A MICRO-BASED COMPUTER MAPPING SYSTEM:

An Application in Health Planning

Edward M. Bosanac
Office of Health Services Research
Department of Community Medicine
West Virginia University
Morgantown, WV 26505

William Detweiler
Office of Health Services Research
Department of Community Medicine
West Virginia University
Morgantown, WV 26505

Bruce L. Palmer
West Virginia Network for
Educational Telecomputing
Morgantown, WV 26505

I. Introduction

The delivery of health services in rural areas has been a problem in this country since at least the early 1900's. In 1924, a study of physician distribution indicated that: "The problem of rural medical service may be regarded as a problem of supplying medical services for towns of less than 2,500 inhabitants and...villages of less than 1,000 inhabitants"[1]. Currently, planners are still wrestling with this same problem.

In West Virginia, the development of rural primary care clinics has been seen as a means of solving the physician shortage in rural areas. Since 1972, nearly 50 new primary care clinics have been developed. During the early stages of this activity, site selection was not very critical since the void was quite large. As development continued, however, increasingly marginal sites were selected. Competition arose among clinic developers, and in one

[1] Mayers, Lewis and Harrison, Leonard V., The Distribution of Physicians in the United States. New York, New York: General Education Board, 1924.

case resulted in the construction of two clinics literally across the street from one another, both supported by public funds. Plans which would have resulted in a similar situation were underway in several other areas. Clinic financial problems associated with small caseloads, large complements of staff, and broad ranges of services were ultimately passed on to the payers of health services. Several clinics experienced costs-per-encounter in excess of $70. The long-term viability of such clinics was tenuous.

Within this environment, the Southern West Virginia Primary Care Study Group formed in the Fall of 1976 with a primary mission of injecting a strong dose of rational analysis into the rural primary clinic development process. The Study Group established a voluntary review process whereby prospective clinic developers would present their clinic proposal to the group, which, in turn, would provide feedback to the developers concerning the adequacy or appropriateness of site selection, scope of services, staffing patterns, building plans, financing and other factors. A demographic-primary care profile was developed to support these reviews.

The profile, a 27-page document, is a combination of maps and tables which: 1) Identify the number and characteristics of the people who reside in a service area, and provides comparisons to a larger subcounty region, the county(s) in which the area is located, and the state. 2) Project medical service demand for the service area population based on 14 different sets of criteria. 3) Identify available third-party coverage for ambulatory care in the area—specifically, United Mine Workers of America Health and Retirement Funds and Medicaid. 4) Identify primary care personnel available within the service area and compare that supply with resources available with 15- and 30-minute driving times of the proposed site as well as with the larger health service region within which the area is located. 5) Provides detailed maps of highways, population density, primary care resources, and existing patterns of medical care.

Originally, the profile was produced manually, with very little computer assistance. It cost 21 man-days, including basic development costs. With table formats and production processes established, the profile costs were reduced to ten man-days. The development of the computer system for construction of all tables required approximately two months. A profile could then be put together in about three days, with the vast majority of the time being spent in map construction. In view of the size of the staff and other contractual obligations, office personnel realized that computer graphics were a more suitable means of producing maps.

In view of this and several other applications, the Office, which had pioneered computer-based health information systems in West Virginia, decided to undertake the development of a computer graphics systems which would include maps, charts, and graphs. The move into graphics was further prompted by increased utilization of the Office of Health Services Research information for policy-related decisions regarding certificate of need applications, health manpower policy analysis, and health facility development.

II. Development of the Mapping System

At about the same time, the West Virginia Network for Educational Telecomputing (WVNET) was expanding their computer graphics hardware and software. (This graphics system is supported by IBM, ITEL, and UNIVAC mainframes and a variety of peripheral devices.) Due to their mutual interest, WVNET and OHSR personnel joined efforts in the design of a new graphics system. A distributive type structure was emphasized to allow for performance of small graphics projects by mico-computers on a stand alone basis, yet maintaining the ability to communicate with the host site. In this manner, final form maps, histograms, line graphs and pie charts could be produced "in house" at each remote site; alternatively, files could be passed to the graphics packages on the large computer. It was also essential that the host site handle pre-processing of large map data bases and perform certain statistical analysis of data. These files could then be down-loaded to the micro.

After conducting a review of various types of graphics hardware, OHSR purchased a Tektronix 4051 Graphics Terminal System. The major factors in the selection of equipment involved: 1) ease of operation and 2) availability of large amounts of software. A digital plotter, a hard copy unit, and an optional communications interface were purchased along with the 32K size memory machine. To service the communications link, WVNET implemented IBM's Conversational Monitoring System (CMS) allowing transmission of display data, map bases, and programs between the micro-computer and the host site, or vice versa. The interface also made possible the production of plots on the remote terminals and plotters when programs are run on the mainframes.

III. Geographic Base Files and Value Data Files

There are several files which serve as input to the mapping programs. The geographic base files (GBF) contain the information necessary to identify and draw the boundaries of a given area and the value data files which include Census population and housing

summary statistics, health resources data, vital statistics information, health insurance coverage data, and travel time information.

The master geographic base files were stored on magnetic tape at the WVNET facility. Prior to use by the micro-computer, the size of the files were reduced by detail filtering and reorganized into a format suitable for micro-processing. This was done using POLYVRT, a computer program purchased from Harvard Laboratory for Computer Graphics and Spatial Analysis. The output file was then transferred to the micro computer's tape and flexible disc for future use.

The structure of the micro-computer GBF's includes the x - y coordinates of each polygon (datazone) recorded in the order in which they are to be drawn. This makes each polygon a separate independent entity. The machine will read in the first coordinate pair; the plotter pen, or screen cursor, is then instructed to move to this point. As consecutive coordinate pairs are read in, the machine is instructed to draw a line between it and the previous point. The polygon is completed, when the first point is input once again and the closing line is drawn. This process is repeated for each desired datazone. Geographic base files commonly used by OHSR include:

DIMECO - Dual Independent Map Encoding (county).
This file was created by the U.S. Bureau of the Census and contains the boundary information for West Virginia's 55 counties.

MCD - Minor Civil Divisions.
These are the largest subcounty administrative units used by the Bureau of the Census for a variety of tabulations. These are often townships or magisterial districts. There are 353 MCDs in West Virginia.

STAM - Statewide Traffic Assignment Model
The 781 statewide traffic zones in West Virginia are represented in this file. This file was compiled by the State Department of Highways. Each zone is a functional unit based on existing traffic patterns, travel time, population, and natural boundaries.

HSR - Health Service Regions
The 37 health service regions in West Virginia were delineated by OHSR as part of a study of health care delivery patterns in the state. These regions have

been used by the Health Systems Agency in conjunction with OHSR to determine primary care physician needs in the state.

IV. Using the System

OHSR's mapping system is written in BASIC with a heavy user orientation. Both clerical and professional staff have used the system to create final form maps.

The production of a map is a very simple process. The user inserts the initializing tape into the machine and pushes in the "auto load" key. This prepares the machine for the mapping programs. The user will then be prompted by easy to understand questions about the type of map to be produced, titles and legends, and method of value data input - through an existing tape or disc file, or by way of the keyboard. For shade maps, the user must specify class intervals into which the data will be divided. The machine completes the rest of the tasks by calculating any needed rates or aggregate values, and producing the final output on the screen (hardcopy is available) or plotter.

An example session on the Tektronix 4051 to create a shade map appears in Table 1.

V. Application to the Profile

The specific application of the mapping system to the primary care profile was the construction of a medical resource map of the area to be profiled. The map identified the specific location to be profiled and the zones within thirty minutes travel time around it. The geographic location of medical resources, including physicians, clinics, and hospitals is displayed on the map along with a 15 minute travel time isochron. This map was the single most useful yet time consuming part of the profile.

Using the current mapping system to automate this portion of the profile required substantial pre-processing of support files. Statistical Analysis System programs were written to extract and restructure the resource and travel time information. This information was downloaded to the micro where a BASIC program keyed by the downloaded files extracted the appropriate zones from the STAM geographic base file stored on the Micro's flexible disc drive. The map is plotted locally with an average of 12 minutes plotting time. The preprocessing functions are performed by technical staff in less than five minutes at a computer time cost of less than $10. The entire procedure which formally required nearly eight hours to complete is now performed in 15 minutes.

TABLE 1
TO CREATE A SHADE MAP OF WEST VIRGINIA COUNTIES

```
      THIS PROGRAM PRODUCES  A COUNTY MAP  OF WEST VIRGINIA.
      EACH COUNTY WILL BE SHADED ACCORDING TO THE VALUE
      OF THE PARTICULAR VARIABLE BEING MAPPED. YOUR DATA
      CAN BE INPUT THROUGH THE KEYBOARD OR BY WAY OF TAPE.
      YOU ALSO HAVE THE OPTION OF DIVIDING YOUR DATA INTO
      1 TO 5 GROUPS.

                PLEASE ENTER KEY OR TAPE? (K OR T) T
ENTER FILE NUMBER 19

YOU CAN HAVE BETWEEN 1 AND 5 GROUPS
FOR DISPLAY OF YOUR DATA.
HOW MANY GROUPS?   1

ENTER THE MINIMUM AND MAXIMUM VALUE FOR EACH GROUP
GROUP 1
4.0
20.0
INPUT TITLE-YOU HAVE 3 LINES OF 25 CHARACTERS EACH
EACH LINE WILL BE CENTERED FOR YOU
THE FIRST LINE OF THE TITLE IS
WEST VIRGINIA COUNTIES
THE SECOND LINE OF THE TITLE IS
EXCEEDING 1978 HSA NORMS IN 1978
THE THIRD LINE OF THE TITLE IS
FOR HOSPITAL BEDS PER POPULATION

YOU CAN HAVE 3 LINES OF LEGEND ON THE MAP
THE LEGEND WILL BE POSITIONED IN THE LOWER RIGHT
THE FIRST LEGEND LINE IS
GENERAL HOSPITAL BEDS
THE SECOND LEGEND LINE IS
PER 1000 POPULATION
THE THIRD LEGEND LINE IS

OUTPUT TO SCREEN OR PLOTTER (S OR P)? P
PUT IN YOUR DATA TAPE AND HIT RETURN
```

Obviously, the cost/benefit of the total system development expenditure relative to these savings would not be impressive. These internal office improvements merely provide additional return on the initial investment. Although that investment exceeds $50,000, two contracts totaling $80,000 can be directly related to the development of the system.

VI. Summary

The application of computer cartography techniques to the construction of the small area data profile reduced the turnaround time for requests by 100% while improving efficiency in the office and accuracy of the profile. The system was also instrumental in acquiring contracts for processing functions related to the establishment of a State Census Data Center for the state of West Virginia and for a Health Data Center at West Virginia University. OHSR has also applied the graphics techniques in publications of the West Virginia Department of Health and Certificate of Need analysis.