobart Manufacturing Company, Troy, Ohio

Jervis B. Webb Company, Detroit, Michigan

Market Forge, Everett, Massachusetts

Mosler Safe Company, Hamilton, Ohio

Powers Regulating Company, Skokie, Illinois

Standard Conveyor Company, North St. Paul, Minnesota

United Service Equipment Company, Morefeesboro, Tennessee

White Manufacturing Company, Kensington, New Jersey

To complete our survey of available systems, we discussed materiel handling with the following manufacturer representatives at the Westinghouse Research and Development Center:

Acme Visible Records, Inc., Crozet, Virginia

Aerojet-General Corporation, Washington, D. C.

AMSCO Systems Company, Division of American Sterilizer Company, Erie, Pennsylvania

Columbus-McKinnon Corporation, Jericho, New York

Diebold Incorporated, Canton, Ohio

Mosler Safe Company, Airmatic Systems Division, Wayne, New Jersey

Powers Regulator Company, Grover Pneumatic Tube Division, Denver, Colorado

Sybron Corporation, Castle Automated Systems Company, Rochester, New York

To see how materiel handling systems are being implemented, we made on-site visits to various hospitals and companies and interviewed staff members who were involved in the purchase and installation of automated distribution components or are planning to include them in current construction. These visits and the distribution concept used by each organization are listed below.

| Location | Application |
|---|---|
| Greater Baltimore Medical Center Baltimore, Maryland | Tugger Train |
| Castle Automated Systems Rochester, New York | Demonstration Model of Cyberail |
| Saint Louis Park Medical Center Saint Louis Park, Minnesota | Mosler Telelift |
| Allegheny General Hospital Pittsburgh, Pennsylvania | Remington-Rand Randtriever |
| Diebold Corporation Canton, Ohio | Power Files |
| Mayo Clinic Rochester, Minnesota | Conveyor and Pneumatic Tubes |

STATE OF THE ART

A totally automated materiel management and distribution system orders and receives incoming shipments from outside suppliers, classifies the items, stores them, and distributes them, as needed, to the ultimate user. This degree of sophistication is presently prohibitive in initial cost and impractical in terms of space requirements. Consequently, a "total" materiel distribution function, in current terms, means automated traffic from or to a central distribution/collection point to or from decentralized stations throughout the BLHC System.

Some of the major planning factors that must be considered in the development and design of a total hospital distribution installation include:

1. The basic characteristics of the materiel to be handled: size, shape, weight, state (solid or liquid), frequency of handling, perishability
2. Storage and handling facilities at work stations.
3. Transportation routes.
4. Environmental factors: sanitation, noise level, temperature control.
5. Central storage and distribution capabilities.
6. Waste and trash disposal methods.
7. Adequacy of maintenance staff.
8. Operator training requirements and capabilities.
9. Flexibility (short term and long term expandibility).

Materiel distribution components can be categorized as follows:

1. Automated carts.
2. Conveyors.
3. Automated dumbwaiters.
4. Pneumatic tubes.
5. Pneumatic linen and trash chutes.

The following section gives brief descriptions of typical improvement alternatives and the materiel distribution trends they represent.

## Automated Carts

Of all distribution components, automated carts offer the closest approach to the "total" function. One alternative, AMSCAR, uses an enclosed stainless steel cart, two feet wide, four feet long, and four feet high, that is dispatched from a central station and is electronically guided by wires imbedded in the floor. Another alternative, ACTS, uses a transporter to pick up and carry standard openshelf hospital carts by means of a power-and-free conveyor. A third alternative in this category, Cyberail, uses a complex monorail-and-conveyor technique.

All three alternatives perform the distribution task in a manner that most nearly approaches the ideal: containers are routed by means of automatic traffic controls, and minimal manual input is employed in the actual transportation of materiel. These alternatives represent the most recent developments in automated carts, and their capabilities make them prime contenders for new systems where size and volume of materiel warrant. Moreover, the manufacturers of the above equipment are developing computerized materiel management alternatives that will be available by 1975 and will integrate inventory control, requisitioning, receiving, storage, and distribution.

Table 1 lists the locations where the above distribution systems are being applied.

## Conveyors

A wide range of choice is available in conveyors, from simple installations such as Lamson's and Olsen's vertical conveyors that handle food trays and supplies both horizontally and vertically, to complex monorail/conveyor installations that nearly duplicate the capabilities of the automated cart alternatives. The Lamson conveyor is also available in a model which uses two separate subveyors to segregate sterile and soiled materiel.

Although conveyors cannot handle the large loads carried by automated carts, their versatility, speed, lower cost, and expansion capability make them quite suitable for smaller systems, as well as important segments of improvement alternatives combinations, such as the Olsen distribution installation in the Veterans Administration Hospital, Washington, D. C.

## The Spiral Supply-Ramp Concept

Custom-designed for the Greater Baltimore Medical Center, this concept entails a tractor pulling a train of supply carts up and down a

Table 1: Summary of Experience for Total Distribution Systems

| System | Hospital | Number Beds | Date |
|---|---|---|---|
| American Sterilizer Company - Amsco | • Loyola University Hospital, Hines, Illinois | 450 | |
| | • Fairfax Hospital, Falls Church, Virginia | 300 | 1969 |
| | • Elliott White Springs Memorial Hospital, Lancaster, South Carolina | | |
| Castle Company - Cyberail | • Strong Memorial Hospital, Rochester, New York | 700 | 1973 |
| | • University of Connecticut Hospital, Farmington, Connecticut | | 1972 |
| | • St. Joannes de Deo Hospital, Haarlem, Netherlands | | |
| | • Meppel, Holland | | |
| | • Hridovre, Copenhagen | | |
| | • Also, about 13 feasibility studies have been performed and are pending decision | | |
| Columbus-McKinnon ACTS | In various states of acceptance or completion: | | |
| | • Baptist Memorial Hospital, Jacksonville, Florida | 750 | 1971 |
| | • Clifton Springs Hospital, Clifton Springs, New York | 250 | 1972 |
| | • Etobiroke Hospital, Toronto, Canada | 500 | 1971 |
| | • Mercy Hospital, Buffalo, New York | 340 | 1969 |
| | • Providence Hospital, Cincinnati, Ohio | 360 | 1970 |
| | • University Medical Center, Cologne, Germany | 2100 | 197[illegible] |
| | • Wadley Hospital, Texarkana, Texas | 350 | 1970 |
| | • Laguna Hills Hospital, California | | |
| | • JFK Memorial Hospital, Collinsville, Illinois | | |

spiral ramp. There are three exits from the ramp at each level, allowing the cart to travel varying lengths down service corridors to planned turn-around points. From these terminals, carts can be detached for individual, manual delivery into nursing units and other smaller areas where needed. A central dispatch center controls the scheduling of the carts.

Pneumatic Linen and Trash Chutes

Several new health systems are installing pneumatic and gravity chutes to move soiled linen and trash. The Aerojet-General's Automated Vacuum Collection (AVAC) alternative uses vertical chutes, horizontal pipes, and an exhauster, with separate chutes and pipes for soiled linen and trash. The initial vertical drop is by gravity, with the horizontal transport into a collection hopper accomplished pneumatically.

Eastern Cyclone Industries' "Airflyte" alternative uses negative air pressure in a cylindrical tube — 12 to 20 inches in diameter — to transport soiled linen or trash up, down, diagonally, around bends, from multiple depository points to one or more collection points. Both items are carried in the same tube with destination selection accomplished by a switch at each depository point.

These alternatives appear to be a significant adjunct to the overall materiel distribution function. They are reliable, easy to operate, and handle a large portion of the materiel distribution load.

Exchange Carts

With this alternative, which represents a good manual approach to one facet of distribution, two carts are assigned to each nursing unit. One cart serves as a storage unit while the other is being refilled in the supply areas. Carts are rotated between nursing units and central supplies at convenient times (low traffic and workload periods.) Carts contain I. V. solutions, linens, and other predictable use items; meals and drugs are handled independently.

Some additional materiel handling considerations are discussed below:

1. The physical handling of hospital materiel is highly sensitive to cubage more so than weight, since we are not, in the main, dealing with highly dense materiel. The hospital, moreover, is confronted with so called loose issue, i.e., items broken down from bulk, and reliable information summarizing the loose issue distribution in terms of cubic feet and delivery frequencies is not available. Some effort has been started by the military to establish data for cubage/day/affliction, but much more needs to be done. Decisions must be made on delivery frequencies, container sizes, manpower requirements, automated system requirements and the like.

2. A system which permits remote supply requisitioning and provides automatic inventory control may be fully integrated into a hospital's electronic data processing system. Such a system would produce hard copy at the supply source via indirect means and enable the requesting party to verify the order before it is sent.

3. Trash removal will become a more significant problem as the impact of disposables, particularly in food service areas, is increasingly felt. A suitable trash compaction device seems highly desirable, if not essential at the points of trash generation, and paper shredders and kitchen disposals may also reduce waste bulk. The problem, however, is not completely solved with the shredder/grinder/compactor device (which might be portable for use by several departments) but should incorporate a system for removing compacted trash to a central collection point. The means of disposing of compacted trash will range from transporting it long distance to abandoned pits and mines,

to using it as a source of energy, to encapsulating it in block form for use as a building material.

4. Software should be developed to permit continuous evaluation of facilities planning and utilization. Warehouse facilities and materiel handling systems should be flexible and be subject to continued analysis.

5. The choice of an "optimal" system cannot be made unconditionally or without the specification of an actual operating system. Factors which greatly influence the behavior and operation of any distribution system are the number of beds and types of services, the number and variety of supporting services, the number and differentiation by specialty of its staff; operating conditions such as patient load, staffing and administrative policies, and patient care practices.

The choice of any system will be greatly affected by the juxtaposition of hospital departments, travel distances involved, and whether the distance is horizontal or vertical. Additionally, trends in the use of disposables and pre-packaged foods will undoubtedly have a significant effect upon the choice of a particular distribution system.

## ADVANCED TECHNOLOGY

Most, if not all, of the considerations for research and development discussed below are not completely new; however, they have not been applied specifically to the unique hospital environment, which often cannot successfully duplicate industrial solutions. The R&D considerations which follow are somewhat arbitrarily segregated into two time frames:

(1) 1972 to 1975.
(2) 1975 and beyond.

1. R&D Considerations from 1972 to 1975.

a. Materiel handling and storage problems can be simplified by controlling bulk package sizes but also by controlling the shapes of the smaller packages within the bulk container. This might be referred to as modular packaging. If for example, a plastic I. V. solution bottle is to replace the glass I. V. bottle, it should be manufactured in a shape amenable to bulk packaging and storage. Although hospitals may not be able to stipulate modular packaging to outside suppliers, they can control modular packaging within the hospital, particularly in such areas as pharmacy, central supplies, linen control, and sterile supplies.

b. With the trend toward packaging single use items, it is possible that all items distributed for consumption or patient care, including linen, food, equipment, and pharmaceuticals, could be delivered on demand from a single warehouse area. Pilot studies should be implemented to determine the effectiveness and efficiency of this " single warehouse" concept. If carried out to the fullest extent, total inventory control would be the responsibility of a single department and would no longer be decentralized throughout the hospital.

c. Patient handling systems have not been treated as an overall systems problem, especially in terms of an automatic or semi-automatic handling. The patient handling solution most likely involves some combination of the stretcher/table/wheelchair/commode/bath array of equipment, and may be able to share the automatic or semi-automatic materiel handling systems.

2. R&D Considerations for 1980 and Beyond.

If a successful solution to modular packaging is found, direct delivery of items to individual patients regardless of location (his room, surgery, X-ray) may be possible. Gravity and/or a conventional pneumatic tube system could probably deliver and remove 95% of all individually packaged items.

On a limited basis, the hospital may possibly play the role of manufacturer, thereby completing the solution of processing/reprocessing and conversion/disposal. For example, plastic and non-woven items may be produced within the hospital from raw materials. Thus, raw material storage is converted to finished products and delivered to patient in a continuous cycle; finished goods inventory ultimately is eliminated and replaced by in-process inventory.

IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: MATERIEL HANDLING**
**COMPONENT: AUTOMATED BULK DISTRIBUTION**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Cyberail, Castle Corporation | Monorail with modular containers moved via electrically powered transporter. The transporter picks up and discharges wheeled carts at strategically located coincidence stations. Substations have push-button control keyboard and can send materiels to any other sub-station. | Initial cost: $100,000 to more than 3 million. | 1. Capable of totally random transfer;<br>2. Mathematical model available as a planning tool;<br>3. Automatic load-unload capability;<br>4. Standard elevator not required;<br>5. Washing scheme and automatic segregation of clean and soiled areas ensure aseptic safety;<br>6. Floor storage reduced;<br>7. Fewer personnel needed for materiel distribution;<br>8. Malfunction of one transporter will not close down entire system;<br>9. Container held upright on vertical, horizonal, or angled track. | 1. Special horizontal and vertical shafts required for transporters--expansion flexibility limited;<br>2. System not efficient for small loads such as individual medical records. |
| AMSCAR, American Sterilizer | Battery-powered car carries special piggy-bank carts and is guided by low voltage wires embedded in the floor. The powered car is dispatched to receiving stations by using a two digit dial system on each car. Cars can automatically call, enter, operate and exit from special elevators. Cars can be programmed for multiple destinations along a predetermined route. Size: 62" long, 26" wide, 73" high. Capacity: approximately 1,000 lbs. | Initial cost: $100,000 to more than 3 million. | 1. Normal patient or staff corridors can be used.<br>2. Existing elevators can be used by installing a control mechanism;<br>3. Cross-contamination is prohibited since all cargo is enclosed in modules;<br>4. Rechargeable battery system reduces operating costs;<br>5. Low maintenance;<br>6. Reliable under peak demands;<br>7. Separate modules are available for laundry, sugical supplies, trash, and heated/refrigerated foods. | 1. Additional elevators may be required;<br>2. Special traffic problems will be created in patient and staff corridors;<br>3. Elevator failure will paralze vertical travel. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: MATERIEL HANDLING**
**COMPONENT: AUTOMATED BULK DISTRIBUTION**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Telelift, Mosler Safe Company | Electrically powered cars travel vertically and horizontally on special tracks at 60 to 150 ft. per minute. Dimensions are 4" x 12" x 15" and 6" x 12" x 18" with loads of 11 and 20 lbs. respectively. Maximum capacity of telelifts is 30,000 lbs. per hour. | Initial cost: $15,000 per station. | 1. Modular components facilitate system expansion;<br>2. No construction requirements for horizontal transport;<br>3. Simple maintenance on electric cars and low operating costs;<br>4. Quiet operation;<br>5. Foam inserts allow glassware and biological specimens to be transported;<br>6. Random transfer via shortest route. | 1. Car size limits load to about 20 lbs. and one cu. ft.;<br>2. Frequent maintenance required on electric cars;<br>3. No provisions for the prevention of cross-contamination. |
| Automated Cart Transportation System (ACTS), Columbus McKinnon | A powered chain monorail moves a special load current frame designed to transport the standard open shelf hospital cart. Four hooks on the load carrier engage the top runners of the standard cart which is then manually pushed up a slight incline to engage the monorail chain. Two dials on the load carrier are used to select the destination and the proper route for each cart. Automatic elevators provide high speed vertical transportation, and carts are automatically loaded/unloaded at lift shaft doors. | Initial cost: $1,300 to $2,000 per bed. | 1. Can accurately predict future cost of materiel handling;<br>2. Separate clean and soil shafts and washing scheme reduce cross contamination;<br>3. Carts can be manually rolled to destination during power failure if elevators are operable;<br>4. Handles all types of hospital materiel, from food to waste;<br>5. Special trolley stops and gravity retarders eliminate undesirable impacts or accelerations;<br>6. Conventional hospital carts may be used;<br>7. Carts cannot get lost or delayed enroute. | 1. Special purpose shafts required for vertical lift;<br>2. Maintenance on monorail track can adversely affect entire system;<br>3. Load carrier frame can be hazardous to pedestrian traffic;<br>4. Expanded corridor width is required;<br>5. Carts can be redirected enroute by passers-by;<br>6. On multiple stop trips load carrier frame must be redirected by receiving station. |

IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: MATERIEL HANDLING
COMPONENT: AUTOMATED BULK DISTRIBUTION

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Selective Vertical Conveyor, Olsen Division of American Chain and Cable Co. | For automatic floor-to-floor delivery, an endless chain is equipped with pivoted cars carried on large sprokets at top and bottom. The operator dials the floor destination and places the container on the loader which automatically transfers the container to the first empty car passing the loading station. Containers remain upright and are automatically discharged at their selected destination. | Initial cost: approximately $10,000 per floor. | 1. Vertical delivery of materiel can be accurately predicted;<br>2. Interior or exterior shafts can be used;<br>3. Loading and unloading is automatic;<br>4. Elevator traffic is reduced;<br>5. Quiet operation. | 1. Shafts not easily relocated;<br>2. Special fire-proofing required;<br>3. Cross contamination difficult to control;<br>4. Limited volume and weight;<br>5. Entire system is down when vertical shaft fails. |
| Selective Vertical Conveyor, Lamson Division, Diebold, Inc. | Steel cars mounted on frames move vertically on a continuous loop-carrying chain and support the trays when they are loaded with supplies or food trays. Other models are designed to carry sterile and contaminated items, respectively. To encode destination, metals tabs are molded into the tray; magnetic heads along the conveyor system write or read signals on or from the tabs. To activate, the operator makes a simple dial selection of destination. | Initial cost: from $8,000 (2 floors) plus $3,000 for each additional floor to $25,000 (2 floors) plus $9,000 for each additional floor. | 1. Advantages same as those listed for Olsen Conveyor, above;<br>2. System can remove responsibility of destination selection from unskilled operator;<br>3. Multiple use of system for trays or boxes. | 1. Disadvantage same as Olsen Conveyor above;<br>2. More expensive method is used for automatic destination selection. |
| Spiral Supply - Ramp Concept | A tractor pulls a train of supply cars up a spiral ramp, and separate cars are detached at the proper location. Up to 4,000 lbs. may be pulled up a 15 percent grade. | Initial cost: $250,000. | 1. Elevators and stairways are freed;<br>2. Fewer personnel required for distribution. | 1. Best suited for a "horizontally" designed hospital. |

IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: MATERIEL HANDLING
COMPONENT: SMALL SCALE PNEUMATIC TUBES

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Selecto-Tube, Lamson Division, Diebold, Inc. | A fully automatic, negative pressure system that moves requisitions, prescriptions, menus, lab. specimens. etc., in containers 6 inches in diameter. Destination is selected by the use of dials at each station. Up to 1,000 carriers per hour can be handled by the loop interchange that redirects carriers to the pre-selected destination. | Initial cost: $6,000 to $8,500 per station. Operating cost for 25 stations: $7,614/yr. Maintenance cost: $75/yr. per station. | 1. Eliminates handcarried documents within the hospital;<br>2. Reduces traffic flow in corridors and elevators;<br>3. Saves travel time for ancillary work requests. | 1. Requires constant maintenance;<br>2. Air tubes easily sabotaged by foreign objects;<br>3. Misdirected or mis-coded containers difficult to locate. |
| Jet-Tube, Lamson Division, Diebold, Inc. | A small point to point negative pressure air tube system using carriers 1 1/2" to 4" diameter. Provides one-way service from patient rooms to nurses' station or COMM center. | Initial cost: $2,000 to $40,000 per line. Maintenance; approximately $100/yr. per line. | 1. Costly manual transportation between two points is eliminated;<br>2. Smaller lightweight plastic carriers may be used. | 1. High maintenance cost;<br>2. Air tubes easily plugged by foreign objects;<br>3. Limited to one-way traffic. |
| Selectomatic, Powers Regulating Company | A varied number of sending and receiving stations are interconnected through an automatically controlled carrier interchange. Carrier destination is selected at the sending station by rotating two selector knobs. The system automatically monitors and directs the carrier to the preselected destination. | Initial cost: $800 to $4,500 per station. Operating cost: $.50 to $2.00 per station per day. Maintenance cost: $50 to $300 per station per year. | 1. Carrier input is controlled to avoid overload;<br>2. Dispatching chamber specially designed to insure proper insertion of carrier;<br>3. Recovery station permits continued operation during a station malfunction or stoppage;<br>4. Conventional non-automatic type carriers can be used. | 1. Total system operation completely dependent upon central control device;<br>2. Recovery of mis-directed carriers difficult. |

IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: MATERIEL HANDLING**
**COMPONENT: PNEUMATIC TRANSFER OF WASTE AND LINENS**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Airflyte, Eastern Cyclone Industries | Cylindrical tube, 12" to 20" in diameter, carries trash or packaged soiled linens by negative pressure air flow. Materiel can be directed to selected collection points by pushbutton control or a color-sensitive photoelectric cell. | Initial cost: $166,320 and $414,447 for 250 and 750 bed facilities, respectively. Operating cost: $2,500 per year. | 1. Performs two functions (waste and linens) at cost only slightly more than single-function system;<br>2. Straight vertical drops not needed;<br>3. Materiel can be moved vertically, horizontally, and around bends;<br>4. Adaptable to existing or new construction;<br>5. No accumulation of trash or soiled linen in patient areas;<br>6. Low maintenance requirements;<br>7. Reduced staff for collection of soiled linen and trash;<br>8. Self-cleaning;<br>9. Safety locks prevent air in tubes from escaping into nursing areas;<br>10. Linens cannot be lost between depository station and central collection. | 1. Limited to trash and soiled linen;<br>2. Tube blockage impairs operation;<br>3. Operator error could dispatch soiled linen to trash hopper. |
| AVAC, Aerojet-General | Vertical chutes feed into horizonal transport pipes which move the materiel to central collection point. Separate tubes are used for trash and soiled linen. A discharge valve controls the release of waste from the vertical tubes. | Initial cost: $140,000 to $190,000 for 250 and 750 bed facilities, respectively. | 1. Workload for collection of soiled linen and trash can be accurately predicted;<br>2. Allows flexibility in location of horizonal pipes;<br>3. Can be incorporated in existing facilities;<br>4. Reduces staff in collection of soiled trash and linen;<br>5. More efficient use of existing trash disposal equipment. | 1. Vertical freefall chute can be located only in limited areas;<br>2. Special fire proofing required;<br>3. Blockage of vertical or horizontal shaft could be critical. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: MATERIEL HANDLING**
**COMPONENT: PNEUMATIC TRANSFER OF WASTE AND LINENS**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Waste Disposal System, Ecology Industries | Trash is sent through a free-fall chute to a conveyor belt or to a common collection area. Most waste is moved by negative pressure to an attrition mill that grinds it to a preselected size, and then to an incinerator, compacter, or storage bin. | Initial cost: $30,000 to $100,000. Maintenance cost: approx. 10% of installations cost. | 1. Existing free fall chutes can be used if available;<br>2. Adaptable to new or existing construction.<br>3. All type of solid waste can be handled.<br>4. System is designed to interface with current waste removal system or on-site incineration. | 1. Designed for trash handling only;<br>2. No effective means for screening waste deposit prior to removal or incineration.<br>3. Blockage of free fall chute would critically impair operations. |

Apple, James M. Plant Layout and Materiel Handling. Ronald Press Company, 1963.

Austin, L. K. Mechanical Supply Distribution Systems for Wilford Hall, USAF Hospital, Lackland AFB, Texas. San Antonio: Baylor University, 1968.

Ayers, D. H. "Simplified Distribution System Accompanies Switch to Disposables." Hospitals, J.A.H.A. 41 (April 1967):60.

Bartscht, K. G. and Burkhauser, B. R. Model of a Hospital Inventory Transportation System. Community Systems Foundation, 1964.

Bentz, F. T. "A Hospital Reviews its Automatic Materials Distribution System." Hospitals, J.A.H.A. 43 (February 1, 1969).

Bondrian, E. M. "Meeting the New Requirements for Hospital Material Handling." Hospitals, J.A.H.A. 43 (February 1, 1965):43.

Carter, E. "Automation in a Central Sterile Supply Department." Nursing Times 61 (May 1965):637.

"Centrally-controlled Carriers Get Hot Orders Out in Minutes." Modern Materials Handling (April 1967).

"Continuous Conveyor Systems Adapted to Nebraska Methodest." Architectural Record 145 (March 1969):162.

Crook, David J. "A Disposable Product Distribution Model for Hospitals." Hospital Topics (December 1964):113.

Department of the Army. Storage and Material Handling. Washington, D. C.: Government Printing Office, 1955. TM743-200.

"First Conveyorized System in United Kingdom Hospital." Hospital Engineering 21 (July 1967):165.

Friesen, G. A. "Mechanized Supply System Providing Supplies When Needed." Hospitals, J.A.H.A. 40 (May 1, 1966):109.

Friesen, G. A. "Newest Concept in Central Services." Hospital Administration 15 (October 1967):29-30.

Grace, Sister M. "Automation: New Methods in C. S. Operation." Hospital Topics (July 1967):85.

Grapski, L. F. and Sanders, H. D. "An Automated Materials Processing and Distribution System." Hospitals, J.A.H.A. 16 (January 1968):77.

"Greenwich District General Hospital: Automatic Conveyor System for Supplies." Hospital Management Plant Equipment 30 (July 1967):364.

Harris, D. H. "Exchange-Cart System for the Distribution of Stores Supplies." Hospital/Medical System Innovation 1 (July 1967):1-4.

Hechinger, Sidney. "Huge Pneumatic Tube System Moves Laundry and Trash." Modern Hospital (July 1969).

"Hospital Automation." Architectural Record 145 (March 1969):150.

Jenks, H. R. "Storage on Wheels: New Cost Savings Through Material Handling -- Toledo, Ohio." Hospital Forum 10 (August 1967):16.

Johnson, A. B. "Food Distribution System for Multi-Story Hospital." Hospital Progress 45 (March 1968).

Knill, B. "Needed: Handling Health for Hospitals." Material Handling Engineering 24 (October 1969):91-100.

Letourneau, C. A. "Automated Transportation of Hospital Materials." Hospital Management 106 (August 1967):45-9.

Letourneau, C. A. "Automated Transportation in Hospitals." Hospital Management 105 (May 1968):39.

McGauritz, M. "Materials Management: Annual Administrative Review." Hospitals, J.A.H.A. 43 (April 1969):147.

McNab, J. A. "Automated Materials Handling." Canadian Hospital 46 (March 1969):46.

"Mobile Storage Speeds Replacement, Cuts Costs." Canadian Hospital 44 (April 1967):7-9.

"Moving Disposables in a Vertical Hospital: The Possibility of Mechanical Distribution of Supplies." British Hospital and Sociological Service Journal (July 1964):1058.

"New Canadian Hospital is Structured for an Overhead Monorail System." Architectural Record 159 (March 1969).

Oudens, G. "An Architect's View: Centralized Distribution System a Must." Hospitals, J.A.H.A. 43 (February 1969):47.

"Pneumatic Conveyor Reduces Linen Hazards." Modern Hospital Illustrated 104 (August 1968).

Saunders, R. and Rousseau, J. L. "How to Get Things Moving Up and Down: A Primer on Vertical Transportation." Modern Hospital 195 (August 1965):120.

Sprink, G. "A Survey of Automatic Materials Distribution Systems." Hospitals, J.A.H.A. 43 (February 1969):53.

Spurrier, E. J. "Mechanical Handling in the Small Central Store." British Hospital Journal Society Review Service 75 (August 1968):1629.

Sternin, M. W. "Do Automatic Materials Distribution Systems Really Save Money." Hospitals, J.A.H.A. 43 (February 1969):75.

"Supply Ramp Is Core of New Hospital at Greater Baltimore Medical Center." Modern Hospital 104 (February 1965):99-100.

"Thousands of Parts at Your Fingertips." Modern Materials Handling (March 1969).

Von Zitzewitz, I. "Conveyor and Pneumatic Tube System Automate Materials Handling at German Medical Center." Hospitals, J.A.H.A. 43 (February 1969):83.

Vouchard, V. E. and Ruggiero, J. S. Drug Distribution in Hospitals. Pittsburgh, Pa.: Duquesne University Press, 1968.

West, M. A. "Materials Management and the Hospital Supply Function." Hospitals, J.A.H.A. 43 (June 1969):96.

Willis, J. R. "Storeroom Design and Location." Modern Hospital (September 1969):42.

## MULTIPHASIC TESTING

### INTRODUCTION

Multiphasic testing is not a new medical concept. As long as there have been tests of organic functions, these tests have been used in tandem as a means of detecting disease. The periodic physical examination is the classical example.

In the recent past much effort has been devoted to automating the process of multiple testing to reduce costs, minimize physician time, and assist in diagnosis of disease through comparison of individual test results to "normal" limits.

The concept of mass screening of a total population in order to detect disease in its early stages and so reduce the overall cost of health care and reduce morbidity and mortality has yet to be proved economically sound. Selective rather than total population screening, appears to be the more valid approach. By selecting age/sex specific components of the populations, testing can be oriented to those diseases most prevalent within the selected group. This requires:

1. Evaluation of age/sex data within the target community
2. Determination of the "high risk" diseases related to that data
3. Analysis of the availability, reliability, and cost of the tests designed to detect these diseases
4. Estimation of the total number of patients involved.

The systems considered in this state-of-the-art survey of multiphasic testing are those most adaptable to the requirements of high volume testing. All these systems perform, at their minimum level, a series of tests which aid the physician in assessing the patient's current state of health.

### TECHNICAL APPROACH

The SOA survey of multiphasic testing was initiated with an extensive literature search of periodicals such as the New England Journal of Medicine, Hospitals, Journal of Occupational Medicine, and Journal of the American Medical Association. A bibliography is included at the end of this section.

In addition, on-site visits were made to:

The Kaiser Foundation Hospital in Oakland, California

The Health Evaluation Center at the U.S.P.H.S. Hospital in Baltimore, Maryland

Health Auto-Data, Inc., Washington, D.C.

Automated Multitest Medical Laboratory, Inc., Palo Alto, California

Medidata Sciences, Inc., Cherry Hill, New Jersey

## STATE OF THE ART

The general trends in modern multiphasic testing are:

1. To expand the list of tests given.
2. To further automate the history taking process.
3. To use relocatable screening facilities.
4. To limit testing to discrete body systems.
5. To utilize the dedicated computer approach to automated screening.
6. To incorporate multitest screening as a routine hospital pre-admission procedure.

### Additional Tests

Inclusion of more tests, especially clinical laboratory tests, for additional disease entities, will expand the total diagnostic capabilities of multiphasic testing. Among the additional tests being considered are:

- Stress testing in the cardiovascular area
- Rectal and hernia examination for men
- Thermography for women
- Phonocardiograms
- Additional blood tests for:
  Electrolyte
  Triglycerides

Free Fatty acids

Protein-bound iodine

Heavy metals

Blood group determination

Stool guaiac test for occult blood.

In many screening centers oral examination and dental radiography are already included. Their use is increasing and may eventually become standard procedure.

Increased Automation of the History-Taking Process

Patient history-taking is becoming increasingly self-administered via questionnaires presented by video and audio-video devices. By developing the pertinency and logic of the questionnaires and reducing ambiguities, more accurate, all-inclusive data can be provided without increasing the time required to complete a history. In addition, a computer can be programmed to review the accumulated history and test results and order any extra test procedures thus indicated before the patient and his test results are referred to the doctor. Specific history-taking devices are discussed in the Communications and Data Management section of this volume.

Increased Handling Capacity of the Chemistry Laboratory

The increase in screening capacity, produced by automation, has created a corresponding need for more blood chemistry work. This can be achieved through the development of more efficient blood chemistry analyzers. In regard to costs, it must be considered that as more determinations become standard, cost per determination decreases. Specific automated analyzers are discussed in the Clinical Laboratory section of this volume.

Relocatable Screening Facilities

On-site screening is best served by the relocatable screening facility. There are two types: the fully mobile and the transportable.

Facilities of the first type are normally housed in special vans or tractor-trailer combinations constructed for maximum mobility. They have their own power traction units and hence can be "buttoned up" and made roadworthy very quickly. Transportable screening facilities, on the other hand, are less mobile. Although they can move from one location to another, once located, they are semi-fixed in place and the traction unit is removed completely. Facilities of this type resemble the portable school rooms used in many parts of the country. Because they are moved about far less, they need not be as roadworthy as the fully mobile units, and can generally be larger in size.

Another version of the transportable system is the coordinated structural component or module approach developed by the Texas A&M School of Architecture and the Health Services Research Branch of the Federal Health Programs Service. This version uses several basic structural components, each 4 feet deep by 8 feet wide by 8-1/2 feet high. Two such modules are joined by 8-foot hinged panels to make an overall compartment that is 16 feet deep by 8 feet wide by 8-1/2 feet high. Movable equipment such as cabinets, medical items, supplies, hygiene components, and furniture can be packed for shipment inside these basic units, which are easily handled by road, railroad, ship, or air. Many different floor plans can be developed from these basic modules by joining them in the desired configurations.

Except in the case of very limited screening procedures such as the familiar chest X-ray, most mobile multiphasic screening systems are housed in two or more vans. Only the largest and most complex, however, include on-site automated blood chemistry laboratories and computer systems. Typically, blood samples and urine samples, along with X-ray results and EKG results, are sent to a central facility or a commercial laboratory for analysis. Test results also may be sent to the central laboratory in the form of keypunched cards. There they are combined with laboratory, X-ray, and EKG analyses to produce a final report for later disposition.

Another approach to multiphasic testing is to use a single facility for a dual purpose; a daytime clinic, for example, could be easily converted to a testing facility during the evening hours. Laboratories, radiology, and staffs would be shared. The obvious advantage of this organization is that costly duplication of facilities and equipment is unnecessary.

Limited Scope Screening

Limited scope screening refers to the dedicated systems approach exemplified by chest X-rays for tuberculosis, dental screening, and screening for female cancer. This approach is now being carried a step further and applied to automated screening procedures for discrete body systems that include cardiovascular screening, psychiatric screening, pulmonary systems screening, and gastro-intestinal screening. By orienting the testing around specific body systems, real economies can be realized in obtaining rapid and accurate diagnoses where these body systems are suspect.

Use of the Dedicated Computer

Several recent designs for multiphasic screening facilities have stressed the use of the fully on-line dedicated computer for practical handling of a larger number of on-line tasks. This means that the computer can handle not only the management and processing of data and the administration of questionnaires, but also such additional functions as the monitoring of patient progress through the facility and the expediting of routing to test stations. The dedicated computer, moreover, can program assessments of collected data. Through programmed diagnostic logic, it can also signal the need for additional tests and/or immediate medical attention. The Medidata Sciences and Kaiser systems offer the capability for such a computerized approach to multiphasic screening.

Use of Multiphasic Testing for Pre-admission Examination

A newer application of multiphasic testing is its incorporation into the standard pre-admission routine for hospital inpatients. The performance of a limited number of pre-admission tests often costs the system as much as if the patient were to complete the full multiphasic battery. The latter procedure, moreover, may yield a great deal of valuable supplemental information as well as an excellent base-line definition of the patient's total situation at admittance. It is thus advisable to have every patient, his condition permitting, undergo complete multiphasic testing upon entering the hospital.

Advanced Technology

During the next three to four years stress testing will be included in cardiovascular screening and new biochemical hematological and immunological variables will be introduced. Cardiovascular testing, generally, will emphasize a systemic rather than a parametric approach. The volume of physiological and historical testing procedures now automated -- some 40% -- is expected to double. Anthropometry studies will be expanded to include lateral thoracic width, body mass, and full body photography. Computer programs will be developed for multivariate-multifactorial analysis and will be used experimentally to aid in diagnosis.

## IMPROVEMENT ALTERVATIVES COMPARISON CHART

**FUNCTION: MULTIPHASIC TESTING**
**COMPONENT: SINGLE PURPOSE FIXED FACILITIES**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Medidata Science, Inc. | Highly automated medical testing system that allows physiological measurements to be executed directly on-line to data processor which compares them against pre-selected limits. Automated patient history-taking console combines visual display of multiple choice answers with handing capabilities. | $25 per patient per 2,000 patients per month. | 1. All details, including computer software, are included in the package.<br>2. Self-administered medical history allows flexibility and branding of pertinent questions.<br>3. Maintenance part of overall package.<br>4. Complete summary of all positive findings available. | 1. 100 or more patients per day necessary for efficient operation.<br>2. Only a very specific series of tests can be performed. These must be universally accepted by medical staff.<br>3. Sixth grade or equivalent education necessary for history-taking. |
| Kaiser System | Similar to above except the longer laboratory results and medical questionnaire are introduced "off-line" a day or two later, then final report is printed. Medical history gathered through use of 207 pre-punched cards which carry single dichotomous questions. They are sorted by the patient into affirmative and negative piles. A psychological test is administered in a similar manner using 155 cards. | $21.32 per patient for 100 patients per day. | 1. Off-line batching through conversion to punch cards allows processing by central computer which has other functions. This allows other functions such as usage data accounting information to be easily tied in with examinations at a reduced cost. | 1. 100 or more patients per day necessary for efficient operation.<br>2. "Off-line" handling of data requires 1 or 2 days before complete record is available. |
| **Component: Mobile Facilities** | | | | |
| California Cannery Workers Health Check-Up Program | Three fully equipped mobile vans, each 10 ft. by 60 ft., are towed to a site and set in place for operation. Blood and urine samples, as well as X-rays and EKG's, are sent to outside laboratories. Exam results are recorded on cards and sent to central processing area. A similiar approach has been developed by Texas A&M University. | $36.95 per patient for 4,000 patients per month. | 1. Permanent site and construction not required; reduced start-up time for new mobile populations.<br>2. Population served can be highly dispersed. | 1. Higher cost per square foot due to transportable motive.<br>2. Control of lab results and outside sources may be more difficult.<br>3. Life of structure less than fixed facility due to construction techniques necessary for mobility.<br>4. Administrative staff may be larger and control more difficult. |

IMPROVEMENT ALTERNATIVES CHART

**FUNCTION: MULTIPHASIC TESTING**
COMPONENT: DUAL FUNCTION FACILITIES

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| PHS Hospital, Baltimore, Md. | Facilities used for OPD in the daytime are used for multiphasic screening at night. Labs, radiology, and staff are shared. | Not developed at this time but should be competitive with or lower than others due to reduced facilities and equipment costs. | 1. Lower than initial construction cost.<br>2. Availability of staff and equipment.<br>3. Less "lost time" by patients since "off job" PM hours are available.<br>4. Workload leveling via use of ancillaries.<br>5. More attractive operating hours for many patients. | 1. Conversion from OPD to Multitest requires cooperation and coordination between staffs in all areas.<br>2. May result in less than optimal patient traffic patterns because of OPD layout.<br>3. Restricted operating hours.<br>4. Not acceptable if full time multitesting facility required. |

# BIBLIOGRAPHY - MULTIPHASIC TESTING


Collen, Morris F. "Computer Analyses in Preventive Health Research." Methods of Information in Medicine 6 (January 1967):8-14.

_____. "The Multitest Laboratory in Health Care of the Future." Hospitals, J.A.H.A. 41 (May 1, 1967):119-25.

_____. "Periodic Health Examinations Using an Automated Multitest Laboratory." Journal of the American Medical Association 195 (March 7, 1966):142-5.

Collen, Morris F., and Davis, Lou F. "The Multitest Laboratory in Health Care." Journal of Occupational Medicine 11 (July 1969):355-60.

Collen, Morris F.; Kidd, Prentis H.; Feldman, Robert; Cutler, John L. "Cost Analysis of a Multiphasic Screening Program." New England Journal of Medicine 280 (May 8, 1969):1043-45.

Collen, Morris F. et al. "Automated Multiphasic Screening and Diagnosis." American Journal of Public Health 54 (May 1964):741-50.

Flagle, Charles D. Personal Communication. September 15, 1969.

Gelman, Anna C. Automated Multiphasic Health Testing 1969. Mimeographed. New York: American Health Foundation, September 1969.

Gitman, Leo. "Automated Multiphasic Health Screening." Journal of Occupational Medicine 11 (December 1969):669-73.

Haessler, Herbert A. "Recent Developments in Automating the Medical History." Computer and Automation (June 1969):24-7.

Health Evaluation Center. Silver Springs, Maryland: Federal Health Programs Service.

Hsieh, Richard K. C. "System Design of a Health Evaluation Center for the Baltimore PHS Hospital." Speech presented at the 1969 Engineering Foundation Research Conference, Deerfield, Massachusetts, August 18-22, 1969.

International Compumedics Corporation. Compuhealth: A Multiphase Health Screening System. Promotional Brochure.

Johns, Richard J. Multiphasic Screening in the Military Screening. Mimeographed. Baltimore: Johns Hopkins University.

Leamnson, George. "Multiphasic Health Screening in Indianapolis." Group Practice (September 1969):17-23.

Love, John. A.M.L. Mimeographed. Baltimore: Johns Hopkins University, 1970.

Mayne, John G. et al. "A Health Questionnaire Based on Paper-and-Pencil Medium Individualized and Produced by Computer." Journal of the American Medical Association 208 (June 16, 1969):2060-3.

Montgomery, Robert L., and Singman, David. "Multiphasic Screening." Hospitals, J.A.H.A. 44 (March 16, 1970):71-4.

Multiphasic Screening Newsletter 2 (September 1969); 3 (May 1970); 3 (June 1970).

Relocatable Multiphasic Health Screening: Two Systems. College Station, Texas: Texas A&M University, July 1969.

Smith, Eleanor F. "The Utilization of Multiphasic Screening in Public Health Centers." Journal of Occupational Medicine 11 (July 1969):364-8.

Sperry Systems Management Division. Multiphasic Testing Center. Great Neck, New York: Sperry Rand Corporation.

_____. Multiphasic Testing Center for the Hospital Environment. Great Neck, New York: Sperry Rand Corporation.

U. S. Public Health Service. From Head to Toe. Washington, D. C.: U. S. Government Printing Office, 1968. No. 1808.

_____. Health Evaluation Center. Washington, D. C.: U. S. Government Printing Office, 1970. O-378-251.

Weber, Thomas B. "Multiphasic Screening: The Next Generation." Journal of Occupational Medicine 11 (July 1969):369-73.

Yedidia, et al. "Cost Requirement of Mobile Health Screening." Journal of Occupational Medicine 11 (November 1969):652-8.

_____."Data Processing." Journal of Occupational Medicine 11 (November 1969):636-9.

Yedidia, et al. "Findings from Multiphasic Screening and Follow-Up." Journal of Occupational Medicine 11 (November 1969):640-6.

_____. "Integration of Screening with the Delivery of Medical Care." Journal of Occupational Medicine 11 (November 1969):647-51.

_____. "The Logistics of Mobile Testing." Journal of Occupational Medicine 11 (November 1969):633-35.

# PHARMACY

## INTRODUCTION

The pharmacist's traditional role within the BLHC System is to compound and dispense drugs prescribed by the physician. Today the pharmacist is closely examining his role in relation to hospital needs and to his professional prerogatives. This scrutiny has revised conventional concepts of drug distribution and communications between clinical areas and pharmacy.

The pharmacy function and the selection of drug distribution and communication methods can have a minor effect on hospital planning, construction, and maintenance. The major impact will be on medical support personnel, specifically pharmacists and nurses, and a lesser impact will be felt by physicians. Most importantly, distribution and communications methods selection will affect the pharmacist's role and his involvement with effective and efficient professional health care delivery.

When considering a new hospital, the pharmacy function must be evaluated by thorough review of the following basic principles:

1. Safety. The prescribing-compounding-distributing cycle must be as clinically safe as possible. Increasing drug variety, complexity, and reactivity, plus the technical nature of medical and pharmaceutical terminology, make it desirable to use the pharmacist's professional education and skills to analyze and interpret physician's orders. Often the pharmacist can eliminate confusion relative to dosage and pharmacological and chemical incompatibilities which could threaten patient safety.

2. Accessibility. Facilities and equipment used for drug storage should be accessible only to physicians, pharmacists, or authorized nurses. Proper security precautions can reduce or eliminate unauthorized drug dispensing, administration errors, and pilferage.

3. Packaging. Methods, equipment, and material used in packaging or repackaging medication or supplies should maintain drug stability and allow product inspection as near to administration time as practical.

4. Drug Identification. Dispensed drugs should be adequately identified with generic name, potency, expiration date, and lot or control number.

5. Service Continuity. If automated dispensing methods are to be used, standby pharmaceutical services should be available in the event of mechanical or electrical failure.

6. Efficiency. The pharmacist's time must be optimally utilized for the maximum benefit of other hospital personnel and patients.

Our state-of-the-art study of pharmacy considers the above principles as they apply to communications and drug distribution, and the advanced technology portion of this report discusses some concepts and equipment that are being researched but will be unavailable for implementation by 1972.

## TECHNICAL APPROACH

Our state-of-the-art survey of pharmacy was initiated with an extensive literature search of periodicals such as the American Journal of Hospital Pharmacy, Drug Intelligence, and Hospitals. A bibliography is included at the end of this section.

To keep abreast of the latest developments, we personally contacted the chief pharmacists of the following health centers, and asked them to estimate costs and judge the effectiveness of the innovative pharmacy concepts they have adopted:

| Health Center | Concept |
|---|---|
| University of Iowa<br>Iowa City, Iowa | Drug Information Center |
| University of Kentucky<br>Lexington, Kentucky | Unit Dose Study funded by the Public Health Service |
| St. Joseph Mercy Hospital<br>Ann Arbor, Michigan | IV Additive Program |
| Mercy Hospital<br>Pittsburgh, Pennsylvania | Unit Dose Program |

Especially helpful in our research were two studies conducted at the University of Iowa: 1) the Unit Dose Drug Distribution Study, 1964-1965, and 2) the Drug Information Study, 1967-1969. These two studies funded by the U. S. Public Health Service investigated new pharmacy procedures at institutions such as the University of Kentucky, the University of Illinois, the University of Michigan, and the Regional Medical Program at the University of Missouri.

## STATE OF THE ART

The general trends in pharmacy functions can be broadly discussed within two major categories: Communications and Drug Distribution.

1. Communications. Communications related to pharmacy are concerned with transmitting physicians' prescriptions to the pharmacist quickly and without error. Present methods include courier or mechanical equipment such as pneumatic tubes, facsimile devices, and automated entry devices.

Automated entry of pharmaceutical data is becoming increasingly popular for the following reasons:

a. Medical support personnel save time because transcribing the physician's original order is eliminated.

b. Time lapse between order entry and response is significantly decreased.

c. The prescription can be compared to patient history through computer techniques enabling the pharmacist to check the prescription's accuracy and applicability to the specific patient's needs.

The general trends in system communications are discussed in detail in the communications and data management sections.

2. Drug Distribution Methods. No single drug distribution method satisfies all the needs of the BLHC System. A total distribution method is a composite of several sub-methods selected after considering such factors as:

a. The Drug. An unstable drug must be distributed more quickly than a stable one; some drugs are too bulky to flow through normal distribution channels; other drugs are too toxic for unrestricted distribution and require specialized techniques.

b. Drug Usage. Each drug order fits into one or more of three basic "time" categories:

- those administered at a specific time or times
- those administered in conjunction with a specified procedure
- those administered within a specified time at the patient's request or when medical or medical support personnel feel administration is necessary. All categories imply the need for different sub-methods.

c. Construction Limitations. Hospital size and layout can affect physical distribution and communications methods, often demanding a variety of sub-methods. Implementation of a centralized unit dose distribution system requires adequate physical distribution methods to all clinical areas.

d. Personnel Limitations. Shortages of medical support personnel and their correct utilization influence function changes. Function evaluation and development can result in more effective utilization of the available medical and paramedical personnel. The trend is toward increasing the pharmacist's involvement in the total drug delivery and administration function with a corresponding re-orientation of the nurse toward patient care.

e. Communication Methods. The type or types of communication methods employed will directly influence drug delivery. A lengthy response time due to lack of direct communication, varied and incomplete communication channels, and lack of documentation will restrict implementation of newer distribution innovations.

f. Type of Service. Service demands vary among hospitals and among departments within a hospital. Short-term, acute-care hospitals have more pressing and varied demands requiring more rapid drug distribution methods than a chronic-care hospital. An internal medicine department will demand more rapid pharmacological response than an OB-GYN department. These varying service requirements can be compounded by patient age, prognosis and diagnosis, extent of research facilities, and type of medical staff.

The following improvement alternatives were studied and represent the state-of-the-art in drug distribution and communications methods:

In the complete floor stock or ward component method, a predetermined drug complement is stored on the nursing units and restocked either by requisition or by routine replacement. Drugs which are expensive or rarely used, or which require strict control are specially requisitioned.

The systematic drug replacement alternative is a variation of the traditional ward stock system used in most large hospitals. Drug packages with a charge slip inside contain three- to seven-day supplies. After removing the drugs, the nurse stamps the charge slip with the patient's plate; a pharmacy technician replaces the drugs and sends the slip to pharmacy for charging. The complete ward component of drugs, as well as the portable medication cabinets used in some hospitals, are periodically updated.

Unit drug dose distribution focuses on the unit-of-use packaging concept and can range from pure centralized to pure decentralized methods. The centralized method dispenses all drugs from the pharmacy; the decentralized method dispenses all drugs from ward stations following prepackaging in the pharmacy. Medication carts set up by patient bed arrangement will periodically deliver to the wards all patient medication scheduled for administration during a specific period. Combinations of centralized and decentralized methods can be utilized to accommodate drugs with various degrees of stability, toxicity, bulk, and other factors.

Mechanical drug distribution uses a dispensing machine as a repository for identified quantities of drugs. Upon receipt of a prescription order, the nurse inserts a patient identification card in the machine which then releases the requested drugs, packaged and identified. The device also creates a billing tape for accounting and drug control purposes. The Brewer Corporation manufactures and markets the "Brewer System" complete with mechanical dispensing devices, medication delivery carts, and prepackaging equipment and materials. The present equipment is primarily for oral solids, such as tablets and capsules.

Because the machine relieves the pharmacist of routine tasks, his efficiency and value to medical personnel can be increased through an expanded role in recommending and implementing new drug therapy.

Automated outpatient dispensing within the controlled environment of the outpatient clinic of a health care facility is feasible. After input of the patient and prescription information on a terminal, a labeled drug and a billing statement would be produced which would facilitate monthly billings; daily, monthly, and yearly management statistics; drug control data; inventory control and purchasing data. Refill prescription information would also be available.

The I. V. additives program is aimed only at intravenous fluids containing added medications. To insure adequate sterility, formulation, and stability, such fluids should be centrally prepared in the pharmacy and delivered to clinical units for administration.

The drug information center provides data regarding drugs, drug therapy, and intra- and inter-hospital utilization. The information center is becoming increasingly necessary because the complexity of drug therapy has surpassed the individual physician's ability to stay current with new technology. Since an additional pharmacist will be needed to select data for the information center, functional costs will be increased. However, benefits in increased safety and use of advanced drug therapy techniques can be significant.

The clinical pharmacy concept of locating a clinical pharmacist in the patient care area was originally tied with the unit dose drug distribution concept, although it can be applied to other distribution systems. On the nursing wards the clinical pharmacists supervise all drug administration, coordinate all medication activity with the nursing personnel, and consult regarding drugs and drug therapy with the medical and nursing staff. Any medications ordered after cart delivery to the wards and any medications not in the cart due to stability, bulk, or control requirements will be periodically prepared and added by the clinical pharmacist. The clinical pharmacist will periodically check all patient medication profiles for incompatibilities, inter-actions, and dubious therapy as well as coordinate and participate in clinical research studies and drug control programs.

## ADVANCED TECHNOLOGY

Improvement alternatives that are in the research and development stage and will be available for implementation only after 1972 are discussed below.

By 1975 the mechanical dispensing system will be able to handle a greater percentage of required drugs, since research is underway to produce devices capable of handling dosage forms other than tablets or capsules.

The pharmacy medication administration concept, which could be implemented by 1975, stipulates that the pharmacy department will have the responsibility for all functions involving drug purchasing, preparation, delivery and administration. Specifically, the clinical pharmacist will supervise the administration of all drugs by medication technicians, freeing nurses for activities more oriented toward patient care.

With the pharmacy prescribing concept, which is essentially an extension of the clinical pharmacy alternative, the pharmacist makes medical rounds with the physician. The physician makes the diagnosis and the pharmacist then prescribes the appropriate medication. This concept will probably not be implemented until 1980.

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: PHARMACY**
**COMPONENT: DRUG DISTRIBUTION**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Ward Component Drug Distribution | Predetermined drug complement is stored on nursing units; drugs which are used infrequently or require strict control are specially requisitioned. | | 1. Most drugs are easily accessible to nursing personnel.<br>2. Fewer individual prescription orders.<br>3. Minimal drug return.<br>4. Less demand for pharmacy personnel in the evening. | 1. Lack of pharmacist's supervision may result in medication errors.<br>2. Financial loss from misappropriated drugs or drugs that become obsolete or deteriorate.<br>3. Billing system depends on nurse efficiency.<br>4. Increased drug inventory.<br>5. Storage facilities must be provided on each ward. |
| Systems Drug Replacement | All drug stock is stored on the wards and replenished on a regular basis. | Only minor initial equipment costs. | 1. Decreases communication and service load between pharmacy and the clinical units.<br>2. Better technical personnel utilization. | 1. Does not decrease nursing involvement and time spent on pharmacy-related activities.<br>2. Limits pharmacy control over drug supply.<br>3. Variety of stocked drugs would probably be limited. |

# IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: PHARMACY**
**COMPONENT: DRUG DISTRIBUTION**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Unit Dose Distribution | Most drug stock dispensed in unit-of-use packages for a specific patient. | Initial equipment cost: $12,625 to $23,075 for 250- and 750-bed facilities, respectively. | 1. Documented increases in efficiency and safety.<br>2. Increased accuracy in documentation and release of nursing time.<br>3. Increased pharmacist availability.<br>4. Ward drug stock component usually reduced. | 1. Necessitates reliable and efficient communication and distribution system.<br>2. Increases space requirements and new equipment needed for central pharmacy.<br>3. Increased cost for labor (additional pharmacy personnel), packaging, and implementation. |
| Mechanical Drug Distribution System, Brewer Corporation | 70% of drug stock is dispensed by mechanical storage and dispensing devices located on the clinical units. | Initial cost: From $56,000 to $169,000 for 250-and 750-bed facilities, respectively. | 1. Improves drug control, charging procedures, and inventory control.<br>2. Fewer pharmacy personnel needed to dispense drugs. | 1. Cannot handle all drug supplies.<br>2. Creates additional requisitioning procedures for the nurse.<br>3. High maintenance costs.<br>4. Increased packaging costs.<br>5. High initial equipment cost. |
| Automated Outpatient Dispensing | In controlled environment of outpatient clinic, patient and prescription information are input to a terminal, and a labeled drug and billing statement would be produced. | | 1. Technicians can assume many of the pharmacist's repetitive tasks.<br>2. Decreased pharmacy personnel and bookkeeping costs.<br>3. Prescription data can identify therapeutic trends, reduce inventory procedures, and maintain drug control records. | 1. Increased space needed for storage and dispensing areas.<br>2. An on-line computer with the necessary hardware will be needed. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: PHARMACY**

**COMPONENT: DRUG PREPARATION**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| **IV Additives Program** | **Most IV solutions containing additives will be prepared in the central pharmacy.** | | 1. Adequate sterility, formulation, and stability are ensured.<br>2. Less nursing time spent in IV preparation.<br>3. Better drug control.<br>4. Possible increase in safety through error reduction. | 1. Laminar flow work benches and a positive air pressure system are required. |

**COMPONENT: PHARMACIST'S ROLE**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| **Clinical Pharmacy Concept** | **A pharmacist located in the clinical area supervises all pharmacy services there, orders necessary drugs, and periodically checks patient medication profiles.** | | 1. Pharmacist has direct control of drugs; fewer medication errors.<br>2. Nurses freed for additional direct patient care.<br>3. Improved professional stature for pharmacist. | 1. Increased number of pharmacists required.<br>2. Ward floor space must be provided for a specially equipped pharmacist's office. |

# IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: PHARMACY**
**COMPONENT: DRUG INFORMATION**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Drug Information Center | The center provides information on drugs and drug therapy to professional staff. The center is usually part of the pharmacy department and is generally directed by a pharmacist interested in clinical investigation and information search and retrieval. | | 1. Physicians have easy access to the most advanced information on drugs and drug therapy.<br>2. Improves the pharmacist's role and image.<br>3. May be a good training tool for pharmacy students and interns.<br>4. Drug utilization audits and evaluations pinpoint trends and drug costs may be actively controlled. | 1. Pharmacy personnel and materials costs are increased.<br>2. Qualified pharmacists may be scarce.<br>3. Some physicians construe this as an infringement on professional prerogatives.<br>4. Space is needed near a physician travel area. |

## BIBLIOGRAPHY - PHARMACY

Alexander, W. E.; Humenchuk, R. J.; and Keeping, D. "A Drug Usage Study." Drug Intelligence 3 (January 1969).

Ashour, S. A Computerized Hospital Information System. American Institute of Industrial Engineers, May 1968.

Barker, K. N. and Heller, W. M. "The Development of a Centralized Unit Dose Dispensing System, Part I: Description of the UMAC Experimental System." American Journal of Hospital Pharmacy 20 (November 1963).

______. "The Development of a Centralized Unit Dose Dispensing System, Part II: Why Centralize the Preparation of Unit Doses?" American Journal of Hospital Pharmacy 20 (December 1963).

______. "The Development of a Centralized Unit Dose Dispensing System, Part III: An Editing Center for Physician's Medication Orders." American Journal of Hospital Pharmacy 21 (February 1964).

______. "The Development of a Centralized Unit Dose Dispensing System, Part IV: The Roles and Responsibilities of the Pharmacist and the Nurse under the Experimental System." American Journal of Hospital Pharmacy 21 (May 1964).

______. "The Development of a Centralized Unit Dose Dispensing System, Part V: The Pilot Study - Introduction and Work Measurement." American Journal of Hospital Pharmacy 21 (September 1964).

______. The Development of a Centralized Unit Dose Dispensing System, Part VI: The Pilot Study - Medication Errors and Drug Losses." American Journal of Hospital Pharmacy 21 (December 1964).

Barker, K. N.; Kimbrough, W. W.; and Heller, W. M. A Study of Medication Errors in a Hospital. Fayetteville, Arkansas: University of Arkansas, November 1966.

Barker, K. N. and McConnel, W. E. "How to Detect Medication Errors." Modern Hospital 99 (July 1962).

Bartscht, K. G.; Estrella, M. A.; and Rothenbubler, E. F. "Pharmacy Staffing Methodology: A Management Tool." American Journal of Hospital Pharmacy 22 (October 1965).

Beckerman, J. H. "The Logistics of a Drug Distribution System: Packaging, Labeling and Storage." American Journal of Hospital Pharmacy 24 (February 1967).

Berman, A. "Review and Criticism of Traditional Drug Distribution Systems." American Journal of Hospital Pharmacy 24 (February 1967).

Black, H. J. and Tester, W. W. "Decentralized Pharmacy Operations Utilizing the Unit Dose Concept, Part III." American Journal of Hospital Pharmacy 24 (March 1967).

_____. "Decentralized Pharmacy Operations Utilizing the Unit Dose Concept." American Journal of Hospital Pharmacy 21 (August 1964).

Blumberg, M. Economic Feasibility of Automating Selected Hospital Activities. USPHS Grant No. W-111.

Burkholder, D. F. "A Coordinated Hospital Pharmacy Program in Support of Rational Therapeutics." Drug Intelligence 1 (March 1967).

_____. "The Future Role of the Hospital Pharmacist in Drug Information Services." American Journal of Hospital Pharmacy 24 (April 1967).

_____. "Operation of the Drug Information Center at the University of Kentucky Medical Center." American Journal of Hospital Pharmacy 22 (January 1965).

_____. "Some Experiences in the Establishment and Operation of a Drug Information Center." American Journal of Hospital Pharmacy 20 (October 1963).

Developing a Parenteral Admixture Program. Columbus, Ohio: Ohio State University Hospitals, December 1968.

Dougherty, K. "Pharmacy Executive Establishes New Standards of Efficiency and Control." Nation's Hospitals, no. 3 (1968).

Durant, W. J. and Zilz, D. A. "Some Deficiencies of the Pharmacists in the Clinical Environment." American Journal of Hospital Pharmacy, 25 (April 1968).

Filosa, L. "New Information System Uses Less Staff, Provides More Data, More Dollars." Modern Hospital 106 (June 1969).

Francke, D. E. "Preparation of Parenteral Admixtures: Nursing or Pharmacy Function?" American Journal of Hospital Pharmacy 22 (May 1965).

______. "The Drug Information Center: A Professional Need and Opportunity." American Journal of Hospital Pharmacy 20 (August 1963).

Godwin, H. N. "Developing a Clinical Role for the Hospital Pharmacist." Drug Intelligence 2 (June 1968).

Gouveia, W. A., et al. "Computers: Basic Principles and Hospital Pharmacy Implications." American Journal of Hospital Pharmacy 25 (January 1968).

Gouveia, W. A.; Diamantis, C.; and Barnett, G. O. "Computer Applications in the Hospital Medication System." American Journal of Hospital Pharmacy 26 (March 1969).

Heller, W. M. "Data Processing in Drug Distribution Systems." Hospitals 42 (December 1, 1968).

Holysko, N., Sr., and Ravin, R. L. "A Pharmacy Centralized Intravenous Additive Service." American Journal of Hospital Pharmacy 22 (May 1965).

The Hospital Pharmacist and Drug Information Services, American Society of Hospital Pharmacists, May 1968.

Hynniman, C. E., et at. "A Comparison of the University of Kentucky Unit Dose Systems with Traditional Drug Distribution Systems," December 1969. American Journal of Hospital Pharmacy, in press.

Hynniman, C. E.; Hyde, G. C.; and Parker, P. F. "Some Results on the Cost and Effectiveness of Unit Dose Systems" American Journal of Hospital Pharmacy, in press.

Kenna, F. "A Pharmacist Looks at Dispensing Machines." Hospitals 37 (February 1, 1963).

Kern, M. S. "New Ideas About Drug Systems." American Journal of Nursing 68 (June 1968).

Levine, M. E. "The Pharmacist in the Clinical Setting: A Nurse's Viewpoint." American Journal of Pharmacy 25 (April 1968).

Madden, E. E., Jr. and Dreyfus, R. H. "Outpatient Pharmacy Prescription Automation." American Journal of Hospital Pharmacy 25 (January 1968).

McConnell, W. E. et al. "Centralized Unit Dose Dispensing." American Journal of Hospital Pharmacy 18 (September, 1961).

McLeod, D. C. "Single Unit Packages of Drugs Available Today, Part I: Oral Medications." American Journal of Hospital Pharmacy 24 (September 1967).

_____. "Single Unit Packages of Drugs Available Today, Part II: Injections in Prefilled Disposable Syringes." American Journal of Hospital Pharmacy 24 (December 1967).

Metzger, R. T.; Dytcowski, R. J.; and Faulk, D. A. "How To Cut Pharmacy Paperwork in Half While Assuring Accurate Control." Nation's Hospitals, No. 2, (1968).

Moody, P. M., et al. "Attitudes of Hospital Personnel at University of Kentucky Medical Center toward Unit Dose." December, 1969. American Journal of Hospital Pharmacy, in press.

Parker, P. F. Guidelines for Practical Hospital Unit Dose Systems. USPHS Grant No. 8-R18-HS-00103-02.

Pellegrino, E. D. "The Role of the Hospital Pharmacist in Rational Therapeutics." Hospitals 37 (February 16, 1963).

_____. "Drug Information Services and the Clinician." American Journal of Hospital Pharmacy 22 (January 1965).

Petrick, R. J. and Kleinmann, K. "Evaluation of a Drug Distribution System Using the Physician's Original Order." American Journal of Hospital Pharmacy 22 (September 1965).

Price, E. M. "A Nurse Looks at Hospital Drug Distribution Systems." American Journal of Hospital Pharmacy 24 (January 1967).

Ravin, R. L., et al. "Two-Year Appraisal of a Centralized IV Additives Service." Hospitals 41 (January 16, 1967).

"A Report on the Iowa Drug Distribution System." Drug Intelligence 2 (November 1968).

Rosenberg, J. M. "Drug Information Center: Mercy Hospital, Rockville Centre, New York." Hospital Pharmacy 3 (June 1968).

Schwartau, N. and Sturdavant, M. "Packaging and Dispensing Drugs in Single Doses." American Journal of Hospital Pharmacy 18 (September 1961).

_____. "A System of Packaging and Dispensing Drugs in Single Doses." American Journal of Hospital Pharmacy 18 (September 1961).

Seibert, S., et al. "Utilization of Computer Equipment and Techniques in Prescription Processing at Los Angeles County General Hospital." Drug Intelligence 1 (November 1967).

Sewell, W. "What is a Drug Information Specialist?" Drug Information Bulletin 1 (July-September 1967).

Slavin, M. "Automation and the Hospital Pharmacist." American Journal of Hospital Pharmacy 19 (June 1962).

_____. "Design of an Automated Medication System." American Journal of Hospital Pharmacy 24 (May 1967).

Simon, R. J. et al. "Attitudes of Nurses, Physicians and Pharmacists toward a Unit Dose Drug Distribution System." American Journal of Hospital Pharmacy 25 (May 1968).

Simpson, C. and Carnek, D. C. "Memorial Hospital Decentralized Pharmacy." American Journal of Hospital Pharmacy 18 (September 1961).

Slater, W. E. and Hripko, J. R. "The Unit Dose System in a Private Hospital." American Journal of Hospital Pharmacy 25 (August 1968).

_____. "The Unit Dose System in a Private Hospital, Part II: Evaluation." American Journal of Hospital Pharmacy 25 (November 1968).

Smith, W. E. "Role of a Pharmacist in Improving Rational Drug Therapy as Part of the Patient Care Team." Drug Intelligence 1 (August 1967).

Statement on Drug Distribution Systems. American Society of Hospital Pharmacists, August 1964.

Tester, W. W. A Study of Patient Care Involving a Unit Dose System. Ames, Iowa: University of Iowa, College of Pharmacy, 1967.

Tucci, R. and Webb. J. "MOSAICS: Medication Order Supply and Individual Charge System." American Journal of Hospital Pharmacy 21 (July 1964).

Vogel, D. P. and Holland, B. F. "Electonic Data Processing in Hospital Dispensing." American Journal of Hospital Pharmacy 26 (April 1969).

Walsh, H. C. et al. "Effective Decentralized Unit Dose Dispensing on a One-Shift Basis." American Journal of Hospital Pharmacy 25 (May 1968).

Walton, C. A. "Education and Training of the Drug Information Specialist." Drug Intelligence 1 (April 1967).

Webb, J. W. "Strip Packaging of Pharmaceuticals." American Journal of Hospital Pharmacy 19 (April 1962).

Wenger, J. C. and Kabat, "A Feasibility Study of a Centralized Intravenous Additive System." Drug Intelligence 1 (August 1967).

Wirth, B. "A Computerized System for Restricted Drug Control and Inventory." American Journal of Hospital Pharmacy 24 (October 1967).

## PHYSIOLOGICAL MONITORING

### INTRODUCTION

Clinical monitoring includes the instrumentation, procedures, and medical concepts used to intermittantly or continuously observe or measure a patient's physiologic conditions; warn personnel when those conditions exceed set parameters; record unusual conditions for future reference; form a data base for predicting future conditions; diagnose unusual conditions and possibly suggest corrective actions; and sometimes assist the patient's vital processes. Monitoring is primarily intended to improve patient care without regard to physician's or nurse's time, and we may expect that calibration and service will result in increased labor and training costs.

Clinical monitoring instruments are used primarily in intensive care sections, i.e., coronary, surgical recovery, fetal care, and pulmonary care units. Developments in these three areas will be the focus of the following state-of-the-art discussion. Equipment or procedures that need research and development and will be available only after 1972 are included in the advanced technology section. Monitoring devices whose operation and use are well-known are included in Appendix B. Laboratory diagnostic instruments and clinical laboratory instruments are discussed in other portions of this volume.

### TECHNICAL APPROACH

In researching current developments in physiological monitoring, we used three approaches. First, we reviewed selected articles published in the past five years in periodicals such as the Journal of the American Medical Association, Biomedical Engineering, Circulation and Journal of Applied Physiology. We also examined pertinent conference proceedings and doctoral dissertations. (Specific references are included in the bibliography at the end of this section).

We then attended conferences and visited hospitals and universities across the nation consulting medical personnel skilled in the application of monitoring equipment. These meetings are enumerated below:

1. St. Mary's Hospital, Rochester, Minnesota.
2. Latter Day Saints Hospital, Salt Lake City, Utah.
3. University of California, Los Angeles, Califronia.
4. Beckman Instruments, Fullerton, California.
5. Presbyterian Hospital, San Francisco, California.
6. Allegheny General Hospital, Pittsburgh, Pennsylvania.
7. Presbyterian Hospital, Pittsburgh, Pennsylvania.
8. Children's Hospital, Pittsburgh, Pennsylvania.
9. University of Alabama, Birmingham, Alabama.
10. University of Virginia, Charlottesville, Virginia.
11. 1969 American Heart Association Meeting, Dallas, Texas.
12. Fifth Annual Association for the Advancement of Medical Instrumentation, Boston, March, 1970. Theme: Automated Patient Care.
13. Computers and Cardiovascular Disease: Detection and Research, presented by the American College of Cardiology, May, 1970.

To complete our study, letters soliciting information on monitoring equipment were sent to 67 companies whose names were obtained from The AAAS Instruments Guide and The Medical Instrumentation Guide. The manufacturers generally responded with descriptive literature of available instrumentation, but several companies supplied detailed analyses of specific systems in the development stage. These catalogs and information were reviewed and are available on file.

## STATE OF THE ART

In physiological monitoring, the need for accurate measurement of the physiologic status, either continuously or intermittantly, is being increasingly recognized. Although specific parameters for continuous monitoring have not been established on a broad clinical basis, monitoring concepts and instrument requirements are being defined in the areas of coronary care, surgical recovery, and fetal and pulmonary care. As research continues to define the nature and action of the important diseases and processes requiring intensive care, more specialized monitors will be developed, possibly organized according to affected organ systems.

Some general trends in physiological monitoring are to:

1. Expand the use of systems analysis techniques to define necessary and significant data so that engineers/manufacturers can design and produce the necessary equipment or modify existing equipment.

2. Collect data continuously to chart patient progress during treatment.

3. Measure, or compare, data with set parameters which when exceeded will warn the physician and diagnose or aid in diagnosis of the patient's condition. If adequate data are not available, the performance of clinical monitoring instruments should be reassessed; respirators for lung support, ventricular assists and drug therapy performance must be reassessed for each change in patient condition. Measurements may be continuous or intermittent.

4. Establish a positive data base to enable the physician to more accurately predict patient condition and take positive corrective action.

5. Expand instrument flexibility to meet broadened data collection and measurement needs and to correlate large quantities of data.

6. Increase cooperation between industry and health-care officials to better characterize data needs by defining the medical problem, the medical parameters to be monitored, and the necessary hardware. More precise problems definition necessitates a reexamination by physicians and bioengineers of the physiologic basis of disease, a difficult and often neglected activity in the past.

Specific trends, which will be discussed below, are:

1. Utilization of advanced monitoring equipment to improve coronary care, including cardiac trend analyzers, blood gas analyzers, arrhythmia monitors, and telemetry.
2. Expanded application of monitoring equipment in the surgical recovery area.
3. Application of ventricular assist devices, respiratory assistors, and blood gas analyzers to improve pulmonary care.
4. Utilization of a computer to manage data generated by monitoring devices.

Coronary Care

The coronary care unit employs the most advanced clinical monitoring equipment. Continuous measurement of a few, relatively simple, physiologic variables have improved patient care and reduced the mortality rate, particularly of patients whose heart attacks did not profoundly affect the heart's pumping action.

The major instruments now being used in coronary care are discussed below:

A. The Lexington Instrument Company produces a cardiac output trend analyzer which indicates cardiac output based on analysis of arterial blood pulse pressure. The device does not measure cardiac output directly but indicates a trend in cardiac output based on changes in pulse pressure assumed to be related to changes in cardiac output. The device uses an arterial catheter to obtain unattenuated central arterial pressure and, consequently, provides pressure measurements as well as the correlation to cardiac output.

B. Instrumentation Laboratories blood gas analyzers both for tensions and saturations perform routine blood gas measurements in intensive care applications. The devices use typical sensors for the oxygen, carbon dioxide, and pH, but incorporate automatic methods for drawing samples and flushing. The devices may be simply and reliably operated by non-skilled personnel.

C. An arrhythmia monitor manufactured by the Hewlett-Packard Company provides selected records of EKG data used to determine life-threatening arrhythmias. If an arrhythmia is detected, drug therapy can be initiated to prevent fibrillation. The device is not diagnostic but does relieve the attendent of some tiring and time-consuming monitoring of the EKG scope.

D. Telemetry, which operates independently of hard wire facilities, permits remote monitoring of the EKG's of cardiac patients. The device is also being used experimentally in mobile coronary care units. In this application, the device is attached to the patient at his home and throughout the ambulance drive to the hospital. The patient's EKG is continuously transmitted to the hospital where it is monitored by a physician. If the physician detects an arrhythmia, he will instruct the ambulance worker on how to care for the patient until he is admitted to the hospital.

## Surgical Recovery

Improved patient care is claimed at several centers where post-cardiac surgery patients are monitored through the surgical recovery stage. Post-cardiac surgery units typically employ respirators to control ventilation and fluid management devices to control cardiac performance. The equipment appears manageable clinically, and probably represents the next surge of a specific monitoring function paralleling that seen in coronary care.

## Cardiovascular and Pulmonary Care

A. The National Heart and Lung Institute, as well as several industrial companies, are developing a ventricular assist device designed to temporarily help the heart fulfill its blood pumping requirements. The device, known as the intra-aortic balloon, consists of a cigar-shaped balloon inserted into the aorta which expands and collapses in synchronization with the patient's heart. Limited clinical studies show that it improves circulatory dynamics during application, but as yet has not been shown to significantly affect mortality due to the disease process. The effect on the circulatory status is encouraging, however, and this device has apparent promise for future use as a ventricular technique.

B. Respiratory assistors are used for intensive care of patients who require assistance and/or control of the respiratory function. The Bennett MA-1 Respirator is an electrically-powered, volume limited controller or assistor for patient respiration. The device can control rate of breathing, length of inspiration, total volume inspired, total minute volume, and will periodically cause deep sighs for the patient. The humidifier moistens the air breathed by the patient and can be used as a nebulizer for medication. Alarms indicate pressure limits, oxygen deficiencies, anomolous ratios of inspiration to expiration, and discrepancies in tidal volume. Additional indicators and alarms assess the performance of the device itself. (Also see the blood analyzer discussed under coronary care.)

## Fetal Care

Fetal Care Unit monitoring has emphasized pulse rate, blood pH, and blood $O_2$ measurement in the fetus during delivery, supplying data which permits positive and aggressive intervention by the physician. The Fetal Care Unit has largely been neglected by industrial concerns, but new instrumentation is being developed. For a further discussion of fetal monitoring, refer to the Obstetrics portion of the General Medicine section.

## Other Considerations

A. The mass of monitor/generated data necessitates an information management and display system, but no existing hardware system is adequate. The extreme complexity of patho-physiological data and the lack of accurate, simple, practical sensors are the primary problems. The computer is often held up as the saving technology, and it must be counted on to play a major role in the future. Computers have been used experimentally to manage the mass of information which accrues in longer term intensive care of a patient, e.g., radiographic findings, and laboratory, clinical, and on line measurements. However, the practical value of computer data management has not yet been realized clinically.

B. Before determining which clinical monitoring instruments or group of instruments should be installed, their effect on planning and construction should be considered. One architectural concept locates all intensive care sections within a small area, on the principle that concentrations of specialized equipment and nurses are most efficient and effective. Another concept places intensive care rooms close to the nurse's station on a typical ward floor; patients requiring less care will be in more remote rooms. A third concept installs all necessary monitoring equipment "plugs" in every room so that any room can be transformed into an intensive care unit. The chosen instrument placement concept will, of course, affect instrument selection and design, especially portability.

## ADVANCED TECHNOLOGY

As research continues and aggressive industries promote new techniques, the number and type of available measurements will spiral upwards. The gap between the type of computerized monitoring described in the scientific literature (and in the press) and the degree of monitoring actually practiced on a broad clinical scale, however, will widen. The gap exists for practical reasons — primarily because of instrument deficiencies but also because the inherent values of the monitors are still being questioned. Systems appropriate for wide clinical application, moreover, are quite different from "workable" research tools, since clinicians usually do not have the training (experience) and motivation (tolerance for "bugs") more characteristic of researchers.

Automatic or continuous monitoring of "vital signs" is and will remain important only in disease processes causing rapid changes in patient status. For general ward patients essentially no value, either in patient care or hospital costs, can be forecast for monitoring variables such as EKG, blood pressure, temperature and breathing rate.

Some areas in physiological monitoring that require additional research and development are listed below:

1. Additional monitoring devices for care areas (fetal care, ambulatory coronary care) other than intensive coronary care units should be developed.
2. Data gathering and storage techniques should be perfected, and data should be available for display on a 24-hour/day basis.
3. Monitors should be equipped with devices which continuously or intermittently check their own operational accuracy. For example, measurements should assess the performance of such equipment as respirators and ventricular assist devices.
4. Monitors should be developed to assess drug effects, a good example being the use of EKG rhythm criteria for administration of anti-arrhythmic drugs. The use of computers to make decisions on the patient's needs for fluids and when to administer them should be explored.
5. The use of continuous monitoring for diagnostic purposes should be further explored.
6. Arrhythmia monitors need to be developed which relieve the operator of continuous surveillance duties by interpreting, to some degree, the incoming EKG rhythm. The device need not provide a "diagnosis," but should alert the attendant and provide a convenient record of data on which clinical decisions can be made. At the same time, it must not sound a large number of false alarms.
7. The measurement of blood oxygen levels and cardiac output must be adapted to perform well in a clinical setting.
8. Mixed venous oxygen level is believed to be a very informative variable for continuous monitoring because it contains reflections of cardiac function as related to metabolic demands for oxygen. Consequently, this single measurement has important information relative to fundamental patient status.

Similarly, arterial blood oxygen levels reflect the status of the lung and the operational status of the respirator. Further development of monitors for these two oxygen levels is needed.

9. At present, monitoring of the heart's output, the oxygen level in the blood returning to the lung, metabolism levels, and the amount of blood available for circulation are being accomplished in only a few research centers in the country, such as Presbyterian Hospital in San Francisco and the Latter Day Saints Hospital in Salt Lake City. In the case of cardiogenic shock, specifically, the complex measurement schemes are used primarily for researching the nature of the condition and developing diagnostic and treatment techniques rather than for general patient care. The above monitoring techniques should be refined so they may be introduced extensively on a clinical level.

Westinghouse has designed two versions of a patient monitoring system combining state-of-the-art instruments and next generation technology. Both models perform three basic functions -- signal conditioning, analysis, and display -- within several patient parameters such as ECG, arterial pressure, and venous pressure. The two systems are similar, except in their approach to the analysis function.

## Signal Conditioning

In both systems two types of input amplifiers are used: 1) the ECG, designed to acquire the varying potentials present on the patient's body which represents the electrical activity normally associated with each heartbeat; and 2) the pressure amplifier which may be constructed in two versions, both to be used with strain guage pressure transducers such as those produced by Statham.

## Analysis

These signals can be analyzed and transmitted to the display panel in two different ways. In the first system the following individual modules perform these functions:

- Arrhythmia monitor calls attention to ECG abnormalties indicative of abnormal conduction paths in the myocardium. Specific functions include signal filtering automatic gain control, positive identification of QRS complexes, artifact detection, arrhythmia detection, abnormal morphology detection, and premature atrial contraction rejection.

- Heart rate module accepts a signal derived from the QRS complex and generates a voltage proportional to rate, sounding alarm conditions when physician-set limits are exceeded.
- Cardiac output device indicates the direction of change of the flow of blood by multiplying pulse pressure by heart rate.
- Pressure analysis unit derives the mean pressure and the pulse pressure, the difference between systolic and diastolic pressure.

The second Westinghouse system, called the MED 70, by-passes the modules and uses a distributed complex of small central processors, all identical and interchangeable, to perform the above functions.

Display

Both systems incorporate three methods of display: analog, alpha numeric, and hard copy. The analog is a non-fading chart-like oscilloscope display using shift register memories, appearing as if a number of pens are just off-screen to the right and the chart paper is moving from right to left. Alpha numeric display includes parameter values, direction of trends, and limits. It provides patient identification limit settings and alarm indications and requires equipment such as the WAND (Westinghouse Alpha Numeric Display) unit which will be given commands by a micro-programmed read-only memory controller. Permanent records of trends and abnormal ECG traces can be provided by a teletypewriter output and a chart recorder.

By combining the elements in different ways, the MED 70 can be tailored to meet specification problems, and the number of parameters can be expanded easily. The system is also compatible with digital computers since the information is stored in digital form in the shift register memory. Information can be automatically drummed into the memory bank of a large central computer every 24 hours.

Three unique features distinguish the system. First, it uses standardized, unified graphical and alphanumerical patient parameter displays. All displays are in one location with the two parameters displayed side by side, and the displays are identical at the bedside and at the central station. Only monitored parameters are displayed because all digital information will be presented on a computer-controlled alphanumeric display rather than a bank of digital meters which could leave blank spaces.

Second, the system has independent, parallel processing for the graphical and alphanumeric patient parameter displays. Should either display system fail, the other would not be disabled, and one display system can be used as a check against the other, thus enhancing reliability.

Third, identical, interchangeable small computers in each unit permit the continuous analysis of patient parameters and further increase system reliability. Since all computers are identical, a single space standby computer could supply backup support in case of a computer failure, and less than 20 minutes would be required to change computers.

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: PHYSIOLOGICAL MONITORING**
**COMPONENT: CARDIAC OUTPUT ANALYZER**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Lexington Instrument Cardiac Trend Module | An electronic device which analyzes the output of an arterial pressure monitor to indicate cardiac output. It is integrated into and dependent upon standard EKG pressure monitoring systems, and estimates cardiac output as a function of the difference in mean arterial pressure and diastolic pressure. | $1,015 | 1. Operation is simple and does not require highly skilled operators. | 1. Requires an arterial catheter to obtain unattenuated central arterial pressure.<br>2. Should be used only for the serious ill, so possible complications are outweighed by advantages of the measurement.<br>3. Incomplete field testing will hinder the device's application in the near future. |

**COMPONENT: ARRHYTHMIA MONITOR**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Hewlett-Packard Arrhythmia Monitor Model 7822 | The arrhythmia monitor measures the output from a standard EKG monitor and sounds an alarm when set parameters are exceeded. Selected data recordings indicate patient trends and form a basis for medicinal decisions. | Initial cost: $4,200.<br>Maintenance cost: $75 to $100 per year. | 1. Continuous monitoring of individual patient EKG's on a twenty-four hour basis offers significant advantages over observers monitoring an oscilliscope screen in a six or eight patient coronary care ward. | 1. Requires approximately double the space occupied by current bedside coronary care monitoring. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: PHYSIOLOGICAL MONITORING**
**COMPONENT: RESPIRATORY ASSISTANCE**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Bennett Model MA-1 Respiration Unit | A portable, electrically-powered, volume-limited respiration controller or assister. It can control breathing rate, length of inspiration, total volume inspired, total minute volume, and will periodically cause deep sighs. Indicators and alarms monitor the device's performance. | $3,850 | 1. Volume control eliminates the problem of pressure limited respirators.<br>2. The self-monitoring feature frees the inhalation therapist of certain monitoring functions. | |

**COMPONENT: VENTRICULAR ASSISTANCE**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Intra-aortic Balloon, Westinghouse Electric Corporation | The intra-aortic balloon consists of an intra-aortic cigar-shaped inextensible balloon "pump"; an electro-mechanical drive to alternately expand and collapse the balloon; and electronic controls to synchronize the action of the balloon with the EKG from the patient. | Initial cost: $8,000 to 10,000 per unit.<br>Operating and maintenance costs: $150 to $200 per CCU bed per year. | 1. Has potential for the treatment of advanced circulatory shock. | 1. Requires an arterial cut-down for balloon placement.<br>2. Demands specific medical and paramedical training which is not a natural extension of existing intensive care training.<br>3. Technique is useless or dangerous without adequately trained personnel. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: PHYSIOLOGICAL MONITORING**
**COMPONENT: BLOOD GAS ANALYZER**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Instrumentation Laboratories Blood Gas Analyzer | Incorporates traditional sensors, water baths, and controls to measure oxygen tension, carbon dioxide tension, and pH in whole blood. | Initial cost: $5,000.<br>Maintenance cost: $200 per year. | 1. Provides accurate and reliable blood gas measurement using simple procedures.<br>2. Highly trained and meticulous operators are not needed. | 1. The instrument is complicated, and will require frequent servicing by a technician trained in the meticulous care of electrodes. |

# BIBLIOGRAPHY — PHYSIOLOGICAL MONITORING


Cohen, G. S. "State of the Art: Intensive Care Equipment." Biomedical Sciences Instrumentation 5 (1969):11-13.

Dammann, J. F. "Assessment of Continuous Monitoring in the Critically Ill Patient." Diseases of the Chest 55 (March 1969):240-4.

Goldman, R. H., et al. "Measurement of Central Venous Oxygen Saturation in Patients with M.I." Circulation 38 (November 1968):941-6.

Hilberman, Mark, et al. "On Line Digital Analysis of Respiratory Mechanics and the Automation of Respirator Control." Journal of Thoracic and Cardiovascular Surgery 58 (December 1969):821-8.

Hutter, Adolph M., Jr., and Moss, Arthur J. "Central Venous Oxygen Saturations." JAMA 212 (April 13, 1970):299-303.

Macdonald, Larry, et al. "An Exploratory Study of the Costs and Cost Implications in the Operation of a MEDLAB Time-Sharing Computer System: A Physiological Measurement Facility." Ph.D. Thesis, University of Utah, 1969.

Maloney, J. V., Jr. "The Trouble with Patient Monitoring." Annals of Surgery 168 (October 1968):605-19.

Osborn, John J., et al. "Measurement and Monitoring of Acutely Ill Patients by Digital Computer." Surgery 64 (December 1968):1057-70.

Phillips, B., et al. "A Comparison of Central Venous and Arterial Blood Gas Valves in the Critically Ill." Annals of Internal Medicine 70 (April 1969):745-9.

Pryor, T. Allow; Gordner, Reed M.; Day, W. Clinton. "Computer System for Research and Clinical Application to Medicine." AFIPS, Conference Proceedings, Vol. 33, 1968.

Rowles, J. M. "Patient Monitoring: A Clinician's Point of View." Bio-Medical Engineering 4 (June 1969):264-7.

Rowles, J. M., et al. "Automation on a General Medical Ward: Monitron System of Patient Monitoring." British Medical Journal 3 (September 20, 1969):707-11.

Scheinman, M. M., et al. "Critical Assessment of Use of Central Venous Oxygen Saturation as a Mirror of Mixed Venous Oxygen in Severely Ill Cardiac Patients." Circulation 40 (1969):165-9.

Shafer, W. A. "Non Contact Physiologic Sensing." Biomedical Sciences Instrumentation 4 (1969):137-41.

Sheppard, L. C. "Automated Treatment of Critically Ill Patients Following Operation." Annals of Surgery 168 (October 1968):598-604.

Suwa, K., and Bendixen, G. "A Mathematical Analysis of Physiological Dead Space in a Lung Model." Journal of Applied Physiology 24 (April 1968).

Uncles, R. W. "Recent Advances in Blood Gas Equipment." Bio-Medical Engineering 4 (June 1969):260-3.

## PLANNING

### INTRODUCTION

Planning is used here to cover the prediction of patient care requirements, including demand on the health care system such as outpatient visits and inpatient admissions, and facility-independent quantities, such as bed occupancy and ancillary usage, required to meet that demand. This definition excludes architectural planning.

Approaches to planning differ both in methodology and in the fineness of detail within a methodology. The efficacy of a planning methodology, however, is difficult to assess quantitatively, for other factors, such as limited finances, may prevent a health care system from developing in the manner indicated by careful planning. This survey discusses present methods of planning and factors which influence planning. The cost of various planning methods has not been studied.

### TECHNICAL APPROACH

An extensive literature search of books, monographs, and periodical articles on various aspects of planning was the first step in the state-of-the-art survey of hospital planning. A selected bibliography is included at the end of this section. The Westinghouse study team also drew on the expertise and experience of several consultants:

C. D. Flagle, Professor, School of Hygiene and Public Health, The Johns Hopkins University

H. Griffin, M. D., Dean, School of Public Health, University of Pittsburgh

E. Libman, Hospital Planner, West Penn Hospital, Pittsburgh

R. D. Smallwood, Associate Professor, Department of Engineering and Economic Systems, School of Engineering, Stanford University.

K. L. White, M. D., Chairman, Department of Medical Care and Hospitals, School of Hygiene and Public Health, The Johns Hopkins University.

To become familiar with military BLHCS planning, the Westinghouse teams also made visits to the following locations in Washington, D. C.:

Air Force: Directorate of Plans and Hospitalization
Office of the Surgeon General

Navy: Utilization and Requirements Branch
Bureau of Medicine and Surgery

Army: Medical Facility Planning
Office of the Surgeon General

To directly observe planning practices in the civilian sector, we visited Kaiser Foundation Health Plan hospitals in San Francisco, Redwood City, and Panorama City in California, and consulted with the Kaiser Medical Methods Group.

## STATE OF THE ART

Planning methods can be classified (1) as extrapolation from past workload viewed as a time series (historical workload) or (2) as projection of population and its estimated usage of health services. If the population is stable or only changing gradually and if medical practice and technology also change gradually, the first alternative will work reasonably well. Should the population change rapidly, a time-series workload analysis may not be sufficient, and patient care requirements may be better predicted by the second alternative.

In the fragmented civilian sector of the U.S. health care system, many planning methods are used. An individual hospital, acting in isolation from the community, uses historical workload by default, since no other method of projection is possible. The principal forces in determining the development of additional facilities and services are usually internal pressures, such as long waiting lists for admission or increased medical staff demands for ancillary services. The rising cost of hospital construction and the stress the Hill-Burton act places on area and community planning is forcing hospitals away from this insular approach.

Over a larger geographic area, or with a defined population, projection of patient care requirements on the basis of population is at least possible. Under the "area health needs approach," a hospital plans its future not only in terms of internal institutional requirements, but also in relation to the health "needs" of the community. The community is usually defined in terms of the geographic area from which the hospital draws its patients. The hospital, of necessity, works with other area health care groups to avoid duplication of efforts. As an example of this approach, the Evanston Hospital, Evanston, Illinois, in 1966 used projections of population growth together with historical demand rates and utilization statistics to arrive at expansion requirements.

Community master plans provide some coordination of health care services over a large geographic area or for a large population. With this approach, health care groups and community leaders establish area health priorities and define a role for each area health service. Each participant may influence the direction of future activities. Because the planning council, as a rule, has little real authority, such plans are rarely drawn up in detail.

The U.S. Public Health Service supervises and assists state-wide planning, as established by the Comprehensive Health Planning and Public Health Service Amendment of 1966 (PL 69-749). It has set up planning procedures which rely heavily on population projections. This plan is not greatly detailed, and beds per population and their distribution among medical services are the main outputs.

The National Center for Health Services Research and Development, Public Health Service, serves as the Federal focus for health services research and development, with programs directed toward planning and organizing health services.

The planning done by the Kaiser Foundation, Southern Group, is perhaps the most sophisticated and detailed of any in the U.S. civilian sector. The numbers, geographic location, and demographic characteristics of the population served are well known. Using present and projected population figures, the following patient care requirements are determined on the basis of per capita demand and utilization in other Kaiser facilities:

1. Bed occupancy on each service (medical, surgical, OB, and orthopedic)
2. Ancillary usage (radiology, laboratory)
3. Nursing staff requirements on the basis of predicted bed occupancy by level of patient dependency

In Europe, Sweden does the most comprehensive health planning. Medical records on each citizen are structured so that longitudinal as well as cross-sectional epidemiological studies can be conducted. Facilities planning uses an age-sex breakdown of the population served and utilization statistics from the area hospitals to determine patient care requirements in a new or expanded facility. These predicted patient care requirements are beds occupied by service (medical, surgical, obstetrics-gynecology) and clinic visits; the requirements are graded according to whether they are to be supplied at local, regional, or specialty referral hospitals.

By administrative fiat (see DOD instruction 6015. 17, Para. VC3), planning for U.S. BLHC Systems follows the method of historical workload. The results of this planning method are discussed extensively in the Systems Analysis volume of this report.

Planning Considerations

1. Health care "needs" are not observable; the only observable quantity is demand, which health care professionals translate into need. Though demand can be statistically correlated with factors such as income, education, age and sex, the statistics do not reveal what it is that prompts people to seek health care. Consequently, personal factors must be studied such as the individual's perceived susceptibility to disease, the perceived seriousness of the condition, specific cues to action, and perceived barriers to taking action.

2. The demographic variables, aside from age and sex, usually chosen for studies in the civilian sector of health care have little application to the BLHC System.

3. For those authorized for care at a BLHCS or for those enrolled in prepaid health care plans, economics disappears as a regulator of demand. As a result, there is an increasing influx of well and "worried-well" patients whose demands must be met. In addition, at a BLHCS there are occasional malingerers.

4. Whether demand will cease to increase when the capacity of a health care system increases beyond some level is still a matter of controversy. Investigators in Finland, where medical care is a state responsibility, have reported that for certain population groups, hospital use does not increase in direct proportion to the supply of beds. In the United States, statistics kept by the Health Insurance Plan of New York, a prepaid health care plan, for the period 1950 to 1965 showed no significant change in the per capita number of yearly physician visits, though the location of the visits shifted significantly from home visits to office or outpatient visits. These results indicate that a saturation limit does exist.

5. Once the number of outpatient visits and inpatient admissions is predicted, patient care requirements on a deterministic, average basis may be found through utilization studies. The details of medical practice and technology determine patterns of resource utilization. The numbers used in the utilization studies may be drawn from the health care system's history, if there is one, or from health care systems which resemble the proposed facilities. Such studies may be crude bed to population ratios or may delve to the level of length of stay and ancillary usage statistics. Even so, advances in medical practice and technology must be anticipated.

6. The previous discussion of resource utilization has concentrated on average figures. The demand for health care services, however, is not deterministic but random, and only to a limited extent can demand be scheduled. Inpatient demands, in particular, are difficult to schedule. The resources to treat a patient, as determined by health care professionals, must be available with as little delay as possible. Outpatient demands, on the other hand, generally have less urgency and may be scheduled to an extent. The importance of the random fluctuations is reflected in the extra staff and inventories required to give some measure of assurance that peak demands can be met without sacrificing quality of care. Statistical characterization of the random nature of inpatient care requirements has allowed patient care requirements to be met in facility design and organization at costs lower than designs and staffing, set on the basis of estimated peaks.

The detailed patient-state model of R. D. Smallwood allows prediction of inpatient care requirements over a time span of days as well as allowing aggregation of the statistics to project the requirements over longer terms.

## BIBLIOGRAPHY - PLANNING


American Hospital Association. History of American Hospital Association's Position on Planning. Chicago, 1969.

Axelrod, J., and Pellegrini, W. "A Fifteen Year Report of Medical Services Under Prepaid Hospital Group Practice." Presented at 94th Annual Meeting of American Public Health Association, Medical Care Section, in San Francisco, November 1966.

Bailey, N. T. J. "Statistics in Hospital Planning and Design." Journal of the Royal Statistical Society 5 (1956).

Balintfy, Joseph L. Mathematical Models and Analysis of Certain Stochastic Processes in General Hospitals. Baltimore: Johns Hopkins Hospital, 1962.

Billings, K., et al. "The Effect of Medical Trends on Future Building Needs." Canadian Hospital 46 (May 1969):35.

Boulding, K. E. "The Concept for Health Services." In Health Services Research, edited by D. Mainland. New York, 1967.

Burgun, J. A. "The Hospital of the Future: Decentralized but Integrated." Hospitals, J.A.H.A. 43 (May 16, 1969):63.

Cardwell, R. L. "How to Measure Hospital Bed Needs." Modern Hospital 103 (August 1964).

Catteneo, G. "The Planning Process." Hospitals, J.A.H.A. 43 (December 16, 1969):58.

Community Systems Foundation. An Evaluation of the Osler Nursing Service of the Johns Hopkins Hospital. Baltimore, January 6, 1969.

deArmas, E. "What are Hospital Architects Planning?" Hospital Progress 50 (November 1969):16.

"Determining Size of Health Facility." Architectural and Engineering News (November 1965):64-71.

Engel, A. Perspectives in Health Planning. London: The Athlone Press, 1968.

"Experimental Modules and SVS Systems for Progressive Patient Care." Architectural Record (September 1965):202-4.

Feldstein, P. J. "Research on the Demand for Health Services." In Health Services Research, edited by D. Mainland. New York, 1967.

Flagle, C.D. "Communication and Control in Comprehensive Patient Care and Health Planning." Annals of the New York Academy of Science 161 (1969):714-29.

______. "The Problem of Organization for Inpatient Care." In Management Science: Models and Techniques, Vol. 2, edited by C. West Churchman and M. Verhulst. New York: Pergamon Press, 1960.

Ford, John L., and Reed, Wallace A. "The Surgicenter: An Innovation in the Delivery and Cost of Medical Care." Arizona Medicine (October 1969): 801-4.

Forsyth, G., and Logan, R.F.L. The Demand for Medical Care: A Study of the Case-Load in the Barrow and Furness Group of Hospitals. London: Oxford University Press, 1960.

Garfield, Sidney R. "The Delivery of Medical Care." Scientific American 222 (April 1970):15-23.

Härö, A.S., et al. Objects and Methods of Research into Hospital Utilization in a Regional Hospital System. Helsinki, Finland: National Board of Health, 1966.

Jacobs, W. F. "Comprehensive Health Planning: Problems and Benefits." Hospital Progress 50 (November 1969):67.

"The Kaiser Foundation Medical Care Program." Excerpt from Report of the National Advisory Commission on Health Manpower, Vol. 2, Appendix 4. Washington, D.C.: U.S. Government Printing Office, November, 1967.

Libman, E. W. "Why Areawide Planning Falters." Hospitals, J.A.H.A. 43 (July 16, 1969):71.

Llewelyn - Davies, R., and Mac Caulay, H.M.C. Hospital Planning and Administration. Geneva: World Health Organization, 1966.

MacMillan, Donald. "Hospital Planning in the British National Health Service." World Hospitals 4 (October 1968):217-22.

May, J. Joel. "Health Planning: Its Past and Potential." Health Administration Perspectives, No. A5. Chicago: University of Chicago, 1967.

Medical Facilities Planning Group. Clinical Teaching and Health Care Systems: Models and Evaluation. Stanford, California: Stanford University, June 1969.

Newell, D. J. "Statistical Aspects of the Demand for Hospital Beds." Journal of the Royal Statistical Society 127 (1964):1-40.

Nuffield Provincial Hospitals Trust. The Demand for Medical Care. London: Oxford University Press.

Nuffield Provincial Hospitals Trust. Studies in the Function and Designs of Hospitals. London: Oxford University Press, 1955.

An Objective Basis for Inpatient Nursing Unit Design. Atlanta: Georgia Institute of Technology and Medical College of Georgia, March 1968.

"Operation Design: Hospitals for Today and Tomorrow." Design (March 1966).

"Operations Research Helped Shape This Hospital Design." Modern Hospital 107 (November 1966):122-5.

Pardee, Geraldine. "Classifying Patients to Predict Staff Requirements." American Journal of Nursing 68 (March 1968):517-20.

Riedel, D.C., and Fitzpatrick, T.B. Patterns of Patient Care. Ann Arbor, Michigan: The University of Michigan, 1964.

Rosenstock, I.M. "Why People Use Health Services." In Health Services Research, edited by D. Mainland. New York, 1967.

Rosenthal, G.D. The Demand for General Hospital Facilities. Chicago: American Hospital Association, 1964.

Smallwood, R. D.; Murray, G. R.; Offensend, F. L.; Silva, D. D.; Sondik, E. J.; and Klainer, L. M. "A Medical Service Requirements Model for Health System Design." Proceedings of the IEEE 57 (November, 1969):1880-7.

Smallwood, R. D.; Sondik, E. J.; and Offensend, F. L. Toward an Integrated Methodology for the Analysis of Health Care Systems. Stanford, California: Stanford University, June 1970. Technical Report No. 6252-3.

Somers, Anne R. "Goals into Reality: The Challenges of Health Planning." Hospitals, J.A.H.A. 43 (August 1, 1969):41.

______. "Some Demand Factors Affecting Individual Hospital Planning in the Next 10 - 20 Years." Hospital Progress (March 1968):59-88.

Survey and Master Plan-Evanston Hospital. Evanston, Illinois: Evanston Hospital, 1966.

"A Systems Analysis Approach to Hospital Design." Architectural Record (March 1970):112-5.

U.S. Public Health Service. Areawide Planning Manual for Hospitals and Related Health Facilities. Washington, D. C.: U.S. Government Printing Office, August 1962.

______. Procedures for Areawide Health Facility Planning. Washington, D.C.: U.S. Government Printing Office, 1963. No. 930-B-3.

______. The Progressive Patient Care Hospital. Washington, D.C.: U.S. Government Printing Office, 1963. No. 930-C-2.

Wallace, McHarg, Roberts and Todd. Interium Report: Long Range Development Plan for the Health Services Center. Philedelphia: Temple Health Sciences Center, April 5, 1967.

Young, John P. A Queuing Theory Approach to the Control of Hospital Inpatient Census. Baltimore: Johns Hopkins Hospitals, 1962.

# RADIOLOGY

## INTRODUCTION

The radiology department uses roentgen rays, radium rays, and other radiation to diagnose illnesses or identify injuries and is complemented by satellite radiology stations, located either within the same building or at remote locations, which perform simple radiography on relatively immobile populations.

The basic procedures of the X-ray Department are (See Figure 1):

1. Registration of the patient
2. File search for previous records of this patient
3. The X-ray examination
4. Processing and development of the films
5. Matching of the films to the patient's previous record
6. Transfer of this package to the radiologist
7. Interpretation by the radiologist
8. Separate filing of the film package, report forms, and record forms.

The study in radiology was performed to determine the state of the art and to identify the advanced technology in this discipline. The state-of-the art portion was directed primarily to techniques and equipment which offer improved films and images and which enable the radiologist to devote maximum time to those care areas for which he is specifically and uniquely trained. The second section of the report details radiologic developments that are currently being researched, but should be available from 1975-1980.

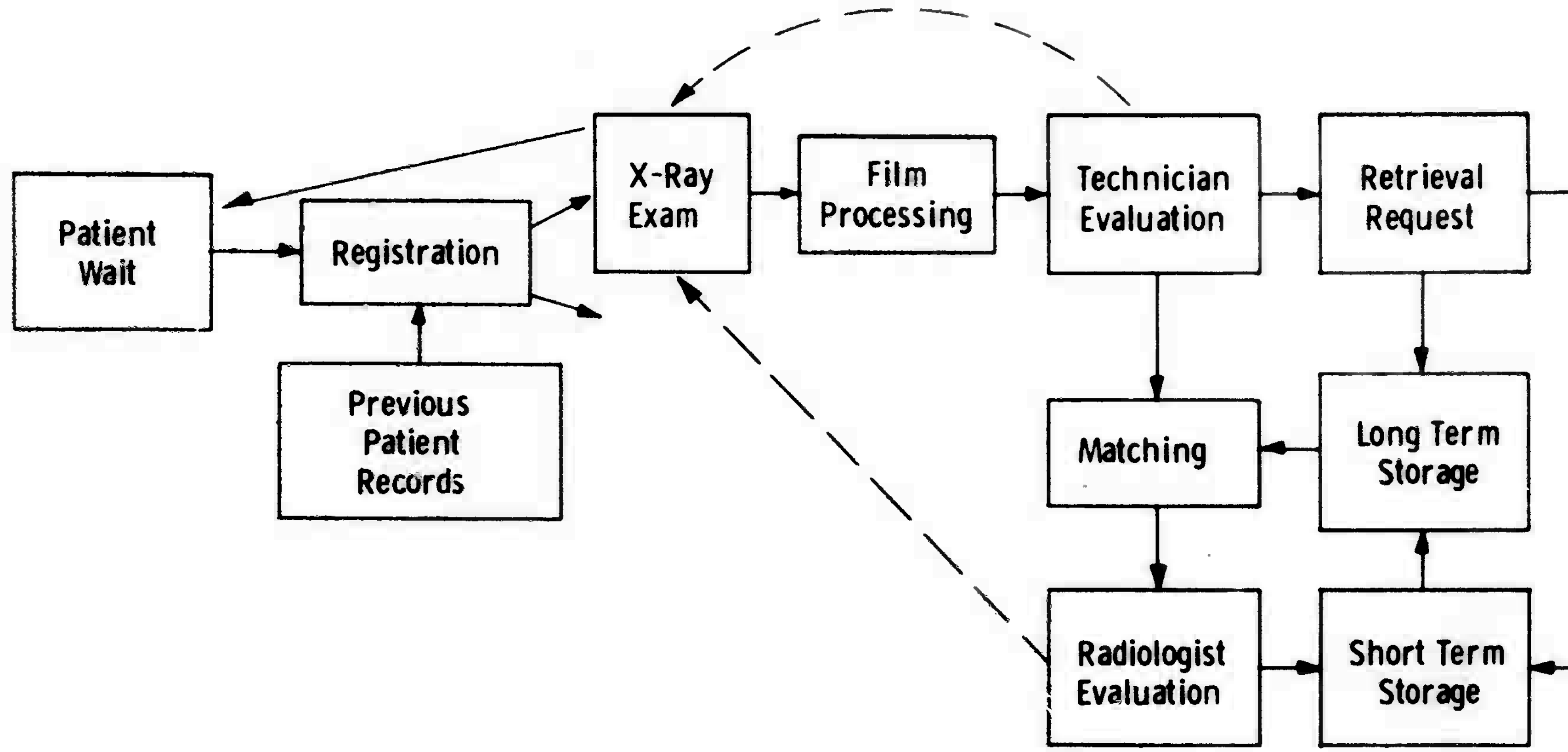


Fig. 1—System flow chart

## TECHNICAL APPROACH

In inaugurating our radiology study, we extensively reviewed current literature, including articles on both future radiological developments and computer use in periodicals such as Radiology, Yearbook of Nuclear Medicine, and Medicamundi. W. G. Scott's Planning Guide to Radiologic Installations in Institutions as well as H. Schepperger's report, Prospects of the Hospital on Future Horizons, were also perused.

To supplement our theoretical data, we conducted in-depth interviews with active hospital and teaching radiologists, radiologic technologists, and specific members of the American College of Radiology and the American Society of Radiologic Technologists. Drs. George Lerman and Abraham Edelmann, Consultants to the Westinghouse Health Systems Department, conducted a second series of structured interviews to further identify desired changes in existing equipment and radiograph storage and retrieval systems. Discussions were also held with the chief radiologists at such institutions as Henry Ford Hospital in Detroit, University of Illinois Hospital, Cardinal Glennon Hospital in St. Louis, and the Mallinckrodt Institute.

Westinghouse, moreover, capitalized on the resources and experience of its own Medical Electronics Division, Product Transition Laboratory, and Research and Development laboratories. Especially valuable was a 1969 Westinghouse survey of radiologists and radiological technologists in 20 medical institutes throughout the United States to determine future requirements for X-ray tables.

## STATE OF THE ART

To increase the effectiveness of X-ray results and to help radiologists cope with the rapidly rising demand for radiologic services, the general trends are to:

1. Reduce the number of retakes
2. Train technicians to assume some of the radiologist's responsibilities
3. Use high reliability, low maintenance equipment
4. Lessen the physical strain on doctors and technicians
5. Obtain high utilization for all radiologic equipment
6. Develop new imaging techniques and equipment
7. Partially automate film handling
8. Implement efficient facilities layouts
9. Institute satellite radiology stations for immobile populations.

These trends are discussed below:

1. The number of retakes can be reduced by eliminating machine setting and patient position errors and by using more reliable phototimers that will soon be on the market. Generators with higher than usual milliamperage as well as spot films will also improve X-ray quality. By 1972 improved spot films should be perfected which can record fluoroscopic images in less time and with less patient and staff effort than conventional overhead radiology.

2. To lessen the workload of radiologists, registered technicians are presently being trained and used to perform some routine fluoroscopic examinations. Such training programs are in force at Duke University and the University of Indiana. Equipment with simplified automatic or semiautomatic controls which minimize the possibility of errors can also help extend the technician's role in radiology.

3. Since unexpected machine breakdown disrupts operations, equipment should be designed for reliable, continuous 24-hour duty. Machines composed of replaceable modules will speed any necessary repairs. The quality and extent of the manufacturer's service contract should be a major consideration in the purchasing decision.

4. Specially designed equipment for moving and placing the patient on the X-ray table should be selected, since it eases the physical stress on doctors and technicians, thereby increasing efficiency. Recommended equipment features include patient rotators, adjustable table height, emergency carts, stretchers, and remote patient handling.

5. To obtain maximum use from radiology equipment, specialized rather than general purpose equipment should be selected. With specialized equipment more patients can be handled per hour than with multiple purpose machines, since set-up procedures take several minutes and exposure only a fraction of a second. Because of cost, complexity, and the need for highly trained operators, such equipment, however, can be justified only in large medical centers.

An effective "patient retrieval" system will also increase department efficiency by delivering patients to the procedure rooms with minimum delay.

6. At present X-ray images are represented on plastic film in shades of gray to black. Image evaluation is performed by shining a light through this semi-opaque image. However, new imaging and diagnostic techniques are available such as isotope imaging, thermography, and ultrasonics. Although at present there are not enough radiologists trained in interpreting the information generated by these techniques, they have great potential for improving health care.

Isotope imaging, the most significant of the above techniques, is becoming an increasingly important adjunct to disease diagnosis as a result of the recent development of the gamma ray camera and a more sophisticated isotope methodology.

Although thermography is used to examine certain conditions affecting the body's periphery, its main disadvantage is that the body area to be examined must be uncovered and must be at the same temperature as its surroundings before detectors can isolate pathologic conditions. This requires closely controlled room climates (70-72°F.) and at least 15 minutes for thermal equilibration. The technology also requires additional development.

Ultrasonics, whose radiation does not produce any known cell or chromosome damage, is presently used for brain scanning (mid-line shift), fetal examination to determine the fetus position, and pericardial fluid evaluation. These measurements require only A-mode imaging, although the time-motion mode is helpful.

Two-dimensional tomography with fluoroscopic positioning is available, and image intensifiers, cinematography, and rapid cassette changes are being improved for specialized procedures such as angiography (especially coronary angiography).

7. Pairing X-ray films with the patient's previous record as well as presenting images to the radiologist will soon be semiautomated, since both General Electric Company and Phillips are developing units for these procedures. Transferral of the radiologist's findings to the patient's chart may also be partially automated.

8. A major factor in determining the optimum layout for the Radiology Department is the size of the hospital. For small and medium sized hospitals (up to 600 beds), a double corridor system may be an effective design. (See Figure 2.) This layout accommodates two flow patterns in the X-ray department: 1) the flow of patients from the registration desk, to the waiting area, and then to a specific examining room, and 2) the flow of technicians and physicians between the film processing units and the doctors' reading rooms.

As shown in Figure 2, the department is rectangular and divided by two parallel corridors. At the head of the unit are a registration desk and basic patient records. On the left are dressing booths, and

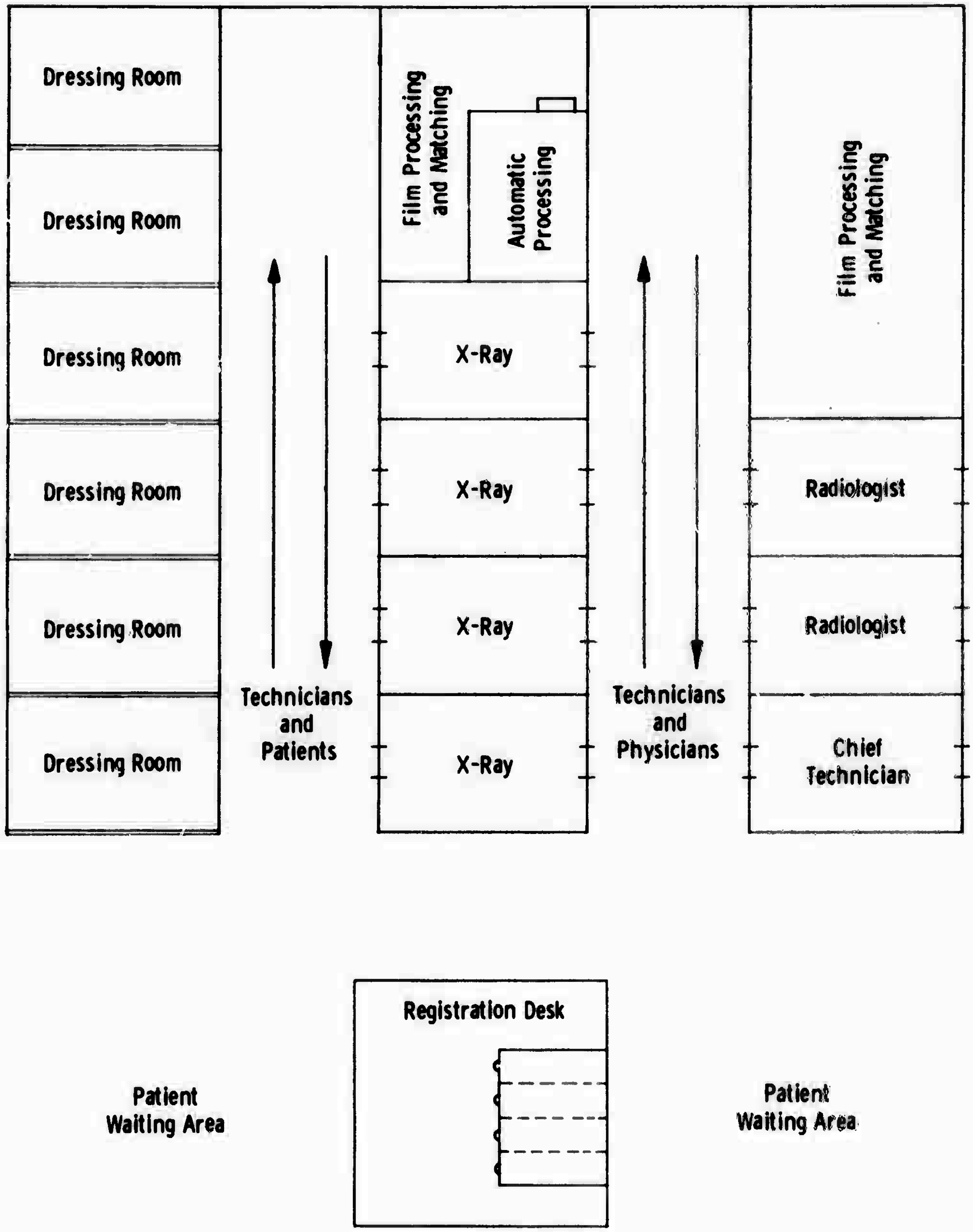


Fig. 2—Double corridor layout

along the midsection are the examining rooms. In the midsection space is provided for film processing and matching. The left corridor is used by patients and X-ray technicians, and the right by technicians and doctors. Such traffic separation is an obvious advantage, since patients are close to the X-ray examining rooms and dressing booths while the doctors and technicians have easy access to the film matching and processing areas and to their own offices.

The equipment distribution for the four X-ray rooms is:

| | |
|---|---|
| Room I: | 1,000 ma. generator<br>90-90 table |
| Room II: | 1,000 ma. generator<br>two-dimensional tomography unit |
| Rooms III & IV: | one 500 ma. generator for each room<br>or a shared 1,000 ma. generator.<br>90-90 table for each room |

A portable X-ray unit is optional equipment.

Film should be stored in the X-ray department, but if space there is limited, storage may be adjacent to the department in any direction including vertically. Good communications between radiology and the film storage areas must be constantly maintained.

The Figure 2 layout is now used in many newer hospital systems, and is perhaps best exemplified by the Radiology Department at Baltimore's Mount Sinai Hospital.

In a hospital with over 600 beds, a room cluster layout may be the economic alternative. Figure 3 shows a central radiology reading station surrounded by rooms for fluoroscopy, intravenous pyelograms, emergency, or general examination. With this system, many examinations of the same type can be localized in one area, a single radiologist-technician team can be assigned to a cluster, thereby optimizing the use of both personnel and

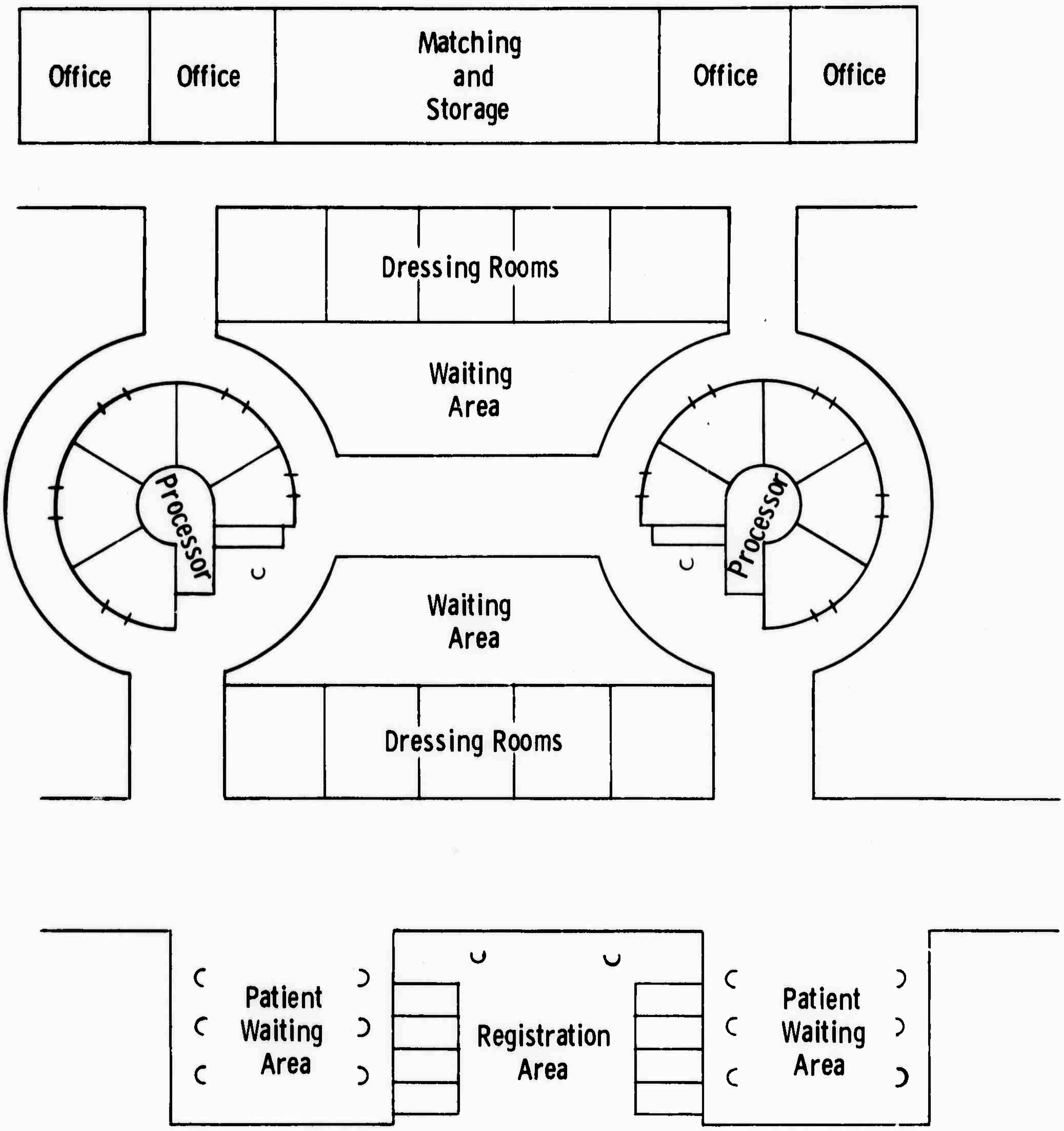


Fig. 3—Room cluster layout

equipment. A cluster can also be used for more than one type of examination; for example, a cluster unit can be used for IVP's and later for fluoroscopic upper gastrointestinal tract examinations.

The room cluster design which actually divides the department into sub-departments has more flexibility for performing specific examinations than does the layout previously described for the smaller hospital. Patients can be handled more smoothly and with more personal attention, and the cluster can have its own dark room and automatic processor to speed patient handling.

The equipment distribution for the five rooms of each "wheel" is:

<u>Wheel One</u>

| | |
|---|---|
| Rooms I and II: | One 1,000 ma. generator for each room, or a shared 1,000 ma. generator |
| | 90-90 table for each |
| Rooms III & IV: | One 500 ma. generator for each room, or a shared 500 ma. generator |
| | 90-90 table for each |
| Room V: | Two-dimensional tomography unit |
| | Image amplifier |
| | TV monitor |
| | 1,000 ma. generator |
| | 90-90 table |

<u>Wheel Two</u>

| | |
|---|---|
| Rooms I and II: | Automatic cassette changer |
| | Flat table with floating top |
| | Automatic injector |
| | 1,000 ma. generator |
| | Image amplifier |
| | TV Monitor |

| | |
|---|---|
| Room III: | Two-dimensional tomography<br>1,000 ma. generator<br>Image amplifier<br>TV monitor |
| Rooms IV and V: | 1,000 ma. or 500 ma. generator for each room, or either generator may be shared by both rooms<br>90-90 table |

All rooms in the second wheel should be capable of being converted to special procedure rooms. They should have conductive flooring and explosion-proof electrical outlets and switches.

If a single generator serves multiple rooms, a relay system should be installed which permits only one room at a time to trigger the generator. Since X-ray exposure times are almost always fractions of a second, the waiting time for another room is not considered significant.

Whatever layout is finally selected, it should be flexible enough to allow for population changes, especially if an increased volume of older patients is expected. These patients require extra radiographic and fluoroscopy procedures as well as specialized procedures such as vascular techniques.

9. Only in military bases where population mobility is restricted should satellite radiology stations be set up, since satellites have several inherent disadvantages:

- A satellite is normally staffed only by technicians since it is difficult to justify assignment of a radiologist.
- Only simple radiography can be performed in the absence of a radiologist.
- Since fewer examinations per unit of equipment are usually performed, higher cost per examination results.

Satellites should incorporate the following minimal equipment and personnel:

1. Single table (fixed) with 300 ma. generator and overhead tube
2. Automatic processor such as Kodak M-6
3. One or two technicians, as the workload demands.

Communication with the central hospital should be direct and continuous. Presently the telephone offers the simplest means. In addition, at least once a day, preferably more often, the films should be sent to the radiologist for interpretation. In emergency situations, films can be sent immediately by messenger. Since emergency X-ray services calling for a radiologist will be rare, preliminary readings may be made by the general physician at the satellite with the help of the technician, who often becomes proficient in reading X-rays.

Examinations performable by such satellites are:

1. All bones, including skull
2. Chest
3. Intravenous Pyelography
4. Abdomen

In all cases, rigid departmental procedures should be avoided, with the various satellites working out their own arrangements with the central hospital.

ADVANCED TECHNOLOGY

The radiologist's duties in 1975-1980 will overlap less into the administrative area, and will focus more on the evaluation of films or images. Images will be presented to him in a slightly different manner and on different material than with present methods.

Radiology equipment will have automatic or semi-automatic control setting for different exposures and, after the patient is positioned, exposure will also be automatic. The procedures, however, will require continuous reliability study and periodic equipment adjustments. Two levels of technicians will probably emerge -- the lower level positioning patients and handling patient flow, and the super-technicians performing adjustments, programming control settings, and handling most administrative duties. In satellite radiology stations, these well-trained technicians may also do fluoroscopy, initial reading of bone fractures, and intravenous pyelograms.

Expected changes in radiology will be gradually implemented until automatic film and image handling is introduced. At this point new procedural changes in the department will be needed since automation will make some personnel superfluous while additional highly skilled personnel will be needed to handle the new equipment.

Other technological developments which can be anticipated include:

1. Electronic transmission of good quality images over various distances with short and long storage capabilities. Such transmission systems, which will convert images to electronic signals and transfer them to a receiver which will convert them back to images, could involve; 1) a television camera mounted on a viewbox to receive the image, 2) a magnetic disc to store several images, 3) coaxial cable connections to 4) a TV monitor with a 5) dial access system to call up the desired image. The components are available, but the system has yet to be demonstrated.

Where coaxial cable is not practical because of distance, scan converters and a second magnetic disc could enable telephone lines to transmit information. A comparable system for the University of Wisconsin Medical School and five area hospitals utilizes voice grade telephone lines for a total distance of 160 miles.

2. Improved X-ray systems with remote control, both for film and fluoroscopic procedures, offering:

a. Higher milliamperage

b. Improved two dimensional tomography

3. Improved image presentation

a. A CRT readout device. The reading station will probably resemble a console with various modalities of presentation including film and X-ray results and pertinent aspects of the patient's chart and history. The CRT image, however, will probably not be equal in resolution to presently available film and so its use will be restricted.

b. Reproduction of a high resolution, positive image on an opaque background for long distance reproduction, greater ease in handling, easier three dimensional imaging.

c. Since holography, the production of an apparent three-dimensional X-ray image of the body's interior, is only slightly different from present radiographs in final appearance, it should be highly acceptable to radiologists. However, much research remains to be done; a source of continuous wave coherent X-rays must be developed. Of importance is the fact that by 1980 many radiographs and holographs will be able to be stored and individually retrieved from small (3 $mm^3$) crystals such as Lithium Niobate by lasers.

4. The technician will position the patient with fluoroscopic control using low level doses of radiation such as an interrupted beam with magnetic disc short-term memory. A series of images of different patient positions will then be taken until the optimum position is obtained.

5. Transferring images to the radiologist, matching images to a patient's previous record, and transferring the radiologist's reading to patient records will be more fully automated.

6. By 1975 automatic filing, storage, and retrieval will be possible. Such systems may include video tape storage, a magnetic disc as a buffer storage, and a TV monitor. An alternative would be image storage on 70 mm film on cards in a Mosler or Kodak System which offers automatic random retrieval. Image transferral by TV camera to a buffer magnetic disc and then to a monitor would complete the system. Since images could be transmitted directly from storage to nursing units, operating rooms, and physicians' offices, the number of radiographs missing from central storage will be reduced to zero.

7. Digital computers will enhance the radiograph by improving resolution and film detail.

8. Differential magnification of various image segments and differential light transmission will be available to the radiologist on demand.

9. By 1975 ultrasonic techniques, using B-mode imaging of significant resolution may be available for brain tumor or liver structure visualizations.

10. By 1980 imaging should be developed to such resolution that ultrasonic tomography, possibly using the Doppler effect, will be in general use.

11. By using advanced data processing equipment in nuclear medicine, camera resolutions may reach 1 mm or less, and images will be stored on video magnetic disc and/or video tape instead of film.

12. By 1975 equipment will permit patient imaging at remote hospitals and information processing at a central station. At the peripheral hospital only a well trained technician is needed; a trained nuclear medicine

physician to review and interpret the images will be located at the central facility.

13. Recommended equipment for satellites will be expanded to include:

a. 90-90 table with 1000 ma. generator
b. Fluoroscopy table
c. Automatic processor
d. A system for image storage and transmission to the central radiology department, possibly including a television camera, two magnetic discs, two TV monitors, and a dial access system.
e. Optional nuclear medicine equipment will be a well counter and scaler, isotope imaging system such as a camera or scanner, and radiographic or other image handling equipment.

14. Satellite examinations could be expanded to include gall bladder, upper gastrointestinal tract, small bowel, and colon.

# BIBLIOGRAPHY — RADIOLOGY


Berci, G. "X-Ray Television Image Storage Apparatus." American Journal of Roentgenology 90 (1963):1290-1300.

DeGroote, V. "Computers in Radiology/Quo Vadimus." Medicamundi 14 (1969):85-6.

Donaldson, S. W. "Practice of Radiology in the United States." American Journal of Roentgenology 66 (1951).

"Electronic Data Processing in Medicine." Radiologic Technology 35 (1964):361-2.

Good, A. "Evolution in the Training of Radiologists." American Journal of Roentgenology 101 (1967):773-8.

Greenwell, F. P., and Wright, F. W. "Rotational Tomography." Clinical Radiology 16 (October 1965):377-89.

Knowles, John H. "Radiology - A Case Study in Technology and Manpower." New England Journal of Medicine 280 (June 5, 1969): 1271-8.

Lindgrene, E. "Tomography." Acta Radiologica 3 (1965):453-64.

McGinnis, K. "Computers in Radiology." Radiology 85 (1965):968-70.

Mesthene, E. "How Technology Will Shape the Future." Science 161 (1968):135-43.

Meyers, P. "Evaluation of Computer - Retrieved Radiographic Image." Radiology 81 (1963):201-6.

"Practice of Radiology." Bulletin of the American College of Radiology, 1957.

Puijlaert, C. "The Expansion of Radiodiagnostics." Medicamundi 14 (1969):137-49.

Schipperges, H. "Prospects of the Hospital on Future Horizons." Electromedica (January 1970).

Scott, Wendell Garrison. Planning Guide of Radiologic Installations. Chicago: Yearbook Inc., 1953.

Templeton, A. W.; Lodwick, G. S.; Turner, A. H., Jr. "RADIATE: A New Concept for Computer Coding, Transmitting, Storing, and Retrieving Radiologic Data." Radiology 85 (November 1965):811-7.

U. S. Public Health Service. Population Exposure to X-Rays (1964). Washington, D. C.: U. S. Government Printing Office, 1966. No. 1519.

U. S. Public Health Service. Protecting and Improving Health Through Radiological Science. Washington, D. C.: U. S. Government Printing Office.

U. S. Public Health Service. Public Health Considerations in Diagnostic Radiology. Washington, D. C.: U. S. Government Printing Office, 1968.

Wohl, G. T. "Experience with 70 mm. Camera." Clinical Radiology 16 (1965):363-8.

# STERILIZATION

## INTRODUCTION

Any improvements in equipment or techniques of sterilizing instruments, utensils, linens, etc. deserve specific attention since they are essential to quality patient care and offer yet another area for potential cost economy.

Sterile processing equipment and activities are sometimes decentralized in high-use hospital areas, but the benefits of centralization are being increasingly recognized and the existence of a Central Sterile Supply Department (CSSD) is usual. Such a department assumes total sterilization responsibility for instruments, utensils, linens, examination and treatment trays, heat and moisture sensitive items, and distilled water, and is involved in the following activities:

- Receiving
- Decontamination
- Clean-up
  - Washing
  - Sorting
- Preparation
- Packing
- Wrapping
- Terminal Sterilization
- Storage

The CSSD should be viewed as a functional hospital element with well coordinated activities, equipment, and personnel. It should operate in accordance with the hospital's operational, philosophical, and procedural requirements, and its processing hardware should interface well with existing hospital storage and distribution systems.

This report discusses available sterile processing equipment such as washing, sonic energy cleaning, and sterilization units, as well as some techniques to ensure patient and personnel safety. The concepts of centralization and automation and the use of sterile disposable goods are also reviewed.

## TECHNICAL APPROACH

To determine the most suitable material sterile processing system, Westinghouse first assigned a project team skilled in hospital planning, industrial engineering, economics, area layout design, computer programming, and business management. For more specialized knowledge, Westinghouse then consulted the Castle Company, whose specialists provided input based on their experience in sterilization, washing, sanitization, decontamination, sonic energy cleaning, hospital planning and aseptic techniques.

During the fall of 1969, various members of the project team visited several of the study hospitals; this data-gathering phase consisted of in-depth interviews with personnel from operating, processing, and administrative areas. The information generated by these discussions were used to define such factors as daily processing requirements and processing objectives, philosophies, and techniques.

## STATE OF THE ART

In planning an effective sterilization system, the following questions should be considered:

1. What is the estimated quantity of goods to be sterilized, and what percentage of these goods will require steam or gas processes?
2. Will specialized areas such as the operating room have sterilization equipment or will all goods be centrally handled?

3. Are special measures taken to prevent contamination of CSSD employees?
4. Are materials washed before being sterilized?
5. Are sterilized goods kept totally separated from goods entering the CSSD for decontamination?
6. Are manual and automated processes balanced to obtain maximum operations?

In the CSSD, the general trends are:

1. To centralize all sterile processing activities in a single hospital area.
2. To decontaminate all goods before they are handled by processing employees.
3. To ensure total decontamination of all goods by sequentially using washing, sonic energy cleaning, and sterilization equipment.
4. To separate the various processing activities by physical barriers.
5. To optimize cost by making automated equipment/ personnel cost trade-offs.
6. To use selected pre-sterilized disposable supplies.

Equipment

The equipment used in the total processing system can be categorized as soiled receiving and clean-up equipment (washing and sonic energy cleaning units) and terminal sterilizing units (steam and/or gas autoclaves). The various units should interface well with each other, as well as be tailored in size to the expected processing demand. The amount or size of equipment needed will also depend on its hourly capacity and the length of time available for processing.

1. Although soiled materials should be rinsed or soaked in the using area, mechanical washing equipment of the conventional, floor-

loading, or tunnel (conveyor) variety is essential. These units remove any remaining foreign matter from utensils and so prevent it from being baked on during the sterilization process. Optional equipment for specialized washing, such as inside glassware, is available.

Mechanical washing offers better quality and higher speed than hand washing and eliminates a possible point of employee contamination. Washing will sanitize if 180°F is reached, although it will not sterilize. Equipment is available, though, which incorporates both the washing and sterilization functions into a single unit.

2. Sonic energy cleaning equipment, which has 97 percent cleaning capabilities, removes any visible or invisible soil remaining after mechanical or hand washing, thereby lengthening the useful life of surgical instruments. This equipment may be manually loaded or automatically loaded via conveyor and offers cleaning, post-rinsing, and drying features. If a large surgery workload is expected, the conveyorized model may potentially pay for itself in labor savings.

Although detailed economic feasibility studies on this unit have not been conducted, there are other than cost considerations. Sonic energy cleaning prevents the build up of a soil shell that could protect live micro-organisms from sterilizing agents; if the shell breaks during a surgical procedure, contamination will spread.

3. The autoclave, the primary sterilization unit, is an air-tight chamber which uses pressurized steam, ethylene oxide gas, or hot air. Some medium and large units have both steam and gas capabilities. In the pressurized steam cycle, air is first displaced by gravity or faster mechanical (vacuum) means. The cycle may be further shortened by preheating the chamber through enclosing it in another chamber in which steam is always maintained. Exposure to ethylene oxide gas under controlled humidity and temperature is especially useful for sterilizing items sensitive to heat and moisture, such as rubber and delicate

instruments. Gas-sterilized goods must be allowed to aerate, but aeration time can be shortened through mechanical assistance. Hot air sterilization is used only on a limited basis because of the extremely high temperatures needed.

The autoclave, whose capacities vary from approximately 4,825 cubic inches to 70 cubic feet, has cycle times ranging from 20 minutes for unwrapped goods to one hour and 15 minutes for liquids. Cycle times are relatively constant regardless of the size of the unit, so output can be increased only by increasing the per cycle capacity of the system. The units may be cylindrical or rectangular, although the latter offers better utilization of chamber space. Depending on their size and configuration, they may be manually or automatically loaded.

Processing Carts, Loading Cars, and Baskets

1. Large sterilizing, or sanitizing, units with floor level loading capabilities offer potential labor savings because a multi-functional sterilizable cart can be used. Such a cart can be employed to collect contaminated items, be moved directly into the sterilization or washing equipment, directly unloaded, and used for storage, interdepartmental transportation, or distribution of sterilized goods.

2. Some medium sized, rectangular units use loading cars which are transported on transfer carriages and then cranked directly into the sterilization chamber. Both the loading car and sterilization cart significantly reduce the number of handlings in the cleaning process.

3. A processing module, or basket, can extend the distribution capabilities of the sterile processing area so that conveyor, automated cart, or monorail systems may be used. These baskets are also essential to the automated conveyor-fed equipment mentioned earlier.

Techniques

1. The CSSD is charged with the responsibility of control and sterilization of all contaminated items; it must also provide protection for its employees by implementing decontamination processes. Some believe that sanitization of items (washing at 180°F) will adequately protect personnel, but no proof exists as yet for this contention.

Decontamination of known contaminants (contaminated operating room cases and/or isolation cases) in sterilizers is a popular method, but much uncertainty is involved in the identification of all such items. Consequently, the trend is to total decontamination, which dictates that all items, after use, must be sterilized in CSSD before handling by employees, and then terminally sterilized after employee processing before return to the patient.

2. To ensure that sterilized goods do not become recontaminated, soiled receiving, preparation and packing, and sterile storage should be separated by walls, and air flow should be controlled by positive and negative pressures.

3. Bedpans, urinals, and other patient utensils should be sterilized before being issued to a new patient as well as being sanitized between uses.

Centralization

Such departments as Surgery, OB, and Emergency require local sterilizing equipment for emergency cases. However, a general trend toward centralizing all sterilization activities, including preparation and packing, has developed in an attempt to:

1. Reduce costly duplication of processing equipment, effort, and responsibility.
2. Improve patient care by relieving medical or paramedical personnel of time-consuming processing duties.

3. Increase equipment utilization.

The main objection to centralization is heard from the operating room, which does not wish to lose "control" of its instruments. Although this may be a valid argument, it is subjective and must be weighed against the quantifiable benefits of centralization.

<u>Automation</u>

Automation in both the processing and storage areas of CSSD can either reduce the total number of employees or free workers from repetitious tasks for more important and responsible jobs. At the present time, automation in central supply primarily means handling the intra-departmental transportation of goods between various processing operations. Storage of high volume, high turnover items presents another application for automated storage and retrieval. However, it must be supplemented by some combination of fixed, permanent, and cart shelving for the lower volume, slower turnover items.

Although costly to implement, automation can be justified if the amount of labor savings over the life of the equipment (physical life and technical obsolescence) is greater than the cost of purchasing and operating the system. In a military hospital, however, with a pay scale traditionally below that of its civilian counterpart, economic justification of fully automated processing techniques will be more difficult. Factors influencing an economic trade-off analysis are:

- Labor rate
- Fringe benefits
- Employee turnover rate and employee hiring and training costs
- Capital investment, including depreciation charges, cost of capital, and annual maintenance charges
- The cost of money.

Disposables

The amount of disposable sterile items the hospital uses will, of course, influence the scope of CSSD activities. However, military hospitals with their lower personnel costs may adopt throw-away items at a slower rate than civilian institutions. In addition, disposables will probably be employed as limited use items, being reprocessed several times before disposal, and so will still need to undergo sterilization. The advent of sterile disposables, however, will require that the CSSD distribution and storage procedures align themselves with the larger general stores distribution pattern.

ADVANCED TECHNOLOGY

Sterile processing technology will probably not change drastically in the next five to ten years, although techniques and equipment will undergo further refinements. The only major exception would be the use of radiation for sterilization, but it is difficult to predict when this concept will be practical enough to introduce on a large scale.

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: STERILIZATION**
**COMPONENT: WASHERS AND SONIC CLEANERS**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Conveyorized Cart or Container Washer, Castle Company | Provides rapid processing and thorough cleaning of hospital carts or containers. | $30,000 | 1. Volume productivity.<br>2. Washes, rinses, and dries.<br>3. Saves on detergent - reusable wash system. | 1. Pit required for installation. |
| Rack Washer - Floor Level Loading, Castle Company | Provides floor loading of utensils and carts; and complete washing, rinsing, and drying of metalware. Capable of processing six 24"W x 30"L x [illegible]"H carts an hour. | $20,000 | 1. Large volume processing.<br>2. Washes, rinses, sanitizes, and dries.<br>3. Provides for floor loading - easier handling. | 1. Pit required for installation. |
| Sonic Cleaner, 3-section 15" x 21" Chamber Size, Castle Company | Complete cleaning, rinsing, and drying of surgical instruments in one console, ready for terminal sterilization. Chamber size: 15" x 24" x 11" deep, manually operated. Instruments processed in trays. | $11,000 | 1. Thorough cleaning in box locks and other inaccessible spots.<br>2. No external venting is needed.<br>3. Three functions in one cabinet. | 1. Size limit on large items. |
| Sonic Cleaner, Automated Conveyor Type, Castle Company | Automatically carries a tray of instruments through pre-rinse, clean, rinse and dry cycles and ejects ready for terminal sterilization. Available with automated storage/feed for up to 8 loads. | $25,000 | 1. Thorough cleaning in box locks and inaccessible spots.<br>2. Reduced need for personnel.<br>3. Proper processing eliminates human errors. | 1. Moderate size of items handled up to 20" x 12 1/2" x 5"). |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: STERILIZATION**
**COMPONENT: WASHER/STERILIZER**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Instrument Washer Sterilizer, AMSCO and Castle Company | Removes visible blood and tissue and renders instruments safe to handle. Chamber Size: 16" x 16" x 26" holding up to three instrument trays. Also used terminally for patient protection i.e., instrument sterilization. | $4,000 - 5,300 | 1. Easy loading.<br>2. Automatic controls.<br>3. Safe method of handling contaminated instruments. | 1. Additional cleaning and terminal sterilization required before reuse of instruments. |
| Cylindrical Sterilizers, AMSCO and Castle Company | Cylindrical vessel uses the gravity air displacement process to provide low volume sterilization of liquids, hardware, or cloth type materials. Sizes available: 16" dia. x 24" long; 20" dia. x 36" long. | $5,000 - 6,000 | 1. Convenient.<br>2. Heavy equipment with automatic controls. | 1. The cylindrical configuration does not lend itself to full usage of chamber capacity. |
| Straightline Sterilizers, AMSCO and Castle Company | A small rectangular vessel sterilizes liquids, instruments, utensils, wrapped goods, and moisture sensitive materials such as plastic tubing and rubber goods. Sizes available: 16" x 16" x 24" and 20" x 20" x 36". | $5,000 - 9,500 | 1. Heavy duty equipment with automatic controls. | 1. Small capacity does not lend to centralized processing. |
| Large Rectangular Sterilizer, Castle Company and AMSCO | A chamber with 18 to 30 cu. ft. capacity is used to sterilize liquids, fabrics, utensils, and heat and moisture sensitive materials. Utilizes both gravity and vacuum air removal systems for high productivity. | $11,000 - 30,000 | 1. Convenient and dependable for sterilizing routine bulk supplies.<br>2. Power operated door and automatic control reduce operator skill requirements. | 1. Goods must be transferred to mobile carts before and after sterilization. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: STERILIZATION**
**COMPONENT: WASHER/STERILIZER**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Floor Level Loading Sterilizer, Castle Company | Liquids, fabrics, utensils, and heat and moisture sensitive materials are sterilized in a chamber with 30 to 70 cu. ft. capacity. Utilizes vacuum air removal for high productivity steam sterilization. | $30,000 - 40,000 | 1. Floor level loading concept eliminates necessity of rehandling goods immediately before and after sterilization.<br>2. Reduces material handling labor. | 1. Costly to install because of pit requirements. |
| Automatic Load/Unload Sterilizer, Castle Company and AMSCO | Provides in-line processing of all precontainerized bulk supplies at the rate of 25 cu. ft. per hour. Washing accomplished by jet spray. | $35,000 - 45,000 | 1. Reduces labor and operator skill requirements for sterilization and handling of goods. | 1. High cost is prohibitive for smaller hospitals. |

**COMPONENT: STERILIZATION TECHNIQUES**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| Steam Sterilization | Sterilization of processed sterile supplies by steam under pressure - 250°F. Required cycle: 1 hour to ensure killing of the most resistant spores. | Dependent on vessel size. | | 1. Slow, long sterilization cycle.<br>2. Basic cycle is destructive to heat and moisture sensitive items. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

**FUNCTION: STERILIZATION**
**COMPONENT: STERILIZATION TECHNIQUES**

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| High Pressure-Temperature Steam Sterilization | Sterilization of processed sterile supplies by steam under pressure - 270°F. Required cycle: 20 min. for wrapped supplies, 5 minutes for unwrapped supplies. Normally vacuum assisted. | Dependent on vessel size. | 1. Faster cycle—reduces amount of capital equipment and investment required. | 1. Cannot process water solutions due to ebullition (boiling).<br>2. Destructive to heat and moisture sensitive material. |
| Ethylene Oxide Sterilization | Sterilization agent is an $O_2$ freon mixture that will kill all spores. Required Cycles: 4 hours for most wrapped goods, 2 1/2 hours for unwrapped items. | Dependent on vessel size. | 1. Will not harm heat and moisture sensitive supplies. | 1. Slow cycle time.<br>2. Aeration of processed supplies required. |

# WARD MANAGEMENT

## INTRODUCTION

Nursing service is an integral link in the chain of activities that results in quality patient care. Not only do nurses carry out specific orders from physicians but they also have the most extended and direct contact with patients while providing round-the-clock care.

The roles of nursing service personnel are traditionally categorized as follows. Nurses with doctoral degrees in administration or supervision generally serve as directors of nursing service or as supervisors. Nurses with master of arts or doctoral degrees in other areas fill positions in education, administration, or research.

Registered nurses with associate degrees, hospital diplomas, or baccalaureate degrees give bedside nursing at a beginning level. These nurses are sometimes called nursing generalists as opposed to specialists.

Because of the 20 percent shortage of registered nurses, auxilliary personnel such as practical nurses, nurses aides, and technicians assist in providing patient care but obviously require more direct job supervision than registered nurses. Practical nurses are trained in 12- to 18-month hospital or secondary school programs. Aides and technicians are usually trained in on-the-job programs.

These nursing service roles, however, are changing in several ways:

1. New positions are being established in an effort to meet the needs of specialized patient care and to relieve nurses of administrative duties.
2. Inservice and continuing education are enabling nursing personnel to assume positions of greater responsibility.

3. Innovative concepts in patient care such as team nursing and progressive patient care are altering the duties of nursing personnel.

Current developments in these areas will be the major subject of this section.

## TECHNICAL APPROACH

In developing the state-of-the-art report for ward management, we conducted an extensive literature search which included the following publications:

American Journal of Nursing
Canadian Hospital
Computer Biomedical Research
Hospitals - Journal of the American Hospital Association
Hospitals - Journal of the American Medical Association
Hospital Management
Hospital Topics
Industrial Medical Surgery
Journal of Industrial Engineering
Modern Hospital
Nursing Forum
Nursing Outlook
Nursing Research
Texas Hospitals

Published works, as well as master's theses and doctoral dissertations from major universities such as Georgia Institute of Technology, Johns Hopkins University, the University of Michigan, and the University of Pittsburgh were also studied.

To corroborate our research findings, we consulted the following people with expertise in both the educational and patient care aspects of nursing service:

Miss E. Alexander, Director of Nursing Service, Allegheny General Hospital, Pittsburgh
Miss J. Celella, Director of Nursing Services, Saint Margaret Memorial Hospital, Pittsburgh

Doctor M. Hill, Director of Continuing Education in Nursing, University of Pittsburgh
Doctor H. Kroeger, Graduate School of Public Health, University of Pittsburgh
Mr. D. Macer, Assistant Vice Chancellor of the Healty Profession, School of Medicine, University of Pittsburgh
Doctor I. Ramey, Chairman of Medical-Surgical Nursing, University of Pittsburgh
Doctor M. Schaefer, Dean of School of Nursing, University of Pittsburgh

## STATE OF THE ART

The general trends in ward management, detailed in the following pages, are:

1. To establish a supervisory postition with dual responsibility for nursing service and nursing education.
2. To use clinical nursing specialists as supervisors, consultants, liaison personnel, or direct administrators of patient care.
3. To delegate clerical and non-nursing administrative tasks to ward clerks and ward managers, respectively.
4. To provide inservice and continuing education to keep nurses abreast of the latest medical advances as well as broaden their knowledge base.
5. To inaugurate "nursing teams" to improve patient care and optimize the use of personnel.
6. To use the technique of progressive patient care.
7. To increase the number of specialty units or areas.
8. To adopt patient-centered nursing rather than disease-centered nursing.
9. To implement patient education programs emphasizing mental health concepts and rehabilitation.

10. To speed patient care by implementing "rooming-in" procedures.

11. To use improved criteria for obtaining optimum staffing of the nursing unit.

12. To design improved layouts for nursing units.

1. Although nursing education and nursing service have traditionally been administered separately, the trend is toward having a single person direct both faculty and service staffs. The objectives of such a dual appointment are: 1) to give the educators an opportunity to control the learning environment for students in the clinical area and 2) to enable the nursing service staff to utilize the knowledge and skills of the faculty to improve patient care.

This symbiotic organization is currently being used by the Frances Payne Bolton School of Nursing at Cleveland's Case Western Reserve University and the Nursing Service Department of the Cleveland University hospitals. Two administrators at the University of Pittsburgh School of Nursing hold such joint appointments. The Chairman of the Department of Psychiatric Nursing is also responsible for the Nursing Service Department at Western Psychiatric Institute (a University of Pittsburgh hospital), and the Chairman of the Medical-Surgical Nursing Department is also the Director of Nursing Service at Presbyterian University Hospital (a member of the Health Center of Pittsburgh).

2. With the recent emergence of master's programs in clinical areas, a new role, the clinical specialist or nurse clinician, has been developed. The primary objective of the clinical specialist is to improve patient care by functioning as a therapist in assessing patients' needs, planning nursing care, giving direct care, delegating other duties to supplemental nursing personnel, and evaluating overall patient care. These nurses are also prepared to assume active leadership in teaching staff and patients and in collaborating with faculty to provide learning experiences for students. The clinical specialist may also conduct research, although in actual practice she is often much too busy.

To make her expertise available to as many patients as possible, the clinical specialist often functions as a consultant in a staff position superimposed upon an existing organizational structure. In this type of role, the clinical specialist often meets with hostility from the head nurse and the supervisor who view her as a threat because of her advanced education. If such resistance extends over several months, it becomes difficult for the clinical specialist to persuade the nursing staff to assist her in carrying out the nursing care plan. The specialist, moreover, must carve out her own role since she does not have the formal authority of a line position.

To avoid these complications, several hospitals have placed the clinical specialist in a line position, replacing the head nurse. In this way, the clinical specialist can concentrate her activities on one group of patients and use a single nursing staff. Consequently, her effectiveness can be more readily evaluated.

3. To enable the head nurse to devote all her time to leadership in direct nursing care, many hospitals have freed her from clerical and non-nursing administrative tasks which formerly occupied over 50 percent of her time. The responsibility for these duties is assumed by a unit manager (ward manager), who may be assisted by a ward clerk. The ward manager position is also an answer to increasing specialization and decentralization. Since it is difficult for the hospital administrator to manage all the proliferating specialty areas under his jurisdiction, he can rely on ward managers for recommendations on budget, staffing, equipment, and programs.

Ward management, or service unit management, then, is an organizational approach to patient units which separates nursing and non-nursing activities. With service unit management, unit managers may report to the administrator, an administrative assistant, the director of nursing service, or a nurse supervisor. The responsibilities of the unit manager vary in accordance with the number of nursing units, the number of patient beds, and the extent of activities delegated to him.

Although ward management offers definite potential for optimizing personnel use, it has not been operating long enough or in enough locations for its effectiveness to be evaluated or for a single approach to the system to be recommended.

4. The explosion of knowledge requires that nurses continue their education in both general medicine and in their specialty areas. To fill this need, continuing education programs are given by nursing service departments as well as by universities and professional organizations. These programs may train nurses to perform such activities as reading electrocardiograms, diagnosing ventricular fibrillation, and initiating medical action in emergencies. A nursing service education department has the additional responsibility of orienting new employees, training nurses' aides and technicians, and developing leadership qualities in nursing personnel -- major endeavors in view of staff turnover.

The educational program for nurses working in specialty units may be handled by inservice faculty, but are usually conducted by physicians and/or clinical specialists with master's degrees in the appropriate nursing specialty. Programs to train promising nurses for the responsibilities of head nurse, an integral part of many hospitals' programs, emphasize administrative skills to ensure efficient planning and provision of services.

Present teaching techniques include lectures, seminars, workshops, programmed instruction materials, and audio-visual aids such as slides, movies, videotapes, and television. Most important, of course, are well-qualified instructors who can orient personnel and teach skills. Budgetary allocations must reflect commitment to this significant area.

5. To optimize the use of personnel, many nursing service departments have created "nursing teams." Each team is headed by a registered nurse who assigns duties of various degrees of difficulty and responsibility to the registerednurses, licensed practical nurses, and nurses'

aides on her team. Each team member plays an important role in contributing information about the patient's history and present condition, in developing individualized nursing care plans for each patient, in enacting that plan through skillful nursing, and in helping to evaluate nursing care in terms of patient progress. The leader conducts team discussions to plan the best approach to each patient's needs, supervises and evaluates the members of her team, and cares directly for patients with especially difficult problems. There may be up to five team leaders who report to a nurse administrator for overall coordination of services. If there is only one team, the head nurse or clinical specialist may serve as team leader.

6. Some hospitals have redesigned patient units to accommodate the concept of progressive patient care. With this system, the extremely ill patient is placed in an intensive care unit. As he improves, he is tranferred to an intermediate care unit, and when he becomes ambulatory, he goes to a minimal care unit. This progressive care system gives the patient evidence of his recovery and allows the most effective and economical use of personnel, supplies, and equipment.

Progressive patient care, however, has several disadvantages:

a. When patients are transferred frequently, continuity of care (both by physicians and nurses) may be interrupted by poor communications.

b. Frequent patient transfers create traffic problems, especially on elevators.

c. Additional housekeeping is required.

d. With each patient transfer, departments such as dietary and admissions must be notified, and inadequate communications may result in dietary trays, laboratory and X-ray reports being sent to the wrong nursing units.

7. Wards are being organized into an increasing number of speciality areas, such as Ophthalmology, Orthopedics, and Ear, Nose,

and Throat areas. This arrangement offers improved patient care since specialized nurses, physicians, and equipment are immediately available. However, although specialty areas provide more expert care, they have several disadvantages:

a. Staff and faculty require extensive specialty training and ongoing education. Nurses, moreover, must also be trained to perform the specialty services usually provided by ancillary departments such as the Inhalation Therapy Department, since these departments rarely operate at night, on weekends, or on holidays. With the current high rate of personnel turnover, such educational programs become costly and are a physical and psychological drain on the teaching personnel.

b. During emergencies, staffing many specialty units is a major problem since personnel cannot be readily reassigned.

c. Because nursing care is focused on a specific medical problem, other patient complaints may not receive proper attention. Nurses must make a concerted effort to maintain their perspective on the total patient and to ensure continuity of care as the patient is moved from one unit to another.

d. Specialty units are often difficult to administer, since their interfacings are complex and the various departments often tend to be somewhat chauvinistic.

e. The technical jargon endemic to each specialty department increases its isolation from other departments.

f. Often no backup equipment is provided for the elaborate systems built into specialty areas. Consequently, equipment breakdown may be disastrous.

8. The concept of considering the total patient, that is, his psychology as well as his pathology, has existed in nursing for some time and is now being incorporated into medical school curricula. In line with this concept of patient-centered rather than disease-centered nursing, nurses now obtain information about social history, living habits, and psychological status. Moreover, since drug therapy allows many patients with psychiatric pathologies to be cared for in general hospitals, nurses are being exposed more often to mental problems and are assisting in group therapy, particularly in day and night care centers. In view of this expanded role, nurses must have extensive training in the psychosocial aspects of patient care. Nursing team conferences are currently evaluating the effectiveness of such psychosocial care in terms of the patient response.

9. In considering the patient's total well-being, nurses are extending their roles to include educating patients in the areas of mental health, rehabilitation, and preventive medicine. They do pre- and post-operative teaching of patients in intensive care units, post-anesthesia recovery rooms, coronary care units, hemodialysis units, and hyperbaric oxygen chambers. Moreover, since many non-psychiatric patients develop unique psychological problems during hospitalization, nurses are needed to discuss such things as body image (important after surgery or traumas), the stress of hospitalization or illness, and dependency.

In planning patient rehabilitation, nurses must stress the patient's abilities, help him cope with his environment, and aid him in restructuring his activities and goals to accommodate his disability. For dealing with long term rehabilitation, both nursing staff and faculty should be trained in speech therapy, transfer techniques, prosthetics, psychological support, and utilization of community resources. Above all, they must develop healthy attitudes toward disabilities, which are not necessarily handicaps.

Out-patient clinics offer an excellent opportunity for nurses to do preventive and remedial health teaching while patients and their relatives wait for appointments. For this purpose audio-visual aids should be provided in the waiting rooms or teaching areas.

Although patient education is essential to mental health and rehabilitation programs, little patient teaching is being done because:

a. Nursing programs provide little or no formal preparation for teaching.

b. With the current understaffing, nurses usually have time to accomplish only the absolute essentials of care.

c. Facilities for teaching patients are generally inadequate.

d. Many patients are hospitalized only during the acute phase of their illness and are unable to benefit from teaching.

Military personnel, however, are expected to resume active duty upon discharge from the hospital and so remain hospitalized during their convalescence. These patients would greatly benefit from an organized education program.

10. Research has shown a better mother-child relationship develops when a newborn infant is placed in his mother's room as soon as the mother is able to assume responsibility for his care. Such "rooming-in" has also proved beneficial for small children, who do not undergo the trauma of separation, with its many ramifications, if provision is made for the mother to stay with the child. Rooming-in entails structural changes in hospitals and means orienting the nursing staff to a new system. In pediatrics, many nurses are resistant, for they must then cope not only with the child but also with the mother.

11. To determine staffing requirements for nursing units, three techniques are available:

a. Ratio of nursing personnel to various types of patients.

b. Time standards based on the amount of nursing time needed by various classes of patient care.

c. Time standards based not only on the amount of nursing time needed by various types of patients but on nursing personnel categories as well.

These methods are listed in the order of their usage but inversely in the order of their validity.

In the first method, the ratios generally express the total number of nursing personnel required by the average number of patients. Usually these ratios are stated in the nursing care hours needed by the average patient: for example, the Hospital Nursing Service Manual of the American Hospital Association and National League of Nursing Education calls for 3.5 hours a day of bedside nursing for surgical patients. Different hours are estimated for medical, pediatric, orthopedic, and obstetric patients. Children's hospital of Akron has computerized such a system; in ten minutes the computer calculates, readjusts, and prints out assignments for each eight hour shift. These ratios may be determined by work sampling or by dividing the total average staff hours by the average patient census.

The second staffing technique is a sophisticated version of the above staffing procedure and is based on detailed nursing activity time standards, such as those developed by the Veterans Administration, the Commission for Administrative Service in Hospitals in Los Angeles, and the Community Service Foundation in Ann Arbor, Michigan. These systems are based on patient classifications and are modeled after the procedures developed by R. J. Connor of Johns Hopkins University.

The nurse staffing procedure developed by Westinghouse is an example of the third technique, which considers not only the number and type of patients but also nursing personnel categories. This method makes it possible to obtain a more realistic staffing of nursing units. Personnel categories include:

- Head Nurse
- Team Leader
- Registered Nurse
- Licensed Practical Nurse
- Aide
- Orderly
- Ward Manager
- Clerk

This technique will be discussed in detail in the systems analysis volume of this final report.

12. In designing nursing units, the trend is toward using all private or semi-private rooms which offer greater flexibility, speed patient recovery, and reduce the possibility of cross infection. Such an arrangement will increase hospital occupancy rates, since, if necessary, patients of both sexes, various ages, and diverse pathologies can be mixed in a single nursing unit. These advantages more than compensate for the operating and construction costs which are slightly higher than for the traditional large ward design.

Other trends in nursing ward design are:

- To design multipurpose sound-proof rooms to obtain maximum utilization of personnel.
- To group facilities frequency used by patients or personnel to reduce travel time and improve traffic control of patients and personnel.
- To capitalize on the therapeutic values of bold color schemes and appropriate music.

## ADVANCED TECHNOLOGY

The changes expected in ward management by 1980 will be further refinements of methods or concepts already in use. Basically we will see additional changes in the nurse's role.

- Nursing specialists will increase in number and will occupy line positions as a matter of course.
- In an attempt to meet increasing care demands, aides and technicians will also proliferate.
- The concept of ward management will become more common, as specialization forces the nurse's administrative and patient care duties to separate.
- Pre-packaged, unit-dose medications will reduce nursing time spent in administering drugs.

- Sophisticated electronic sensors and recording devices which monitor vital patient signs will be adopted on a larger scale and computers may even be used to interpret data reported by the monitors. The nurse's role will alter in direct proportion to the availability and implementation of such devices.

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: WARD MANAGEMENT

COMPONENT: NURSING UNIT STAFFING

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| 1. Variable Nursing Team Size | Nursing team varied (quantity and mix) to meet the demands of varying patient workloads (quantity and mix); unit size remains fixed. | | 1. Optimal staff-to-patient ratio maintained.<br>2. Staffing flexibility permitted. | 1. Nursing personnel prefer permanent unit assignment.<br>2. Dearth of personnel with a wide range of capabilities.<br>3. Patient-nursing staff relationship disrupted. |
| 2. Variable Unit Size | Unit size varied to meet changing patient demand; permanent staff maintained. | | 1. Good patient-nursing staff relationship maintained. | 1. Adjacency layout configurations may inhibit adequate flexibility. |
| 3. Duty Station Assignments | Nursing staff personnel assigned to a specific duty station. | | 1. Increased work quality and personnel satisfaction if assignment extends to 2-3 years.<br>2. Development of long range nursing care plans promoted. | 1. Personnel career development inhibited if permanent assignment extends beyond 3 years. |
| 4. Unit Manager | Relieves nurses of clerical and administrative activities. | | 1. More nursing time devoted to direct patient care. | 1. Nurses disinclined to give up responsibilities related to nursing unit.<br>2. Cooperation and coordination possibly hampered since the nurse and unit manager report to different supervisors.<br>3. Higher operating cost. |
| 5. Clinical Nurse Specialist | Nursing personnel with advanced degree or equivalent experience supervises and controls unit patient care. | | 1. Improved patient care resulting from utilization of patient assessment, nursing care plans and follow-up evaluations.<br>2. Nursing personnel can perform certain medical tasks, otherwise done by physicians. | 1. Limited number of accredited schools offering advanced nurse specialist degrees.<br>2. Role of Clinical Nurse Specialist not clearly defined and place in the organizational structure unclear. |

# IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: WARD MANAGEMENT

COMPONENT: NURSING CARE

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| 6. Progressive Patient Care (inter-ward) | Patients placed in a nursing unit commensurate with medical needs; when medical conditions change, patients moved to another ward. | | 1. Effective and efficient utilization of personnel, supplies and equipment.<br>2. Patient has evidence of his recovery as he is moved to different wards. | 1. Care continuity disrupted by patient transfers.<br>2. Traffic flow problems increased.<br>3. Additional administrative communications needed, i.e., to Dietary, Laboratory, Hospital Information, etc. |
| 7. Specialty Units | Units dedicated to specific medical specialties. | | 1. More expert patient care provided in the various specialties.<br>2. Improved utilization of skilled medical and paramedical personnel. | 1. Considerable advanced education and training of nurses required. With current high rate of turnover such education and training programs become expensive.<br>2. In emergency situations staff reassignment difficult.<br>3. Traditional unit care needed by patients with several medical problems.<br>4. Administration of many specialty units more difficult. |
| 8. Patient Monitoring | Physiological monitoring of patients at bedside and from the Central Nursing Station. | | 1. Continuous monitoring accomplished without requiring constant or frequent bedside observations and measurement by professional personnel. | 1. Equipment and installation is expensive.<br>2. To monitor output, trained nurses must be on duty at the nurses station. |

COMPONENT: NURSING UNIT OPERATIONS

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| 9. Computer Terminal | Computer terminal for storage and retrieval of patient data, drugs and supplies orders, etc. | | 1. Information more accessible.<br>2. See Communications SOA.<br>3. Limited nursing station space required. | 1. Expensive equipment.<br>2. Extensive and costly programming required. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: WARD MANAGEMENT

COMPONENT: NURSING UNIT OPERATIONS

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| 10. Microfilm | Microfilm used for storage and retrieval of nursing procedures, emergency reference materials, etc. | | 1. Readily accessible information.<br>2. Less storage space required.<br>3. See Communications SOA. | 1. Required special viewing equipment utilizes nursing station space. |
| 11. Centralized Scheduling | Patient trips to all support areas are centrally scheduled. | | 1. Nursing unit activities are coordinated and the workload of all support areas is better proportioned.<br>2. Fewer patient queuing problems. | 1. Programming effort required. |
| **COMPONENT: NURSING UNIT FACILITIES** | | | | |
| 12. Patient Wards | Incorporation of six beds per ward. | | 1. Construction cost reduced over private room concepts.<br>2. Reduced maintenance costs.<br>3. Improved staff utilization. | 1. Greater danger of cross infection.<br>2. Less flexibility than private room concept. |
| 13. Private Rooms | Utilization of all private room construction. | | 1. Maximum flexibility in admission and room assignments.<br>2. Greater protection from cross infection.<br>3. Greater patient privacy. | 1. More expensive to construct.<br>2. More expensive to staff and maintain. |
| 14. Multi-purpose Rooms | Flexible patient room that can be converted to several specialty care areas. | | 1. A wide variety of diseases or conditions can be treated in a single room. | 1. High construction cost. |
| 15. Nursing Units of Reduced Size | Nursing units accommodating 30-35 patients. | | 1. Improved control of unit by nursing personnel.<br>2. Improved patient-nurse relationship. | 1. Less efficient administrative control. |

## IMPROVEMENT ALTERNATIVE COMPARISON CHART

FUNCTION: WARD MANAGEMENT

COMPONENT: NURSING UNIT SUPPORT SYSTEMS

| NAME | DESCRIPTION/USE | COST | ADVANTAGES | DISADVANTAGES |
|---|---|---|---|---|
| 16. Convenience Foods | Frozen foods are delivered to the nursing unit where they are heated by nursing unit personnel in a micro-wave oven and distributed to patients. | | 1. Meals can be served at most appropriate time.<br>2. Refer to Dietary SOA. | 1. Increased workload for nursing unit personnel.<br>2. Space needed in the nursing unit for a micro-wave oven and refrigerator. |
| 17. Unit Dose Drugs | Central pharmacy dispenses individual patient's unit dose of medications to nursing unit. | | 1. Decreased nursing personnel time required for preparation of medications.<br>2. See Pharmacy SOA. | 1. High initial cost for drug supplies. |
| 18. Clinical Pharmacist | Clinical pharmacist in the nursing unit supervises all aspects of patient pharmacy service. | | 1. Closer communication between Pharmacy and the nursing unit.<br>2. Refer to Pharmacy Section. | 1. Limited number of licensed pharmacists in the military. |

# BIBLIOGRAPHY - WARD MANAGEMENT


Abdellah, Faye, G. "Criterion Measures in Nursing." Nursing Research (Winter 1961).

______. "Work Sampling Applied to the Study of Nursing Personnel." Nursing Research (June 1954): 11-160.

Arnstein, M. G. How to Study Nursing Activities in a Patient Unit. Washington, D. C.: U.S. Department of Health, Education and Welfare. PHS Pub. 370.

Asselmeier, Doris. "Pediatric Unit for Children." Nursing Forum (Fall 1964): 81-95.

Ayers, R., et al. "Action for Change: An Experiment in Nursing Service Reorganization." American Journal of Nursing (April 1969).

Barnett, G. O., et al. "A Time-sharing Computer System for Patient-care Activities." Computer Biomedical Research (March 1967): 41-51.

Barrett, Jean. "The Head Nurse's Changing Role." Nursing Outlook (November 1963): 800-04.

Bartscht, K. G., et al. "The Development of an Effective Methodology for Determining Staffing Requirements in Hospitals." Project report, Hospitals Systems Research Group, University of Michigan, February 1965.

Bates, Barbara, M.D. "The Better the Doctor Does His Job, the Better the Nurse Can Do Hers." The Modern Hospital (January 1967): 72-5.

Beahrs, O. H. "Patient Care in the Hospital of Tomorrow." Industrial Medical Surgery (August 1968): 609-15.

Bennett, Leland R. "This I believe . . . That Nurses May Become Extinct." Nursing Outlook (January 1970): 28-32.

Benz, Edward G. "Annual Administrative Reviews — Nursing Service." Hospitals, J.A.H.A. (April 1, 1969).

Birney, Martha. "How the Unit Manager Can Work with Central Service." Hospital Topics (June 1968): 137.

Blake, Florence G., and Wright, F. Howell. Essentials of Pediatric Nursing. New York: J. B. Lippincott, 1963.

Blickensderfer, Bertha. "Unit Manager Can Help in OR Too." Modern Hospital (June 1967): 97-8.

Booth, Marie. "The Area Supervisor." Hospital Management (June 1966): 61.

Bosworth, Patricia. "Project Report of Unit Management." Texas Hospitals (August 1966): 20.

Brady, Norman A.; Herman, James A.; and Warden, Gail R. "The Unit Manager." Hospital Management (June 1966): 30-6.

Brodt, Dagmar E. "The Service Manager: Innovation for Nursing and Health Organizations." Hospital Progress (September 1966): 69.

Brown, Elaine, and Roche, John. "Methods Study Shaped Team Nursing Plan." Modern Hospitals (September 1966).

Christman, Luther P., and Jelinek, Richard C. "Old Patterns Waste Half the Nursing Hours." The Modern Hospital (January 1967): 78-81.

Conner, Hatell L. "The Departmental Administrative Assistant: A New Career in the Hospital." Hospital Management (May 1967): 33-7.

Connor, R. J. "A Hospital In-patient Classification." Ph.D. dissertation, Johns Hopkins University, 1960.

______. "A Work Sampling Study of Variation in Nursing Workload." Hospitals, J.A.M.A. (May 1961).

______. "Hospital Work Sampling with Associated Measures of Production." Journal of Industrial Engineering (March-April 1961).

Connor, R. J., et al. "Effective Use of Nursing Resources: a Research Report." Hospitals, J.A.M.A. (May 1, 1961): 30-9.

Cransioun, J. "The Changing Concept of Nursing." Canadian Hospital (December 1964): 40-42.

Daschback, James M.; Gerken, John A.; and Morrow, Gary H. "A Task Auditing Method to Determine Personnel Utilization in Hospital Nursing Service." South Bend, Ind.: University of Notre Dame, Department of Mechanical Engineering, Technical Report Number 67-01-01.

Davis, K. G. "Give Nurses the Chance to Explore These Twelve Routes to Better Care." Modern Hospital (October 1968): 82-5.

DeMarco, J. P., and Snavely, S. A. "Nurse Staffing with a Data Processing System." The American Journal of Nursing (October 1963).

Dennism, Ann J. "Pavilion Manager." Modern Hospital (June 1953): 79-80.

Donnelly, Cynthia. "Why Not Try Floor Managers?" Hospital Progress (February 1952): 55.

Dudley, Martha. "Here They Let Nurses Be Nurses." RN (September 1961).

Ehrlick, Ira. "Supervision: Process Not Position." American Journal of Nursing (January 1968): 155.

Feldman, Herman. "Validity of a Feedback System for Evaluation of Pediatric Nursing Case." Nursing Research (Summer 1965): 257.

Ferriss, Margaret J., and McWillie, Nancy A. "Unit Management in the Operating Room." Hospital Topics (December 1963): 69-7 .

Ford, Loretta, and Silver, Henry. "Physician's Assistants: The Pediatric Nurse Practitioner at Colorado." The American Journal of Nursing (July 1967).

Galton, Robert. "Improved Manpower Utilization Requires a System for Developing and Maintaining Changes." Hospital Management (March 1969).

Garrison, Ella P., 1969. Computerization - Implications for Nursing Service Departments. Paper read at the Third Annual Meeting of the Council of Hospitals and Related Institutional Nursing Services, October 1969.

Glagle, C. D. "The Problem of Organization for Hospital Inpatient Care." Management Sciences Modes and Techniques, vol. 2. New York: Pergamon Press, 1960.

Gordon, H. Phoebe. "Who Does What— The Report of a Nursing Activities Study." The American Journal of Nursing (May 1963): 564-6.

Hammer, S. L., and Eddy, Jo Ann. Nursing Care of the Adolescent. New York: Brown Company, 1966.

Hanck, Leon C. "The Area Administrator: A Remedy for Misplaced Responsibility." Hospital Forum (March 1966): 40.

Harris, A. M. "Measuring the Nurses Effectiveness." American Association of Industry Nurses Journal (November 1968): 9-12.

Hartman, J. "Floor Managers Share Responsibility in This Food Distribution System." Modern Hospital (February 1963): 124.

Henderson, Cynthia. "Freeing the Nurse to Nurse." American Journal of Nursing (March 1964): 72-7.

Hershey, N. "Automation in Patient Care: the Legal Perspective." American Journal of Nursing (May 1967): 1037-9.

Hill, Mary S., and Ramey, Irene G. Trends and Issues in American Nursing. Mimeographed. Pittsburgh: University of Pittsburgh, 1970.

Howland, D., and McDowell, W. E. "The Measurement of Patient Care: A Conceptual Framework." Nursing Research (Winter 1964).

Jelinek, Richard C. "A New Approach to the Analysis of Nursing Activities." Hospitals, J.A.M.A. (October 1968).

_____. "A Structural Model for the Patient Care Operation." Health Service Research (Fall 1967): 226-42.

Lambertsen, Eugene C. "Communications Is Vital Link to Effective Nursing Care." Modern Hospitals (August 1966): 122.

_____. "Evaluating the Quality of Nursing Care." Hospitals, J.A.M.A. (November 1965): 61-6.

_____. "Nursing Care Requires a Problem-solving Approach." Modern Hospital (June 1968): 140.

_____. "Patient Service Will Improve if Nurse-Doctor Communications Do." Modern Hospital (December 1965): 108.

_____. "Re-organize Nursing to Re-empahsize Care." Modern Hospital (January 1967): 68-70.

Leonard, R. C., et al. "Small Sample Field Experiments for Evaluation of Patient Care." Health Services Research (Spring 1967): 46-60.

Lervis, E. P. "Action for Change: Four Nurses Who Wanted to Make a Difference." American Journal of Nursing (April 1969): 777-82.

LeTournean, Charles U. "Unit Managers: One Solution to the Nursing Shortage." Hospital Management (December 1967): 31-2.

Levine, Eugene. "Nurse Staffing in Hospitals." The American Journal of Nursing (September 1961).

Levine, Eugene; Siegel, Stanley; and LaPuente, Joseph. "Diversity of Nurse Staffing among General Hospitals." Hospitals, J.A.M.A. 35 (1961): 42-8.

Ludwig, Patric. Establishing Staffing Criteria for Evaluating Nursing Service Functions: A Management Engineering Contribution. Paper read at the Third Annual Meeting of the Council of Hospital and Related Institutional Nursing Services, October 9-10, 1969.

Lundstedt, S., et al. "Effects of Increased Staff Participation on Patient Care and Staff Attitudes." Mental Hygiene (July 1966): 432-8.

Manion, Mary E. "New Aid for Your Hospital Work." Medical Economics (February 1967): 98-102.

Marlow, Dorothy R., and Sellew, Gladys. Pediatric Nursing. Philadelphia: W.B. Saunders Company, 1961.

McBeth, Max A., and Carpenter, Douglas C. "Seven-year Appraisal of a Ward Manager System." Hospitals (March 1966): 79-84.

Mercadante, Lucille T. "Functions and Benefits of the Unit Manager." Hospital Progress (January 1966): 144.

Myers, R. S. "Lack of Liaison in Hospital Care Impairs the Quality of Patient Care." Modern Hospital (February 1966): 122.

Nelson, Roger B. "Full Time Nurses Should Nurse Full Time." Modern Hospital (January 1967): 66-7.

Petznick, M. "A Guide for Staffing a Hospital Nursing Service." WHO Public Health Paper 31 (1966): 1-93.

Patterson, Thora K. "Patient-centered Nursing." Hospitals (November 1966): 80.

Phaneuf, M. C. "The Nursing Audit for Evaluation of Patient Care." Nursing Outlook (June 1966): 51-4.

Public Health Service. How to Study Nursing Activities in a Patient Unit. Washington, D.C.: U. S. Government Printing Office, 1964.

Raphael, W. "Patient-care: Patients and Staff - Their Likes and Dislikes." Nursing Times (December 1965): 1654-6.

Reader, George G., and Schwartz, Doris R. "Joint Planning for Patient Care." Hospitals, J.A.M.A. (August 1967): 104-7.

Rudick, Eleanor. Pediatric Nursing. Dubuque, Iowa: William C. Brown Company, 1965.

Shanks, and Kennedy. The Theory and Practice of Nursing Service Administration. New York: McGraw Hill Book Company, Inc., 1965.

Shaw, David R. "Mathematical Models for Predicting Hospital Personnel Availability." Master's thesis, Georgia Institute of Technology, December 1967.

Smalley, Harold E. "Comments on Work Measurement in Perspective - Universal Time Data." The Journal of Industrial Engineering (January - February 1964).

Smalley, Harold E. "Industrial Engineering in Hospitals." Industrial Engineering Handbook. Edited by H. B. Maynard, 2nd. edition. New York: McGraw-Hill Book Company, Inc., 1963.

Smalley, Harold E., and Freeman, John R. Hospital Industrial Engineering. New York: Reinhold Publishing Corporation, 1966.

Souga, Lawrence E. "Unit Management and the Use of the Clinical Specialist in Nursing." AORN Journal (July 1967): 46-9.

Stacey, James. "R.N.'s Tell Why They Took Off Their Caps." Modern Hospital (January 1967): 76-7.

St. Charles, Sister Maureen. Effecting Changes in Design of Nursing Service Function. Paper read at the Third Annual Meeting of the Council of Hospitals and Related Institutional Nursing Services, October 9-10, 1969.

Stearly, S.; Noordembos, A.; and Crouch V. "Pediatric Nurse Practitioner." American Journal of Nursing (October 1967): 2083.

Streeter, Virginia. "Reallocation of Nursing Activities." The American Journal of Nursing (February 1950): 102-4.

Walsh, Henry C. "Unit Manager Concept." Hospital Pharmacy (June 1968): 24-5.

Weaver, K. "Good Nursing Care is Patient Centered." RN (September 1965): 99.

Weil, T. P., et al. "The Use of Computer Systems in Patient Care." Nursing Forum (Spring 1967): 207-17.

Weil, T. P. "Will Computer Installations Improve Quality of Patient Care?" Hospital Management (September 1967): 40-3.

Yett, D. E. "The Supply of Nurses: an Economist's View." Hospital Progress (February 1965).

Young, J. P., and Wolfe, H. "Staffing the Nursing Unit, Part 1: Controlled Variable Staffing." Nursing Research 14 (Summer 1965): 3.

_____. "Staffing the Nursing Unit, Part II: The Multiple Assignment Technique," Nursing Research, 14 (Fall 1965):4.

## APPENDIX A

### CATALOGUE OF FILMS AND FILMSTRIPS SUITABLE FOR IN-SERVICE TRAINING OF HOSPITAL CORPSMEN

This catalogue documents the availability of numerous films and filmstrips suitable for use in a media based in-service training program for hospital corpsmen. Films and filmstrips have been selected which are readily accessible to the Armed Forces and have been found useful by recognized reviewing groups including the American Medical Association, the National Medical Audio-Visual Center, and the Armed Forces Institute of Pathology.

Basic tasks which hospital corpsmen are expected to perform have been derived from existing job descriptions and job training standards. Appropriate training films and filmstrips are listed beside each task.

Each listing includes the following information: the title of the film or filmstrip, an abbreviated physical description, year of release, author, sponsor, producer, and distributor (including an order number, if any), and a brief description of its content.

Bibliographic sources of information contained in the catalogue include the following:


1. U. S. Government Films: A Catalog of Motion Pictures and Filmstrips for Sale by the National Audio-Visual Center. Washington: National Archives and Records Service, General Services Administration, 1969.
2. Film Reference Guide for Medicine and Allied Sciences. Atlanta: National Medical Audiovisual Center, 1968.
3. The Armed Forces Institute of Pathology Catalog of Audio-Visual Educational Aids. Washington: Departments of the Army and the Air Force, 1967. Includes lantern and microscope slide sets as well as films.
4. Medical and Surgical Motion Pictures: A Catalog of Selected Films. Chicago: American Medical Association, 1969.

| | | |
|---|---|---|
| Function: | Patient Care | |
| Knowledge/Skills: | Basic Nursing Techniques | A V Training Aids |

1. General medical terminology

2. Interpersonal relationships

3. Psychological aspects of illness

4. Take and record

   a. temperature

   b. pulse

   c. respiration

   d. blood pressure

Vital Signs. Part 1: Cardinal Symptoms (21 min., sd., B&W, 16 mm, Order No. MN 8211-A, $37.00, USN). Explains temperature, pulse, respiration, and blood pressure by means of live action, animation, art work, and sound effects; tells how these vital signs present a picture of the condition of the body.

Vital Signs. Part 2: Taking Temperature, Pulse, and Respiration (20 min., sd., B&W, 16 mm, Order No. MN 8211b, $35.25, USN). Demonstrates, in live action, the techniques of taking temperature (oral, rectal, axillary), pulse, and respiration of patients with a variety of conditions. Shows equipment needed and includes sanitary procedures and charting.

Vital Signs. Part 3: Taking Blood Pressure (11 min., sd., B&W, 16 mm, Order No. MN 8211-C, $19.25, USN). Explains and demonstrates the principles of taking systolic and diastolic pressures and the procedures followed with patients. Uses sound effects to show the significant changes in pulse tone.

The Vital Signs and Their Interrelation: Body Temperature, Pulse. Respiration, Blood Pressure (32 min., sd., B&W, 16 mm, Order No. OE 406, $55.25, USOE).

Function: Patient Care

Knowledge/Skills: Basic Nursing Techniques

A V Training Aids

---

Describes the physiology of the respiratory, heat regulatory, and circulatory systems and their interrelationships; shows how to ascertain and record the vital signs - temperature, pulse, respiration, and blood pressure.

Blood Pressure Readings (29 min., optical sound, B&W, 16 mm, PHS #MIS-690). Demonstration sequences from which measurements of blood pressure can be taken in a similar manner to the clinical measurement of blood pressure with the sphygmomanometer and stethoscope. Each scene shows the mercury being lowered in a manometer and the sound track presents the accompanying blood pressure sounds. A teaching film for persons who observe and record blood pressure readings.

5. Prepare patient for and assist with physical exam

6. Comfort and personal hygiene

   a. make bed

Basic Care of Patients-Part 1-Cleaning the Patient's Unit and Making an Unoccupied Bed (15 min., sd., B&W, 16 mm, Order No. TF 8-2471, $27.00, USA). Stripping bed of soiled linen - cleaning bed, chair, and bed-side cabinet - making bed with clean linen - final straightening of the unit.

Basic Care of Patients-Part III-Making an Occupied Bed (17 min., sd., B&W, 16 mm, Order No. TF 8-2473, $30.50, USA). Positioning the patient - sequence and technique for removing foundation linen, draw sheets, top sheets, and pillow cases - replacing them with clean counterparts.

Function: Patient Care

Knowledge/Skills: Basic Nursing Techniques

A V Training Aids

---

Making the Occupied Bed (15 min., sd., B&W, 16 mm, Order No. MN 8567-c, $27.00, USN). Demonstrates the procedure to be followed and the supplies and equipment needed to arrange a bed unit in the hospital room or ward while the bed is occupied by a patient.

Making a Recovery Bed (10 min., sd., B&W, 16 mm, Order No. MN8576-b, $17.50, USN). Demonstrates the procedure to be followed and the equipment and supplies needed to arrange a bed unit in the hospital ward or room to ensure a safe, warm, comfortable bed for the patient returning from surgery.

Making an Unoccupied Bed (14 min., sd., B&W, 16 mm, Order No. MN 8576-a, $25.50, USN). Demonstrates the procedures to be followed and the equipment and supplies needed to arrange a bed unit in a hospital ward or room.

b. give bath

Basic Care of the Patient-The Bed Bath (22 min., sd., B&W, 16 mm, 1964, Order No. TF 8-3387, $38.50, USA). Value of bed bath for patient; equipment and preparation for bath; steps in giving the bath; and after bath care.

Bed Bath (29 min., optical sound, B&W, 16 mm, 1965, Iowa - Univ. of #U-6372). A professional nurse demonstrates a systematic procedure for administering a complete bed bath to a nonambulatory patient. The importance of observation and evaluation of the patient's physical capacity and status, mental capacity and status, and skin condition is emphasized.

c. give back rub

The Bed Bath (19 min., sd., B&W, 16 mm, Order No. MN 8567-d, $33.75, USN).

Function: Patient Care

Knowledge/Skills: Basic Nursing Techniques — A V Training Aids

| | |
|---|---|
| | Shows the supplies and equipment needed, demonstrates the order of the bath, and the correct techniques to follow in giving the patient a back rub. |
| d. give oral hygiene | Basic Care of Patients-Part IV-Physical Comforts (11 min., sd., B&W, 16 mm, Order No. TF 8-2474, $19.25, USA). Mouth care of conscious and unconscious patients - changing position of patient in bed - use of helpful appliances.<br><br>Oral Hygiene for Hospitalized Patients (15 min., sd., c, 16 mm, mp) VA, 1957. |
| e. administer bedpan and urinal | |
| f. maintain good posture and body alignment | Balance in Action (14 min., sd., B&W, 16 mm MP, 1956, Valifilm Productions, Inc. in cooperation with Mt. Zion Hospital, San Francisco, and the Industrial Indemnity Insurance Co., USA). Demonstrates the importance of the application of good body mechanics to nursing assignments. Designed specifically as a supplement to hospital-in-service training, this film uses non-technical language to emphasize principles involved. Of particular importance to those whose activities impose unusual strain upon back muscles and lower spine. |
| g. assist with patient exercise | Techniques for Maintenance of Range of Motion (19 min., sd., c., 35 mm (tape), FS, Plymouth State Home and Training School, USA). Demonstrates various passive exercises which can be used to aid the patient in maintaining joint mobility. Explains that the exercises |

are also used in helping the mentally retarded or physically handicapped to know what their limbs are doing, although they are applicable for any patient confined to prolonged bedrest.

7. Measure and record intake and output

8. Ward records, admission and disposition of patients

   a. admit patient and process records

   b. orient new patient to hospital rules and surroundings

   c. maintain patient records during hospitalization

   d. process leaves and passes, interward transfers and discharge of patient

Nursing Care - Ward Admission Procedure (20 min., optical sound, B&W, 16 mm, 1966, Navy #MN-10220-A). This film depicts the duties of the hospital corpsman relative to the admission of the ambulatory patient and his cooperation with the nursing staff to make the patient feel at ease in his new surroundings. Shows the hospital corpsman's responsibility in the admission of the seriously ill patient who is brought directly to the ward and the team work involved between the corpsman and the nurse to alleviate the patient's worry and to make him comfortable.

9. Principles of public health

   a. use medical aseptic techniques in

      (1) performing general housekeeping functions

      (2) using personal protective measures

      (3) cleaning and disinfecting patient areas

Basic Care of Patients. Part VII: Sterile Technique (13 min., sd., 16 mm, MP, B&W, USA, 1957). Demonstrates the practice of sterile technique, emphasizing the importance of 3 rules - use only sterile equipment, keep equipment sterile while in use, and keep the area sterile. Shows sterilization of equipment by means of moist heat, dry heat, and chemicals, with particular emphasis on autoclaving, boiling, baking, and flaming methods. Depicts the proper use of sterile forceps

| Function: | Patient Care | |
|---|---|---|
| Knowledge/Skills: | Basic Nursing Techniques | A V Training Aids |

| | |
|---|---|
| (4) disposing of contaminated materials | and towels in handling sterile equipment, and explains the cleansing and protection of the area being treated. |
| (5) collecting laboratory specimens<br>(6) investigating outbreaks of hospital sepsis | Chain of Asepsis (29 min., sd., B&W, 16 mm, MP, 1944, USN, Produced by DeFrenes & Co.). Emphasizes the importance of sterile linens, pre-operative preparation of the patient, scrub technique, preparation of the operating room, and maintenance of the chain of asepsis. |
| | Disinfection of Clinical Thermometers, Part 1: Oral Thermometers (67 fr, sd., c., 35 mm (disc ls 12 in 33 1/3 pm 10 min) FS, 1952, USPHS). Demonstrates procedures to be followed in cleaning and disinfecting oral thermometers. |
| | Handwashing in Patient Care (15 min., sd., c., 16 mm, MP, 1961, USPHS). Demonstrates the importance of the conscientious practice of hand washing in order to avoid transmission of pathogens. |
| b. use surgical aseptic techniques in | |
| (1) application of dressings | Control of Infection in Surgical Dressing, Part III-Dressing Technique for Large Wounds, Particularly Burns (28 min., optical sound, color, 16 mm, 1949, Imperial Chemical #M 20). This part of the film demonstrates a unit at the Birmingham Accident Hospital designed specially to overcome airborne infection. Shots of models and actual layout show how the unit is ventilated and air treated before entering the unit. The efficacy of the air treatment and other precautions |

is demonstrated by means of the slit sampler, by which it is possible to estimate the bacterial purity of the air. Air samples taken in the unit are compared with those taken in other parts of the hospital. The film then demonstrates the technique of a dressing. The functions of each member of the team and the handling of the patient are clearly demonstrated. The film is concluded with some of the results. Recent scientific advances have made parts of this film somewhat out-of-date.

Control of Infection in Surgical Dressings, Part II, Dressing Technique for Small Wounds (18 min., optical sound, color, 16 mm, 1949, Imperial Chemical #M 19). A diagram demonstrates the sources of self-and cross-infections. This part deals with the treatment of relatively small wounds where the risk of airborne infection is not very great, the emphasis being placed on the risk of contact infections which can be prevented by a good aseptic dressing technic. This is first demonstrated by showing the technic for one nurse in a factory surgery, followed by the technic adopted for a team of nurses in a hospital outpatient department. Recent scientific advances have made parts of this film somewhat out-of-date.

(2) applying heat and cold

Therapeutic Uses of Heat and Cold. Part I: Administering Hot Applications (21 min., sd., B&W, 16 mm, Order No. OE 408, $37.00, USOE). Body reactions to heat; use of heat in the

Function: **Patient Care**

Knowledge/Skills: **Basic Nursing Techniques**

| | A V Training Aids |
|---|---|
| | alleviation of pain; how to apply hot water bottles, electric pads, chemical pads, and paraffin bath; use hot soak, compresses, infra-red lamp, and shortwave diathermy. |
| | Therapeutic Uses of Heat and Cold. Part II: Administering Cold Applications (22 min., sd., B&W, 16 mm, Order No. OE 409, $38.50, USOE). Body responses to cold; therapeutic uses of cold; how to administer contrast baths and ice bags; apply ice packs as anesthesia; and use refrigerating blankets and cold chamber. |
| (3) assisting the nurse and physician with sterile procedures | Basic Care of Patients-Part VII-Sterile Technique (13 min., sd., B&W, 16 mm, Order No. TF 8-2477, $23.75, USA). Sterilizing equipment with moist heat, dry heat, and chemicals - |
| (4) sterilization of equipment and supplies | Handling sterile equipment - Care of equipment when not in use - Keeping area being treated sterile. |
| 10. Diets | |
| a. basic nutrition and diet therapy | Feeding the Patient (15 min., sd., B&W, 16 mm manual MP, 1955, USOE with the cooperation of USPHS, produced by Willard Pictures). Describes factors which affect appetite and digestion; preparation of the environment and the patient for the meal; proper balance of food and arrangement of the tray; individualized feeding care; and factors to be considered in after-care of the patient. |

Function: Patient Care

Knowledge/Skills: Basic Nursing Techniques

| Knowledge/Skills | A V Training Aids |
| --- | --- |
| b. serve diets and feed patient | Basic Care of Patients - Part V- Feeding the Patient (8 min., sd., B&W, 16 mm, Order No. TF 8-2475, $14.25, USA). How corpsman prepares patient for meals, serves trays, assists semi-helpless and postoperative patients, and feeds helpless patients. |
| 11. Preoperative care<br>a. make and report observations<br>b. identify problems and needs<br>c. perform nursing care to meet problems and needs | Basic Care of Patients, Part VIII: Preoperative Care (9 min., sd., B&W, 16 mm, MP, 1957, USA). Describes the mental and physical care given the patient before surgery, defining the responsibilities of each member of the medical team - doctor, nurse, corpsman, and operating room specialist. Emphasizes the importance of allaying the patient's fears, and points out that the success of the surgery may depend on how well the patient is prepared for it. |
| d. perform administrative procedures related to preoperative care | Preoperative Care (16 min., sd., B&W, 16 mm, Order No. MN8576f, $28.50, USN). Presents the duties and responsibilities of hospital corpsmen in preparing a patient for surgery in the 16- to 24-hour period immediately preceding the operation. Demonstrates the specific procedure of checking for completion of laboratory work; supervision of patient's meal; intake of water and other liquids orally; administration of the cleansing enema; preparation of the skin at the operative site; administration of hypnotic the evening before surgery; provision of routine morning |

| Function: | Patient Care | |
|---|---|---|
| Knowledge/Skills: | Basic Nursing Techniques | A V Training Aids |
| | | care on day of surgery; and procedures to be accomplished immediately before patient is taken to surgery. |
| 12. Postoperative care | | Basic Care of Patients, Part IX: Postoperative Care (12 min., sd., B&W, 16 mm MP, 1957, USA). Describes the special care given the patient after surgery, and emphasizes that the patient's ultimate recovery may be dependent upon the proper techniques used by the corpsman and other members of the medical team during this phase. |
| a. make and report observations | | |
| b. identify problems and needs | | |
| c. perform nursing care to meet problems and needs | | Postoperative Care (14 min., sd., B&W, 16 mm, Order No. MN8576g, $25.50, USN). Describes the duties and responsibilities of hospital corpsmen in caring for a patient immediately after surgery. Depicts in detail the preparation of the bedside area; inspection of operative site for bleeding; observation and recording of temperature, pulse, respiration, and blood pressure; assisting the respiration of the patient, if necessary, including the technique of removal of an artificial airway; administration of medications for pain; assisting the patient to move in bed; assisting the patient to void; observation of patient for signs of any complication following the surgery; and general encouragement toward recovery. |

| Function: | Patient Care | |
|---|---|---|
| Knowledge/Skills: | Basic Nursing Techniques | A V Training Aids |

| | |
|---|---|
| 13. Blood and blood substitutes | |
| a. procedures for obtaining and giving blood | |
| (1) request typing and cross-matching | |
| (2) obtain blood from blood bank | |
| (3) assist with transfusions | |
| b. observe and report the condition of patient receiving blood and blood substitutes | |
| 14. Oxygen therapy and resuscitation | Oxygen Therapy-Theory and Procedure (23 min., sd., color, 16 mm, MP, 1962, USA). Describes the symptoms and effects of hypoxia and the treatment thereof by oxygen therapy. Methods, equipment, and procedures employed in the administration of oxygen therapy are highlighted. |
| a. operate oxygen equipment | |
| (1) tent | |
| (2) mask | |
| (3) catheter and cannula | |
| b. operate IPPB apparatus | Introduction to Prolonged Artificial Ventilation (38 min., sd., color, 16 mm, MP, 1962, USA). Teaches the principles of safe prolonged mechanical artificial ventilation, safe tracheotomy care, and transportation of the apneic patients. Demonstrates the differences between intermittent positive pressure ventilation and ventilation with the tank respirator. The techniques shown |
| c. operate oxygen analyzer | |
| d. operate mechanical suction equipment | |
| e. operate inhalator | |

Function: Patient Care

Knowledge/Skills: Basic Nursing Techniques

A V Training Aids

---

f. operate respirator

g. operate resuscitator

h. insert oral airway

include: monitoring of ventilation, the use of cuffed and uncuffed tracheotomy tubes, a "minimal leak" technique with cuffed tubes which permits the patient to talk, humidification of the inhaled air, sterile atraumatic tracheotomy care, artificial coughing and "sighing", change of posture, nursing care and transportation.

Nurse in Emergency Cardiopulmonary Resuscitation (15 min., optical sound, color, 16 mm, Cinema Pictures, Inc.). The film illustrates the nurse's function and responsibility in a hospital cardio-pulmonary resuscitation from the initiation of resuscitation through to the transfer of the patient to the care of the physician.

i. nursing care of patient with a tracheotomy

(1) suction patient

(2) clean inner cannula

(3) change dressings

(4) support medical nursing care plan

Use of Inhalation Therapy Equipment, Part I. Simple Application (29 min., optical sound, B&W, 16 mm, 1968, ##TF 8 3872, USA). Teaches medical technicians the proper procedures and associated safety precautions in the use of inhalation therapy equipment for patients who can breathe without assistance. Requirement for standard safety practices in handling compressed gases, and for asepsis in handling inhalation therapy equipment is under-scored. Steps in preparing and admin-istering the following items of inhalation therapy equipment are depicted: nasal cannula, nasal catheter, oxygen mask, oxygen tent, oxygen analyzer, croupette, and isolette. Special procedures for administering inhalation therapy equip-ment to the patient with a tracheotomy

Function: Patient Care

Knowledge/Skills: Basic Nursing Techniques

A V Training Aids

| | |
|---|---|
| | are demonstrated. Finally, use of emergency inhalation equipment in ambulances, dispensaries, and dental clinics is discussed briefly. |
| | Use of Inhalation Therapy Equipment, Part II, Intermittent Positive Pressure Breathing (28 min., optical sound, color, 16 mm, 1968, #TF 8-3873, USA). Teaches medical technicians the use of inhalation therapy equipment for intermittent positive pressure breathing in the treatment of patients who are unable to breathe without assistance. Design and operation of the Bennett Respirator, the Bird Respirator, and the Morch Respirator are described. A step-by-step demonstration is given to the procedures necessary to set up and put each unit into operation. Special safety precautions are pointed out. |
| 15. Administration of medications | Administration of Drugs (10 min., optical sound, B&W, 16 mm, 1957, AF #FTA 367). |
| a. give medications under the supervision of a nurse or physician | Demonstrates procedures for oral, rectal, and intravenous administration of drugs. |
| | Ounce of Prevention (27 min., optical sound, B&W, 16 mm, 1965, AMA #182, Amer. Hosp. Assoc.). The subject matter of this film is the prevention of errors in medication practice. The tone of the presentation is positive and straightforward. The principles of proper medication practice are presented without the details of a particular hospital routine. Five basic considerations for good medication practice are individually |

| | | |
|---|---|---|
| Function: | Patient Care | |
| Knowledge/Skills: | Basic Nursing Techniques | A V Training aids |
| | | discussed by a commentator, and clear examples of each are enacted in a hospital setting. The positive approach of the film is exemplified by these five basic considerations which are termed five rights of good medication practice -- right drug, right dose, right route, right time, and right patient. This film is highly recommended for students of nursing who have had some instruction in medication practice, as a useful tool for the inservice education of hospital nursing staff, and for all hospital personnel involved with medication practice. |
| | (1) oral | Oral Administration of Medications (14 min., sd., B&W, 16 mm, Order No. MN 8576j, $25.50, USN). Presents the duties of hospital corpsmen in administering medications by mouth to patients in wards of naval hospitals. Demonstrates in detail the preparation of medication and treatment cards in accordance with the orders of medical officers; the use of medication and treatment board as a convenient method for reminding personnel to administer medication at correct times; the preparation of specific doses of various types of oral medications; and the procedure to be followed when administering the medications to patients. |
| | (2) parenteral | Techniques of Parenteral Medication (25 min., optical sound, color, 16 mm, 1963, ANA-NLN, Becton Dickinson & Co., Inc.). Fundamentals in the administration of subcutaneous, |

intradermal, intramuscular and intravenous injections. Emphasis on principles involved, simplification and standardization of procedures. A teaching film of timely interest to nurses, as increased responsibility is being transferred to nursing by the medical profession for parenteral administration of medicants.

Needle Injections, Part I: Equipment and Medications (15 min., sd., B&W, 16 mm, MP, 1957, USN). Illustrates the purposes of needle injections, emphasizes the need for sterile techniques, and describes in step-by-step detail the preparation of equipment and of the various forms of medication used for injection. Shows cleaning up after the injection, and the recording of information on the patient's chart. Includes close-up photography.

| Knowledge/Skills | A V Training Aids |
| --- | --- |
| a. intradermal<br>b. subcutaneous<br>c. intramuscular<br>d. immunizations | Needle Injections, Part 2: Intradermal, Subcutaneous, and Intramuscular Injection Techniques (8 min., sd., B&W, 16 mm, MP, 1957, USN). Defines and demonstrates intradermal, subcutaneous, and intramuscular injections, using art work and live photography. Shows each procedure by steps, then repeats it as a single action for review. |

Technique and Sites for Subcutaneous and Intramuscular Injections (31 min., sd., B&W, 35 mm, FS, 1954, USA). Illustrates approved medical procedures for administering subcutaneous and intramuscular injections, various types of hypodermic equipment and their application, and the necessity of following prescribed procedures for the safety and health of patients.

| Function: Patient Care<br>Knowledge/Skills: Basic Nursing Techniques | A V Training Aids |
|---|---|
| (3) sublingual | |
| (4) rectal | Basic Care of Patients-Part VI-The Enema (10 min., sd., B&W, 16 mm, Order No. TF 8-2476, $17.50, USA). Proper way to administer cleansing enema - Preparation of equipment and solution - Preparation of patient - Administering the enema - After-care of patient and equipment - Observation of results. |
| b. Intravenous medications and fluids<br>(1) assist with procedures<br>(2) observe patient during therapy | Intravenous Administration of Fluids (18 min., sd., B&W, 16 mm, Order No. MN 8576-e, $32.00, USN). Describes the responsibilities of hospital corpsmen and demonstrates the specific procedures that they must follow when preparing a patient and in assisting the medical officer to administer large doses of fluids to patients in naval hospitals.<br><br>Intravenous Fluid Infusion, Basic Theory and Practice (27 min., optical sound, color, 16 mm, 1968, Abbott Labs, ANA-NLN, LaRue Films, Inc.). The first part of this film is devoted to the theory and rationale for fluid therapy. This part of the film explains the water content of the human body. Electrolytes are defined and related to their role in maintaining the body's fluid and chemical equilibrium. The delicate balance between acidity and alkalinity with various disturbances to this equilibrium are illustrated. The necessity for correcting such fluid and electrolyte disturbances is stressed. The second part of the film shows the actual administration of intravenous fluids. The proper handling and |

Function: Patient Care

Knowledge/Skills: Basic Nursing Techniques

A V Training Aids

assembling of IV administration set is followed by a detailed step-by-step needle venipuncture using a hospitalized patient.

Needle Injections, Part 3: Intravenous Needle-Injection Technique (5 min., sd., B&W, 16 mm, MP, 1957, USN). Demonstrates in detail the technique of I-V injection, using art work and live photography. Shows the medical officer and corpsman working as a team, and makes the point that the doctor performs the actual insertion except when the corpsman is called upon to do so in an emergency.

| Function: | Patient Care | |
|---|---|---|
| Knowledge/Skills: | Special Nursing Techniques | A V Training Aids |

| | |
|---|---|
| 1. Care of patients with maxillo-facial injuries | |
| 2. Care of patients with dermatological disorders | |
| 3. Care of patients with cardiovascular, lymphatic and blood disorders | Care of the Cardiac Patient (33 min., sd., B&W, 16 mm, Order No. OE 419, $56.75, USOE). Nursing care given a cardiac patient, including comfort, rest, sleep, diet, feeding, elimination, cleanliness, and diversional and occupational therapy.<br><br>Introduction to Nursing in a Coronary Care Unit (20 min., sd., color, 16 mm, Order No. M-1461, $88.00, NMAC). Demonstrates the nurse's role in the care of the coronary patient. Includes lifesaving procedures which should be used before the doctor arrives and explains electronic equipment which can determine the type of heart attack the patient is having. |
| a. perform diagnostic, therapeutic, and special nursing procedures<br><br>(1) apical-radial pulse<br><br>(2) electrocardiograph | Nursing Care: The Cardiac Patient (23 min., sd., color, 16 mm, MP, 1966, USN). Illustrates the hospital corpsman's part in the care of a patient suffering from a myocardial infarction, covering such details as frequent taking of vital signs, administration of oxygen, awareness of effects of anticoagulant therapy, bathing, feeding, assistance and observation during patient's gradual recovery. Particular attention is given to the importance of charting and to the corpsman's attitude and manner toward the patient. |
| 4. Care of patients with orthopedic disorders | |

| Function: | Patient Care | |
|---|---|---|
| Knowledge/Skills: | Special Nursing Techniques | A V Training Aids |

a. perform diagnostic, therapeutic, and special nursing procedures

(1) apply and remove plaster casts

(2) apply traction devices

(3) apply orthopedic appliances including crutches

5. Care of patients with urological disorders

a. perform or assist with diagnostic, therapeutic and special nursing procedures

(1) catheterization

(2) irrigation

(3) operate drainage equipment

(4) cystoscopy

Catheterization Technique (18 min., sd., c., 16 mm, MP, 1961, USA). Describes the anatomy and physiology of the urinary tract, and outlines clinical indications for catheterization of the urinary bladder. Shows the equipment required, sterile precautions to be followed, and the technique for catheterizing a male patient using the standard red rubber catheter; illustrates the use of the Foley catheter for continuous drainage of the bladder.

Use of the Condom Appliance for the Incontinent Patient (8-1/2 min., sd., color, 16 mm, Order No. M-1335, $29.25, NMAC). Presents in detail the assembly and application of the condom appliance, which provides a means whereby the incontinent male

Function: Patient Care

Knowledge/Skills: Special Nursing Techniques — A V Training Aids

---

patient can be kept dry without the use of an indwelling catheter.

Nursing Care of Urinary Drainage (13 min., sd., color, 16 mm, 1969, Davis and Geck #CS-1046). The film discusses the reason for care in urinary catheter drainage and demonstrates a good technique for use with both male and female patients.

6. Care of patient with gastro-intestinal disorders

   a. perform or assist with diagnostic, therapeutic, and special nursing procedures

      (1) gastric suction

      (2) enemas

Basic Care of Patients. Part VI: The Enema (10 min., sd., B&W, 16 mm, MP, 1957, USA). Explains that the enema treatment is given on the doctor's orders and should be performed with care and precision. Demonstrates the procedure to follow in administering the cleansing enema.

Enemas (20 min., sd., B&W, 16 mm, MP, 1944, Produced by Chicago Film Lab, USN). Discusses two main types of enemas, retention and evacuant; demonstrates the procedure for giving them and the after care of the patient and equipment.

      (3) gastric analysis

      (4) sigmoidoscopy

      (5) radiographic studies

| | | |
|---|---|---|
| Function: | Patient Care | |
| Knowledge/Skills: | Special Nursing Techniques | A V Training Aids |

7. Care of patients with neurological disorders

   a. perform or assist with diagnostic, therapeutic, and special nursing procedures

      (1) turning frames — Use of Turning Frames (35 min., sd., B&W, 16 mm, MP, 1966, USA). Teaches nursing personnel the clinical requirement for and proper use of turning frames. Physiological reasons for the use of turning frames for patients with spinal cord injuries or other conditions requiring immobilization are stressed, namely the prevention of decubitus ulcers, respiratory complications, and kidney complications. Improvisation and use of turning frames in the field are illustrated. Features and use of the standard Stryker, Foster and Circo-Electric frames in military hospitals are depicted in turn. Throughout, emphasis is placed on the importance of proper positioning and care of the patient on the frames; and correct turning procedures.

      (2) lumbar punctures — Lumbar Puncture (13 min., sd., B&W, 16 mm, Order No. MN 1511-n, $23.75, USN). Shows how to prepare a patient for a lumbar puncture; indicates the position of the patient; describes the operation; and by animation demonstrates what happens when the injection is made.

8. Care of patients with metabolic disorders — Nursing Care: The Diabetic Patient (29 min., sd., color, 16 mm, MP, 1966, USN). Explains the sugar-insulin imbalance which is diabetes mellitus.

   a. test urine

Function: Patient Care

Knowledge/Skills: Special Nursing Techniques

A V Training Aids

---

Illustrates, for the hospital corpsman, five points in the care of the diabetic patient: testing of urine, administering of insulin, proper diet, regulated physical activity and proper personal hygiene. Particular attention is given to accuracy in testing urine, administering insulin and to helping the patient learn self-care.

9. Care of patients with EENT disorders

   a. perform and assist with special nursing procedures

      (1) irrigations

      (2) compresses

      (3) instillations

      (4) dressings

Ear, Nose and Throat Treatments (15 min., sd., B&W, 16 mm, Order No. MN 8576-i, $27.00, USN). Explains the duties and responsibilities of hospital corpsmen in providing certain simple treatments for the ear, nose and throat as ordered by medical officers, for patients in wards of naval hospitals. Depicts in detail the following treatments: instillation of ear drops; irrigation of the ear; instillation of nose drops; application of a nasal spray; application of a throat spray; and irrigation of the throat.

Surgical Nursing Care of the Eye Patient. (22 min., optical sound, color, 16 mm, 1963, Davis and Geck #ECS-765). The eye nurse is an important part of the eye surgical team. She must have certain abilities innate in any surgical nurse, but specialized in this field. She must have a thorough knowledge of the anatomy and physiology of the eye — must know eye instruments and their special care — and must be familiar with the technic of the operation. In many hospitals without residents she acts as the first assistant to the ophthalmic surgeon.

Function: Patient Care

Knowledge/Skills: Special Nursing Techniques

| | A V Training Aids |
|---|---|
| 10. Care of pediatric patients | |
| 11. Care of geriatric patients | Years for Living-Changing Concepts in Care for the Aging (27 min., sd., B&W, 16 mm, Sandoz Pharmaceuticals ##GER-1). The number of patients over 65 requiring effective and long lasting management of their health problems is increasing daily. This film describes and explains a series of varied but inter-related concepts which are essential for both understanding and dealing with the problems of the aging patient. The film centers upon the essential planning and teamwork effort that the family physician and his colleagues in the paramedical professions must provide in order to deal with the progressive infirmities of old people. The nursing home is no longer considered a dead end for the elderly but rather a goal directed therapeutic facility where many of its patients are treated and rehabilitated for return to their families and communities. The basic role that all types of paramedical personnel exercise in the running of a successful and modern nursing home is presented. |
| 12. Care of patients with mental disorders<br>a. apply restraining devices | Psychiatric Nursing: The Nurse-Patient Relationship (34 min., sd., B&W, 16 mm, MP, 1958, Smith Kline and French Labs and ANA-NLN Film Svc, USA). Discusses principles in psychiatric nursing, emphasizing the importance of the therapeutic nurse-patient relationship in the care and treatment of the mentally ill. Describes the importance of the nurse's acceptance of patient behavior, and explains that the nurse, as a person, can help a mentally ill patient bridge the gap from her own world to reality. |

Function: Patient Care

Knowledge/Skills: Special Nursing Techniques

A V Training Aids

---

A Positive Approach to the Psychiatric Patient (30 min., sd., B&W, 16 mm, $52.00). Shows the treatment in Veterans Administration hospitals for psychiatric patients who have emerged from acute episodes of mental illness but who are not yet well enough to leave the hospital. Uses a hospital ward unit as the focal setting, and stresses the roles of the nurse, aide, and physician.

Nurses Day with the Mentally Ill (22 min., sd., color, 16 mm, 1954, PCR # PCR 2042K). Shows typical activities of a student nurse in a modern psychiatric hospital. Reassuring and supporting roles explained and demonstrated. Nursing care in connection with the shock therapies illustrated. Nurses part in a lobotomy operation is shown. Examples of the didactic training of nurses are given. The film includes many spontaneous examples of the behavior of the mentally ill.

13. Care of patients with infectious and parasitic disorders

Isolation Technic (24 min., sd., B&W, 16 mm, MP, 1960, produced by Willard Pictures, USN). Demonstrates how to perform medical aseptic techniques when caring for a patient with a communicable disease. Shows how to set up an isolation unit, how to organize the work, when to wash the hands, how to remove and clean items used in the unit. Concludes with a short summary of basic principles to be observed when caring for a patient in isolation.

Function: Patient Care

Knowledge/Skills: Special Nursing Techniques — A V Training Aids

---

| | |
|---|---|
| 14. Care of burned patients | Management of Burns. Part 1: Supportive Care (18 min., sd., c., 16 mm, MP, 1958, USA). Explains the diagnosis, care and treatment of patients suffering from burn injuries. Describes how to make an accurate appraisal of injury, how to administer sedation and how to establish the venous life line; gives requirements for tracheotomy and for maintaining the patient's urinary output; demonstrates planned fluid therapy and the use of hematocrit to determine relative amounts of plasma and corpuscles in blood. |
| | Management of Burns. Part 2: Local Care (15 min., sd., c., 16 mm, MP, 1958, USA). Describes procedures followed in the dressing and operating rooms, including cleansing the wound, debridement of the skin, occlusive dressing treatment, air treatment and skin grafting. Emphasizes the importance of preventing contamination of the wound. |
| | Management of Burns. Part 3: Skin Grafting (21 min., sd., c., 16 mm, MP, 1959, USA). Depicts the operative care given to burn patients undergoing skin grafting of limbs, hands and body areas. Illustrates and explains various techniques and methods of grafting, including removal of devitalized tissue, preparation of granulated area for grafting, selection and preparation of donor site, removal of skin from donor site, grafting on recipient area and dressing the wound. |

Function: Patient Care

Knowledge/Skills: Special Nursing Techniques

A V Training Aids

---

Management of Burns, Part 4: Rehabilitation (9 min., sd., c., 16 mm, MP, 1959, USA). Describes the rehabilitation care given to burn patients to obtain maximum usage of damaged areas and prevent contracture: optimum nutrition, hydrotherapy, infra-red light and ultra-violet light treatment, massage, active and passive exercise, functional retraining and occupational therapy.

Early Management of the Severely Burned Patient (30 min., sd., c., 16 mm, MP, 1956, American Cyanamid Co. Surgical Products Div., USA). Presents the important steps in managing the severely burned patient. Discusses the prevention of infection and the treatment of shock, demonstrates the technique of the initial treatment of the burned surface and the application of occlusive, absorptive dressings and shows interim care to the time of the first grafting. Professional use only.

Early Intensive Therapy-Burned Hands (15 min., sd., c., 16 mm, MP, 1966, USA). Depicts the treatment and early intensive therapy of patients with burned hands as performed at the Brooke Army Medical Center, Fort Sam Houston, Texas. Shows how first, second, and third degree burns are handled to gain maximum degree of function in the shortest possible time. Salient teaching points cover: diagnosis of depth of burn, surgical excision of burned skin, skin grafting, and dynamic therapy. Therapy phase, splinting, exercise hydrotherapy, and functional therapy are shown.

| | | |
|---|---|---|
| Function: | Patient Care | |
| Knowledge/Skills: | Special Nursing Techniques | A V Training Aids |

15. Care of obstetrical and newborn patients

| | |
|---|---|
| a. assist physician with deliveries | Maternity Care: Labor and Delivery (38 min., sd., c., 16 mm, MP, 1964, USN). Depicts events occurring during labor and delivery to help the pregnant woman understand how she can contribute to her own comfort and her baby's safety. The film is designed to minimize and possibly eliminate the apprehension normally experienced by primiparas. Art work is used to differentiate false from true labor, explains what happens to the cervix and uterus during labor, and describes the usual signs which portend the start of labor. |
| | Emergency Childbirth. (21 min., sd., c., 16 mm, MP, 1961, USN). This film is designed to prepare corpsmen psychologically and technically to render necessary assistance in the emergency delivery of a baby. It presents the indications when delivery is too imminent to risk transportation to a hospital, the detailed procedures to follow, cautions to be observed in the actual delivery, and the care of mother and baby immediately following delivery. |
| b. prenatal and postnatal care of mother | Postnatal Care. (12 min., sd., B&W, 16 mm, MP, 1952, Medical Films - later name Medical Arts Productions, USA). Shows a mother in the hospital room doing exercises, caring for baby, nursing, etc. Discusses father's relation to new situation and portrays joy to be found in the new family pattern. Diagrams show how mother's body returns to normal. |

Function: Patient Care

Knowledge/Skills: Special Nursing Techniques — A V Training Aids

---

Prenatal Care. (23 min., sd., B&W, 16 mm, MP, 1952, Medical Films - later name Medical Arts Production, USA). Through the prenatal care of three pregnant women, this film tells the need of medical examination and care, discusses correct diet, presents exercises for daily use, shows proper clothing, etc.

c. nursing care of infant

d. operate incubators

16. Care of patients with gynecological disorders

    a. perform or assist with diagnostic, therapeutic and special nursing procedures

        (1) vaginal examinations

        (2) Papanicolaou smear

        (3) vaginal irrigation

17. Care of patients with pulmonary disorders

    a. perform or assist with diagnostic, therapeutic, and special nursing procedures

Chronic Obstructive Pulmonary Disease: Breathing Patterns (5 min., sd., color, 16 mm, Order No. M-1569, $18.00, NMAC). Shows patterns of breathing and how to teach them to a patient with chronic obstructive pulmonary disease.

Chronic Obstructive Pulmonary Disease: Diaphragmatic Breathing (6-3/4 min., sd., color, 16 mm, Order No. M-1571, $24.50, NMAC). Shows method for correcting faulty breathing patterns of the patient with chronic obstructive pulmonary disease with the ultimate goal of restoring normal use of the diaphragm.

| Function: | Patient Care | |
|---|---|---|
| Knowledge/Skills: | Special Nursing Techniques | A V Training Aids |
| | | Chronic Obstructive Pulmonary Disease: Intermittent Positive Pressure Breathing (6 min., sd., color, 16 mm, Order No. M-1570, $21.25, NMAC). Explains how to teach a patient with chronic obstructive pulmonary disease to use a mechanical respirator as an adjunct to the total respiratory rehabilitation program. |
| | | Chronic Obstructive Pulmonary Disease: The Use of Oxygen in Physical Therapy Management. (5-3/4 min., sd., color, 16 mm, Order No. M-1572, $21.51, NMAC). Shows how various machines, depending on the particular need, are used to supply oxygen to the patient with chronic obstructive pulmonary disease. |
| | (1) sputum collection | |
| | (2) gastric washings | |
| | (3) closed chest drainage | |
| | (4) thoracentesis | Thoracentesis (20 min., sd., c., 16 mm, MP, 1963, USA). |
| | (5) postural drainage | |
| 18. | Care of very seriously ill patients | Intensive Care in Critical Illness. (29 min., sd., c., 16 mm, 1968). The film outlines the scope and development of intensive care, and illustrates the specific methods used in the assessment and treatment of critically ill patients. |
| | | Intensive Care (18 min., sd., color, 16 mm, Order No. M-693, $61.75, NMAC). Explains establishment and operation of an intensive patient care ward in the hospital. Gives a detailed |

description of the intensive care room and its relation to progressive patient care. Covers the flexibility of the units, the skilled staff which operates the unit, and some of the administrative policies.

Nursing Management of the Patient with Cancer. (29 min., sd., c., 16 mm, 1966, Amer. Cancer Society #3759). Three essential factors of life - breathing, nourishment, and elimination - are considered in relation to the patient being treated for cancer of the larynx, colon, or urinary bladder. Notation is made at the beginning of the film that principles of nursing care are universal and that techniques may vary. However, techniques are developed and receive the major emphasis in the film. Diagrams of normal and altered anatomy, and then, demonstrations in actual patient situations are used to illustrate nursing care involved in each of the factors. This film is recommended for showing to nurses, nursing students, practical nurses, and occupational therapists.

| | |
|---|---|
| 19. Care of patients with chronic diseases | Chronic Bronchitis and Pulmonary Emphysema. The Application of Physical Medicine and Rehabilitation: Part 1. (29 min., sd., c., 16 mm, MP, 1965, USPHS in cooperation with the Institute of Physical Medicine and Rehabilitation, NYU, USA). Reviews the physiology and pathology of chronic bronchitis and pulmonary emphysema. Describes and demonstrates equipment and diagnostic techniques used in the management of the patient. |

Function: Patient Care

Knowledge/Skills: Special Nursing Techniques — A V Training Aids

| | |
|---|---|
| | Chronic Bronchitis and Pulmonary Emphysema. The Application of Physical Medicine and Rehabilitation: Part II. (24 min., sd., c., 16 mm, MP, 1964, USPHS in cooperation with the Institute of Physical Medicine and Rehabilitation, NYU Medical Center, USA). Gives results from a study concerning treatment and rehabilitation of patients with chronic bronchitis and emphysema. Discusses postural drainage, breathing exercises, and usual clinical methods which can increase patient's tolerance to daily activities and permit him to return to vocational pursuits. |
| 20. Prepare patient for aeromedical evacuation<br>a. patient care<br>b. prepare medical records, supplies, and equipment for air evacuation | Aeromedical Evacuation System (25 min., sd., c., 16 mm, MP, 1962, USAF). Portrays mission of Aeromedical Evacuation System. Depicts care used in preparing patients for air evacuation and outlines procedures for reporting them to military regulating agency. Points out administrative steps and professional requirements necessary to process patients and care for them in flight. |

## APPENDIX B

### ON-GOING PHYSIOLOGIC MONITORING APPLICATIONS

The following table illustrates the on-going developments of practical monitoring systems. The examples are not listed in order of importance or functional performance.

<u>Surgery and Anesthesia</u>

EKG Monitors
Blood Pressure Monitor
Blood Gas Monitor
Respiratory and Anesthesia Gas Analyzers
Temperature Monitor
EEG Monitor
Pain Threshold Monitor
Blood Loss Monitor

<u>Cardiac Laboratory</u>

EKG Monitors
Blood Pressure Monitor
Cardiac Output Monitor
Blood Gas Monitor
Oxygen Uptake Monitor
Respiratory Exchange Ratio Monitor

<u>Pulmonary Laboratory</u>

Blood Gas Monitor
Respiratory Gas Monitor
Respiratory Flow Rate and Volume Monitor
Airway Resistance Monitor
Lung and Thoracic Compliance Analyzer

<u>Coronary Care</u>

EKG Analyzer (Arrhythmia Monitor)
Blood Pressure Monitor
Blood Gas Monitor
Cardiac Output Monitor

Intensive Care

Arrhythmia Monitor
Blood Pressure Monitor and Pulse Analyzer
Blood Gas Monitor
Respiratory Gas Monitor
Temperature Monitor
Blood Volume Monitor
Cardiac Output Monitor
Respiratory Flow Rate and Volume
Airway Resistance Monitor
Lung and Thoracic Compliance Monitor
Respiratory Rate Monitor
Blood Electrolyte Monitor
Urine Flow Rate
Work of Breathing Monitor
Oxygen Uptake Monitor
Respiratory Exchange Ratio Monitor

## APPENDIX C

## TERMS AND DEFINITIONS

| | | |
|---|---|---|
| 1. | BLHCS | Base Level Health Care System |
| 2. | CAI | Computer Assisted Instruction |
| 3. | CCTV | Closed Circuit Television |
| 4. | COM | Computer Output Microfilm |
| 5. | CONUS | Continental United States |
| 6. | CPU | Central Processing Unit |
| 7. | CRT | Cathode Ray Tubes |
| 8. | CSSD | Central Sterile Supply Department |
| 9. | DAIRS | Dial Access Information Retrieval Systems |
| 10. | DDD | Direct Distance Dial |
| 11. | DNA | Desoxyri bonucleic acid |
| 12. | DNA | Diversified Numeric Applications |
| 13. | DOS | Disc Operating System |
| 14. | ECG | Electrocardiogram |
| 15. | EKG | Electrocardiogram |
| 16. | HEW | Health, Education, and Welfare |
| 17. | HVAC | Heating, Ventilation, and Air Conditioning |
| 18. | ID | Identification |
| 19. | I/O | Input/Output |
| 20. | ICU | Intensive Care Unit |
| 21. | IV | Intravenous |
| 22. | LSI | Large Scale Integration |
| 23. | MBM | McKee - Berger - Mansueto |
| 24. | MISP | Medical Information System Processor |
| 25. | OB-GYN | Obstetrics-Gynecology |
| 26. | OCR | Optical Character Readers |
| 27. | OS | Operating System |
| 28. | R&D | Research and Development |

TERMS AND DEFINITIONS (cont'd).

| | | |
|---|---|---|
| 29. | REACH | Real-Time Electronic Access Communications for Hospitals |
| 30. | RTKL | Rogers, Taliaferro, Kostritsky, and Lamb |
| 31. | SOA | State of the Art |
| 32. | THIS | Total Hospital Information System |
| 33. | VA | Veteran's Administration |