An automated dental epidemiology system was designed for installation at the Naval Regional Dental Center, Great Lakes, IL, as an ongoing information system development and test project. In this design three data entry sites serve a high volume inprocessing clinic, and two large definitive care clinics. Data from the inprocessing clinic establishes individual electronic dental records which are updated as treatment is received. Hard copy dental records are produced, as are routine reports detailing individual and group dental treatment needs. Treatment provided information is recorded in chronology files and analyzed for service evaluation and productivity determinations. Rapid data entry techniques save considerable clinician time, thus providing increased time for treatment of oral diseases. The electronic files developed are expected to be a comprehensive and timely source of information for sophisticated management and administrative systems.

**Background**

The Navy Dental Corps has been tasked as the lead agency of the Department of Defense to conduct research in oral diseases and dental emergencies. Investment in such research has the potential for considerable return through reduction of both dental morbidity levels and the incidence of dental emergencies in military forces. Readily apparent benefits include reductions in the time and expense involved in dental treatment and patient time lost from military duties. Military dental treatment can thus be expected to become more cost-effective; the potential contribution to enhanced operational sustainability, readiness and mission performance is apparent.

To conduct research in these task areas involves extensive use of dental epidemiology. The incidence of caries and periodontal disease continues to be of concern to the Navy, especially relative to the efficacy of improved preventive dentistry programs. Comprehensive epidemiology information to predict the risk of dental emergencies in Naval and Marine Corps personnel is required to reduce the incidence and detrimental effects of these events in the field and afloat.

A preliminary investigation that was conducted at the Naval Dental Research Institute (NDRI) revealed that major improvements in Navy dental epidemiology could be obtained. In this study, the effects of dental emergencies in military forces were summarized and the potential uses of timely, comprehensive epidemiology information were determined. A review of civilian and military developments in automated data processing applications to dentistry, dental service management and dental epidemiology was performed. This study determined that these benefits could be best realized through a fully automated dental epidemiology information system. This investigation indicated that routine epidemiology reports generated by this approach would be valuable for local dental clinic management and for regional administration.

On a larger scale, the information developed by this approach would likewise be valuable for Dental Corps administration, particularly in service planning and evaluation. An automated dental epidemiology system would also be an excellent information source for a dental Management Information System (MIS) concentrating in the supply, fiscal, maintenance and personnel areas of Navy Dental Corps administration. This system could also provide long-term treatment information to evaluate dental materials, devices and techniques. Such information, used to enhance dental treatment efficacy, would be available to a degree of comprehensiveness and on a scale not obtainable in the civilian sector.

**Analysis**

During the first quarter of FY 1983, a requirements-oriented systems analysis was conducted at the Naval Regional Dental Center (NRDC), Great Lakes, using established techniques. The objective of this analysis was to gather sufficient information to enable the design of a flexible, high-utility and user-oriented automated system. Several guidelines for this analysis were established. Though intended to be developed within the existing organizational structure and operations of the regional dental center, an open-ended design philosophy would permit implementation at other Dental Corps facilities without a major redesign effort. It was deemed imperative that system implementation not adversely affect clinical operations. Where possible, priority development was undertaken of those specific applications requested by NRDC personnel to directly assist management and clinical operations. The information gathering techniques used were personnel interviews, group discussions, observations,
participatory exercise, and document review. Extensive use was made of experience obtained and information developed from previous data processing and systems analysis projects.7,8

Dental service in each of the three main clinics was characterized as groups of procedures, composed of a group or sequence of individual tasks. Relationships among procedures and tasks within and between clinical facilities were determined. Work distribution, time expenditure and personnel requirements were determined for those existing procedures and tasks within the scope of this study.

The three main clinics studied included a high volume personnel inprocessing clinic and two large dental treatment clinics. At the inprocessing clinic, 100 to 400 personnel per day receive dental screening examinations. Five dental officers are normally assigned to screening examination duties and each is assigned a dental assistant to record examination findings on a standard dental chart. Patients each require 5 to 8 minutes for examination, charting, record review and treatment planning. Screening examinations require from 20 to 100 separate data entries per transaction. Flow of the inprocessing procedure is illustrated in Figure 1.

![Figure 1. Information Flow in Dental Screening Examinations](image)

Figure 1. Information Flow in Dental Screening Examinations

- Health History Screening
- Dental Radiographs
- Oral Screening Examination With Charting
- Additional Radiographs as Required
- Case Review and Treatment Planning
- Record Complete

Treatment is provided at the inprocessing clinic by an additional five dental officers working in a separate, centralized mini-clinic. Dental care delivery at each of the two main treatment clinics is provided by 30 to 36 dental officers. Information flow is functionally equivalent for treatment delivery procedures at all three clinics, as illustrated in Figure 2. The density of data entries and transactions is considerably lower in the treatment clinics compared to that in the inprocessing clinic.

![Figure 2. Information Flow in Dental Treatment Provision](image)

Figure 2. Information Flow in Dental Treatment Provision

Appoint/Select Patient
Assign Patient for Treatment (Route Record)
Provide Treatment
File Record Reappoint Patient as Required
Release Patient

The requirements approach was used to specify the essential features and operational characteristics for the system. Immediate and future operational requirements were determined, as were project management requirements. The immediate operational requirements identified included the generation of routine dental epidemic reports to enhance local clinical service planning and evaluation, and the reduction of time spent by clinical professionals in performing clerical tasks. The primary managerial requirements were to maintain system economy and provide for non-disruption of clinical operations during implementation. Technical aspects considered were system organization, equipment capabilities and availability, data handling characteristics and implementation methods. On an experimental basis, an additional requirement was specified: to scientifically evaluate numerous devices for dental data capture in the clinical environment.

Functional Design

The functional design was constructed as a conceptual overview of the system, with components arranged to provide a logical progression of information processing from input through output. A structured design process was selected to facilitate system design. The overall system concept was established and major components identified. A functional design was then developed by matching data processing technology to system requirements.

Because of the diversity of clinic operations, the differences in amount of transactions conducted, and the separate locations of regional center facilities, a mix of centralized and distributed processing was selected. For the inprocessing clinic, characterized by high trans-
action rates in peak data entry periods, multiprocess- ing on-line using the Great Lakes Data Auto-
mation Facility (NAVDAF) center was found to be
appropriate. For the two large dental treatment
clinics, with their relatively low rate of continu-
ous data entry transactions, stand-alone micro-
computers with end-of-day communication to the data
processing center were found to be a more cost-
effective solution. For epidemiologic research
and system monitoring purposes, a small business
microcomputer was planned for installation at the
Naval Dental Research Institute. Figure 3
illustrates the design layout for this network.

At the inprocessing clinic, provision was made
for installation of a touch-screen monitor in each
of the five dental screening examination stations.
These terminals were dedicated to screening exami-
nation data capture, examination review and edit-
ing, and treatment planning operation. A master
controller, and a CRT/keyboard terminal was allo-
cated to the records preparation area, where a high
speed printer would be used to prepare specially
designed dental charts and the required routine
management reports. An American Bell AIS Dataspeed
4540 network was selected for this operation.
Communication to the data processing center was

FIGURE 3. DENTAL EPIDEMIOLOGY SYSTEM FUNCTIONAL DESIGN

SCREENING EXAMINATION

TOUCH-SCREEN TERMINALS

DATA LINE

NAVDAF IBM 4341

VIA TTY MODEM

CP/M

LS PRINTER

10-MEG

NDRI MICROCOMPUTER

TREATMENT CLINIC MICROCOMPUTERS

CP/M

LS PRINTER

DATA CAPTURE DEVICES

CP/M

LS PRINTER
designed using Dataphone II modems and a private line between the clinic and the NAVDAF facility. A touch-screen monitor and low-speed printer were selected for treatment data entry at the mini-clinic area: treatment information would be entered into the system and printed directly onto each patient’s dental treatment record.

A Z-80 based microcomputer operating CP/M was selected for installation at each of the two large dental treatment clinics. An asynchronous TTY protocol ASCII modem would provide data communications to the data processing center. The microcomputer option was selected to provide a test bed for both remote processing and non-online data communications concepts, and to evaluate a variety of data capture devices for dental information in the clinical environment.

For epidemiologic research and system monitoring functions, a Z-80 based CP/M small business microcomputer was selected. A 10-megabyte hard disk unit was included in the design to provide primary data storage for scientific studies. All applications programs for both the central processing facility (NAVDAF) and the microcomputer installations were custom designed in ANS COBOL. Centralized data processing at NAVDAF, using an IBM 4341 computer, was selected based on mass data storage, availability of high speed utilities, ability to provide rapid response terminal operation support, and the potential use of existing electronic files for additional applications such as the Navy Preventive Dentistry Program.11

Implementation by phases was selected to minimize disruption of regional center clinical operations. Initial installation was specified for the inprocessing clinic, with subsequent installation of the microcomputer stations in the two treatment facilities. During installation, applications program development was undertaken at the Naval Dental Research Institute. A phased implementation, which provided for debugging on-line operations prior to completed installation was found to be ideal.

References


7. Diehl, M. E.: Independent research project on dental clinic automation conducted during 1981-82 under the guidance of D. J. Forrest, Director, Data Processing Service Center, USNS Rota Spain.


