DISPLAY REQUIREMENTS FOR THE PHYSICIAN'S OFFICE

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ABSTRACT

This paper presents a summary of the experience gained in operating a medical information system in a rural private physician's office. In particular, data is presented on this operational system which should be helpful to designers for defining the requirements of patient interactive devices.

INTRODUCTION

One of the principle problems encountered when attempting to apply advanced technology to the delivery of health care concerns the lack of specific definitions and requirements for acceptable systems. Without definitive specifications, the designers and the manufacturer cannot create and produce cost-effective systems. To be widely adopted by the medical practitioners, systems must be cost-effective.

The material presented in this paper is a summary of the experience gained from the design of an information system which has been field tested for over a year in a physician's office in rural Missouri. Hopefully, this material will contribute to the formulation of definitive specifications for display devices and systems for use in similar classes of service.

DESCRIPTION OF MIS STUDIED

The implementation of the medical information system studied consists of an IBM 360/50 computer connected via data sets and leased telephone lines to IBM 2260 CRT terminals (see Figure 1). The computer provides storage for patient records and controls in an interactive manner the acquisition of data about the patients. The 2260 terminals located in the physician's office remote from the computer are used by the patient himself for entry of history data. The physician and his staff enter other categories of data as pertinent to the needs of individual patients. These categories include one or more of the following: vital signs, pulmonary function, urinalysis, physician's X-ray interpretations, physical examination, EKG analysis, progress notes, diagnoses, and any other pertinent data. Data concerning blood chemistry analyses, hematology analyses and radiologist's X-ray interpretations are entered via similar terminals located in the consulting pathology and radiology offices, respectively (see Figure 2).

The physician and his staff have access to the patient data at all times via the display function of the system. A request to display a certain patient's record is entered into the system by keying in the patient's identification number. The record as displayed consists of a series of one or more frames which can be paged through at will by the terminal operator.

Data acquisition is accomplished in an interactive mode. That is, data is entered in response to questions or commands displayed sequentially upon the screen. Entry data can be of three different types; numeric, multiple choice or free text. Numeric data can be either integer or can include a fractional portion indicated by a decimal point. Multiple choice answers are selected by entering a one or two digit number. Free text consists of a string of characters which can be arbitrarily chosen from the allowable keyboard set.

An "item" is defined to be an element of information which has some medical significance pertaining to the state of a patient's health. Examples include: temperature, weight, presence of an abcess, etc. One or more displays may be required to acquire the data associated with an item. Each item gives rise to one or more symptoms, signs or findings which constitute the significant medical information used for diagnostic purposes. For purposes of this discussion, all such diagnostic information will be referred to as symptoms. Table I summarizes, for the system studied, the number of items, symptoms and displays involved. The number of displays required has also been broken down as to type of data entry. The EKG data is not entered via interactive terminals and hence, requires no displays. The output of the EKG analysis program is transferred into the patient file as an internal computer operation.

DISPLAY TERMINAL

The display terminal used for this study is a standard IBM model 2260 CRT as illustrated in Figure 3. This unit can accomodate twelve lines, each of 80 characters on a screen approximately 5 inches by 10 inches in size. The entry and control of transmission of data to the computer is accomplished by depressing keys as appropriate on the keyboard.

TABLE I.

Type of Test	Number of Items	Number of Symptoms	Number of Displays			
			Numeric	Multiple Choice	Free Text	Total
Vital Signs	7	24	9	1	0	10
Hearing Test	14	34	12	3	0	15
Vision Test	15	55	12	4	0	16
Chemistry	12	36	13	2	0	15
Hematology	16	61	14	4	0	18
Urinalysis	16	89	1	19	0	20
Physical Examination	64	640	0	95	53	148
History	144	568	4	159	3	166
Pulmonary Function	6	6	6	1	0	7
EKG	273	120	0	0	0	0

CHARACTER OF TEST DATA AND ACQUIRING DISPLAYS

VITAL SIGNS DISPLAY

As an introduction to the study of the display requirements, consider the entry of vital signs data. An example of a completed vital signs report is shown in Figure 4. To enter this data, a branching questionnaire is used to elicit responses from the terminal operator. This questionnaire consists of 10 displays. The topology of this questionnaire is shown in Figure 5. In this figure, questions are represented as nodes and the flow between nodes is represented by lines terminated with arrows. A triangle represents a question having a numerical response. For example, the first question represented in Figure 5 is "height in inches?." A two digit numeric reply is entered via the keyboard. Successive nodes in Figure 5 represent questions concerning weight, temperature, pulse rate and respiration rate. The dotted node (sixth from the left) represents a multiple choice question. In this example, a choice was inserted so that if blood pressure was not entered, the time to complete the questionnaire would be shortened by branching to the end. If blood pressure was taken, the questionnaire branches to the next triangular node which represents a command to enter the systolic pressure of the left arm. Successive nodes represent questions concerning diastolic pressure of the left arm and systolic and diastolic pressures of the right arm.

Six different items are involved in the vital signs. Five of these items are entered using a single display per item. One item, blood pressure, is more complex and requires five displays. Figure 6 indicates that the majority of these displays consist of two lines with the maximum being three lines. Figure 7 indicates that most of the lines have between 10 and 15 characters while another significant number have between 20 and 24 characters. The maximum number of characters in any line is 25. Figure 8 indicates that most of the displays have between 30 and 40 characters. The maximum number of characters is 39. Figure 9 indicates that most of the displays require three characters to be entered as a response. As mentioned previously, most of the displays require numeric entry responses. Figure 10 indicates that between 10 and 25 characters are generated in the patient file for each datum entry.

The results for this type of test are not typical of the MIS in totality, but have been chosen as the first topic of discussion for sake of simplicity and to bring out some initial concepts.

PATHOLOGY LABORATORY TESTS

Three different types of tests typically performed in a pathology laboratory are included in the APA system. These types are: blood chemistry, hematology and urine analysis.

Figure 11 illustrates the topology of the urinalysis part of the questionnaire. The loops shown illustrate how the branching capability of the multiple choice type questions can be used to allow multiple entries to a single question to be made. The questions are predominantly of the multiple choice type.

Of the 51 items of the complete laboratory questionnaire, only three require more than one display each. Two require two displays each and one requires three displays. Figure 12 shows that most of the displays require only two lines. However, in contrast to the vital signs, the maximum requirement is for eleven lines. Figure 13 shows that the most likely value of the number of characters per line is between 10 and 15 with a maximum value of 50. Figure 14 shows the total number of characters per display. Most displays utilized between 25 and 75 characters. However, the maximum value was 225 characters. Since this questionnaire is predominantly multiple choice, a single character is usually sufficient for data entry. This is illustrated in Figure 15. Some of the multiple choice questions, however, have more than nine possible choices, and hence, two characters are sometimes required. Some questions are also numeric and, as a result, a maximum of five characters is required. Figure 16 illustrates the number of characters in the patient file as a result of a data entry. The most likely number of characters generated lies between 50 and 60. A maximum of 70 characters is generated.

PATIENT HISTORY

The patient history questionnaire is structurally the most complicated. Figure 17 illustrates the topology of this questionnaire. The hollow circles represent questions, the branching of which depends upon the answer to a previously asked question rather than upon the answer to the current question. The solid and hollow hexagons represent questions which allow variable length free text entries to be made.

Of the 163 items in this questionnaire, only two require more than one display. Figure 18 shows that the most likely number of lines per display is three, although a substantial number require four. The maximum number of lines required is 11. Figure 19 shows that the most likely number of characters in a line lies between 6 and 10. The maximum number required is 70. Figure 20 shows that the most likely number of characters per display lies between 51 and 75. The maximum is 275. Table II shows that most of the data entry requirements are met with a single character. Free text entry, however, requires between 49 and 53 characters. Figure 21 shows that the most likely range of characters generated in the patient's file is between 10 and 40. As many as 90 characters are required in a few cases.

TABLE II.

Number of Characters Entered and Transmitted	Number of Occurrences
1	489
2	3
3	0
4	2
49	1
50	0
51	1
52	0
53	1

DATA ENTRY STATISTICS, PATIENT HISTORY

PHYSICAL EXAMINATION

The physical examination has a considerable number of items having large numbers of choices. As a result, the number of displays per item is greater than for any other type of test. Figure 22 illustrates that the most likely number of displays per item is two, but that as many as five may be required. Figure 23 shows that the tendency is toward the maximum possible number of lines per display, eleven. A large number of displays also exist having no lines at all. These displays are used for entry of free text where the physician finds that the preprogrammed choices are inadequate. Figure 25 shows that the distribution of the number of characters per line is fairly uniform from 0 to 30. The maximum number required is 80, which is the physical limit of the display used. Figure 25 shows that the most likely number of characters per display is in the neighborhood of 200 if the large number of displays requiring no characters is disregarded. The maximum value is 600. Figure 26 shows that the most likely number of characters entered is one. Free text entries are shown as requiring 49 characters, although they can be of any length up to a maximum of 49. Figure 27 shows that the most likely number of characters generated in the patient file per entry is in the range of 30 to 40 characters with a maximum of 100.

SUMMARY

An existing medical information system has been studied with respect to the values of parameters which can be used to specify certain aspects of the display requirements. The system studied employs a total of 415 different displays to acquire up to 567 different items of medical information. These items, depending upon their value, are translated into corresponding symptoms, signs, findings, etc., which are significant for diagnostic purposes. Up to 1633 different possibilities are included explicitly in the system. Free text entry capability allows the entry of other information not explicitly included in the system as desired by the physician.

Analysis reveals that most of the displays are of the form of multiple choice questions. For most displays of this type, a total of about 100 to 300 characters is required. However, a single character is sufficient to specify the answer to a multiple choice question. Occasionally, two characters are needed.

About 15% of the displays require numeric answers to be entered. From one to five characters must be entered in response to the question. The number of characters required per display is less than the number required for the multiple choice questions, being about 100.

Both the multiple choice and numeric inputs generate on the order of 40 to 60 characters in the patient file.

The free text tvpe questions require that relatively few lines be displayed. Data entry is relatively lengthy, being on the order of 50 characters. Entries into the patient file are also on the same order of length. About 13% of the displays require free text data entry.

The information has been presented in the form of frequency distributions. Hopefully, these curves will be of use to others whose task is the preparation of specifications for display systems and communications systems of the future for use in physicians' offices. Cost-effective systems are urgently needed for such applications.

ACKNOWLEDGEMENTS

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2) Miller, O.W., Adams, G.E., Simmons, E.M., "Development of the Automated Physician's Assistant," Proceedings of the Society of Advanced Medical Systems, Memphis, Tennesse, October 4-6, 1971.

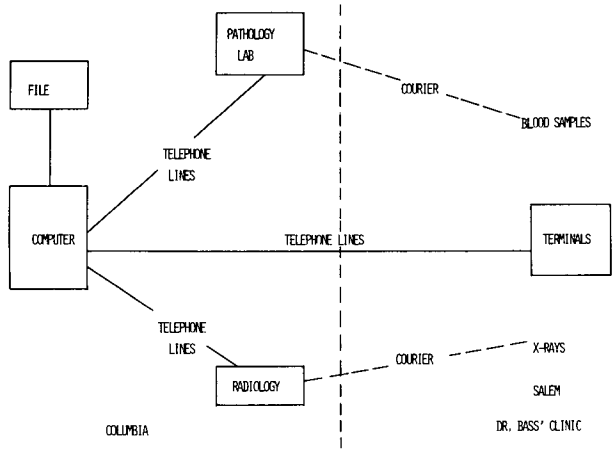

FIGURE 1. Block Diagram of Medical Information System.

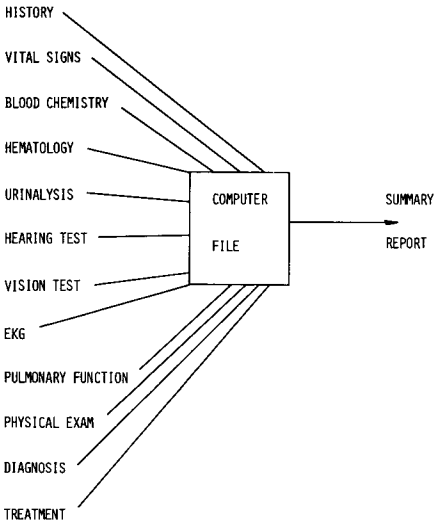

FIGURE 2. Components of the Patient File

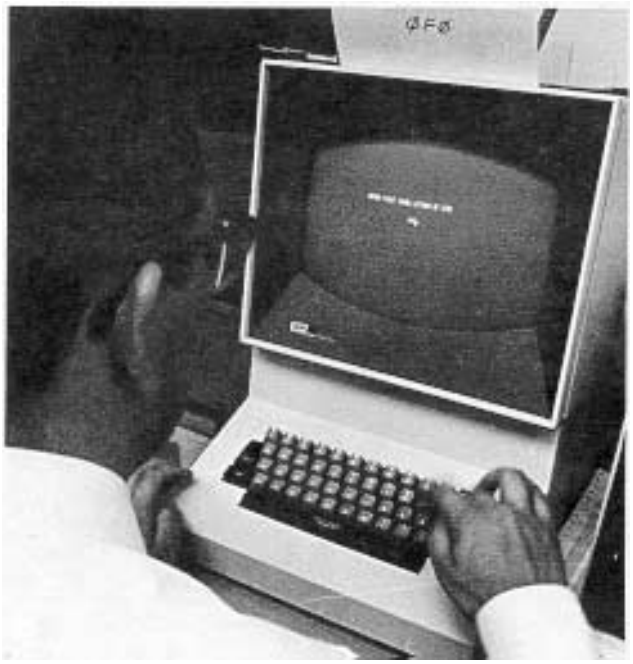

FIGURE 3. IBM 2260 CRT Keyboard Entry and Display Device

ATP REPORT 01/18/71 10:00 0001724

Vital Signs

Height: 64 inches
Weight: 165 lbs.
Temperature: 99.4
Pulse Rate: 76
Respiration Rate: 20
Blood Pressure:
Left Systolic 149
Left Diastolic 67
Right Diastolic 92
Right Systolic 148

FIGURE 4. Example of a Vital Signs Report

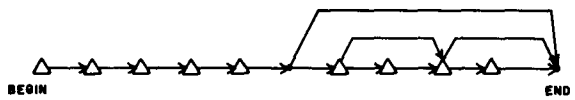

FIGURE 5. Vital Signs Questionnaire Topology

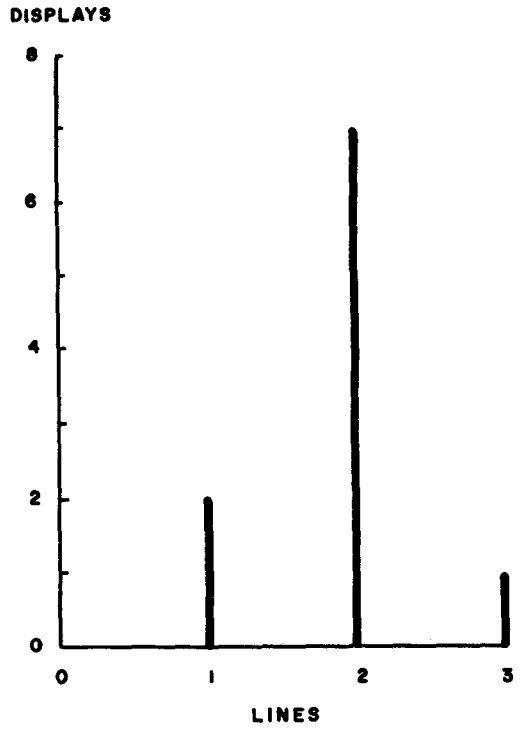

FIGURE 6. Frequency Distribution of Number of Lines Used for Vital Signs Displays

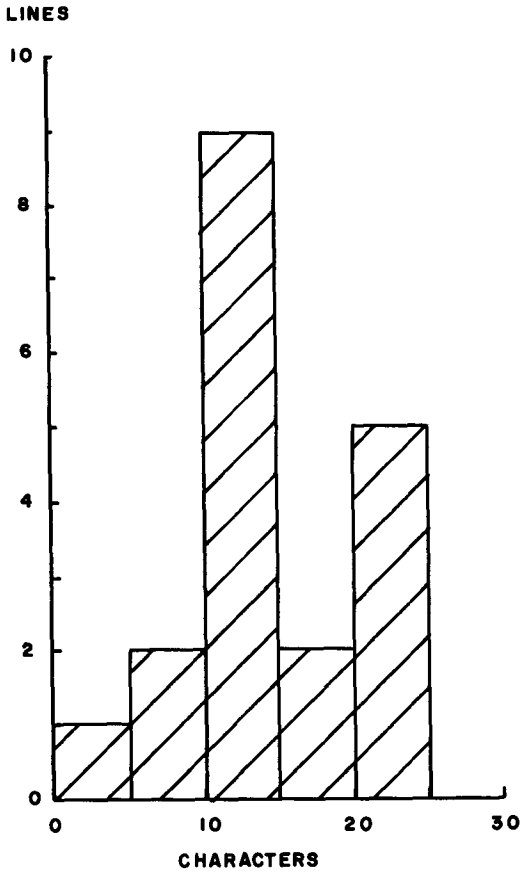

FIGURE 7. Frequency Distribution of Number of Characters per Line Used for Vital Signs Displays

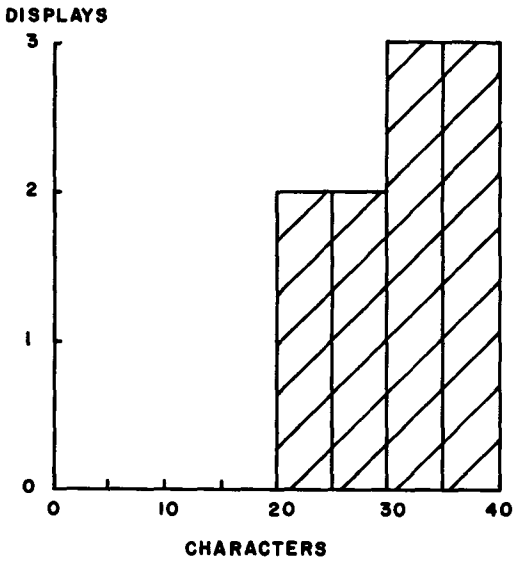

FIGURE 8. Frequency Distribution of Total Number of Characters per Display for Vital Signs Displays

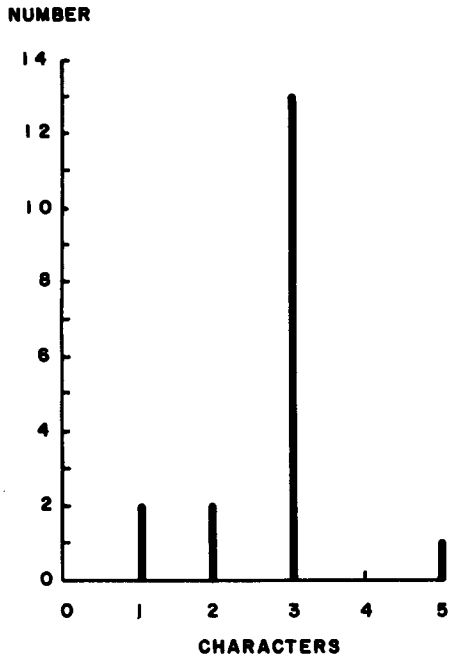

FIGURE 9. Frequency Distribution of Number of Characters of Data Entered Per Display for Vital Signs Displays

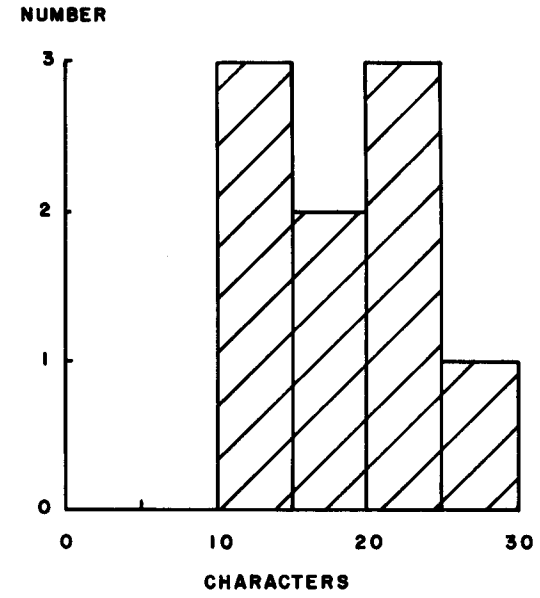

FIGURE 10. Frequency Distribution of Number of Characters Generated in the Patient File per Datum Engry for the Vital Signs Displays

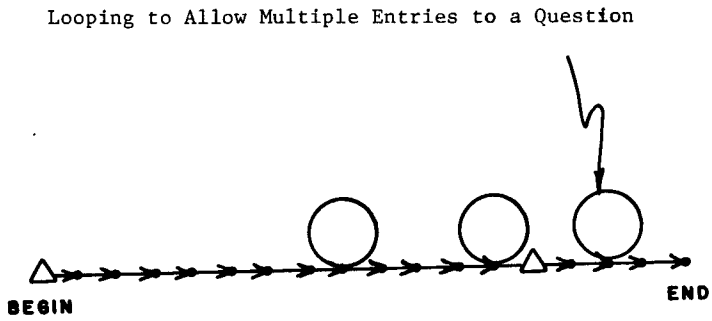

FIGURE 11. Urinalysis Questionnaire Topology

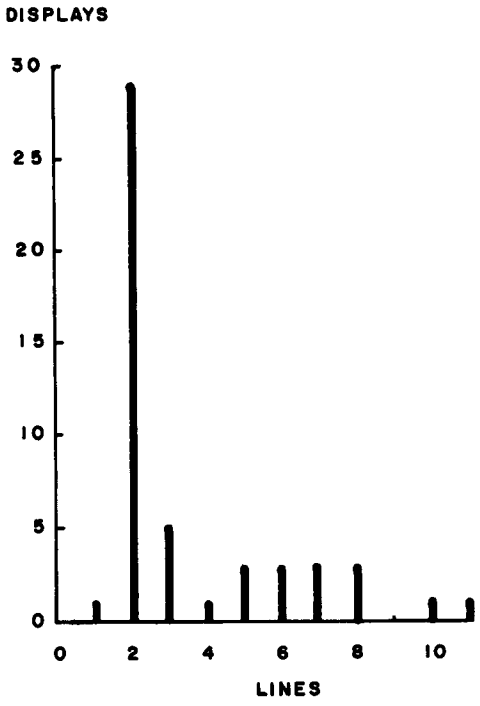

FIGURE 12. Frequency Distribution of Number of Lines Used for Pathology Laboratory Displays

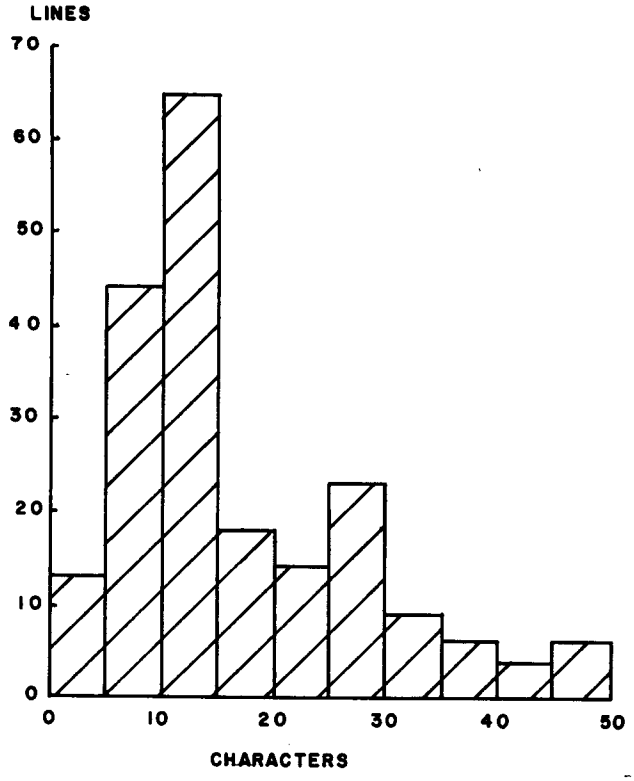

FIGURE 13. Frequency Distribution of Number of Characters per Line Used for the Pathology Laboratory Displays

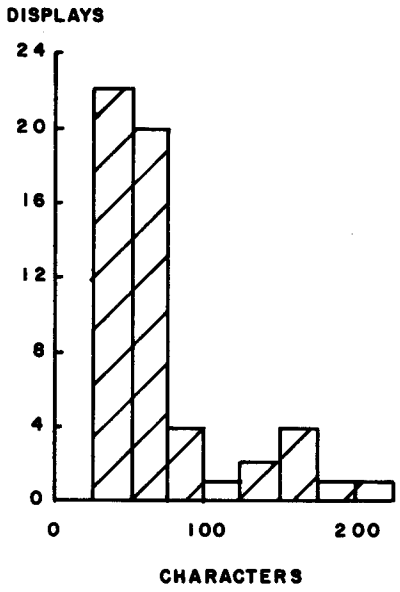

FIGURE 14. Frequency Distribution of Total Number of Characters per Display for Pathology Laboratory Displays

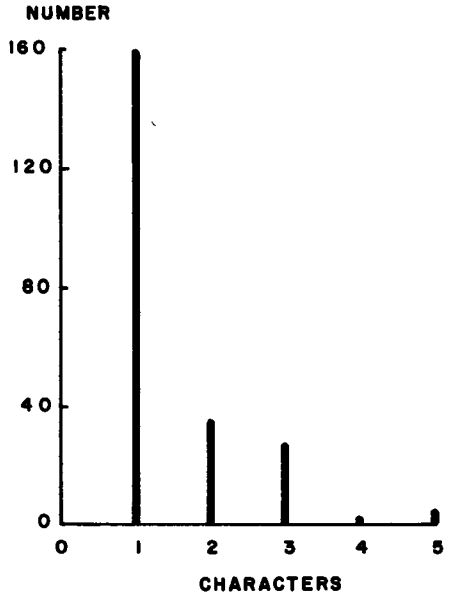

FIGURE 15. Frequency Distribution of Number of Characters of Data Entered per Display for Pathology Laboratory Displays

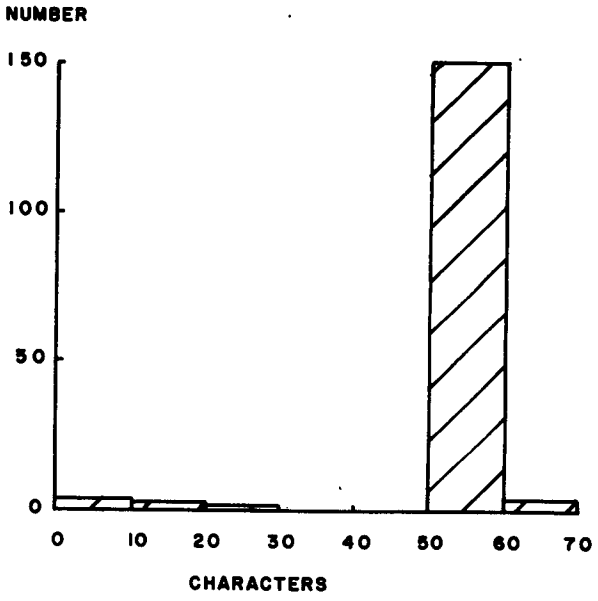

FIGURE 16. Frequency Distribution of Number of Characters Generated in the Patient File per Datum Entry for the Pathology Laboratory Displays

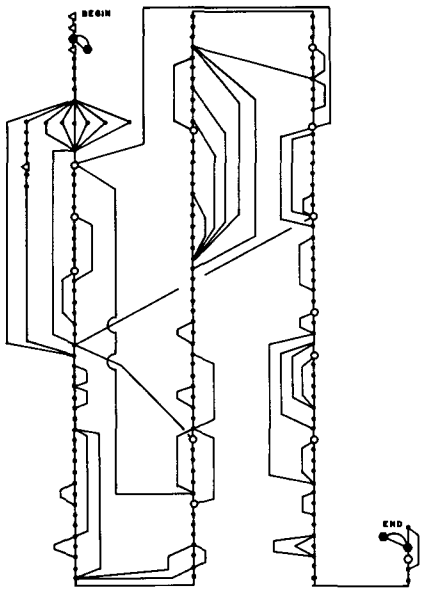

FIGURE 17. Patient History Questionnaire

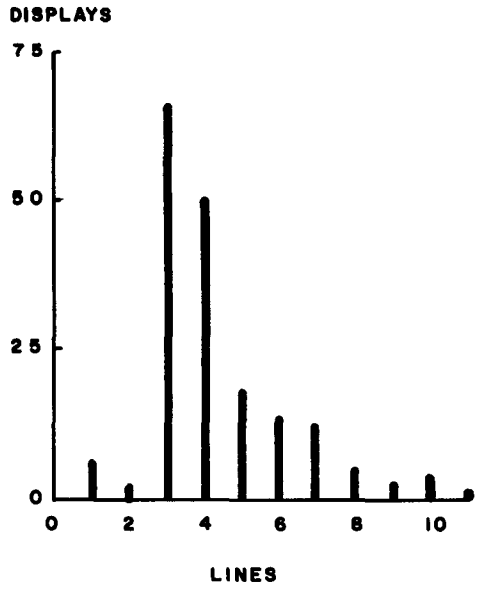

FIGURE 18. Frequency Distribution of Number of Lines Used for Patient History Displays

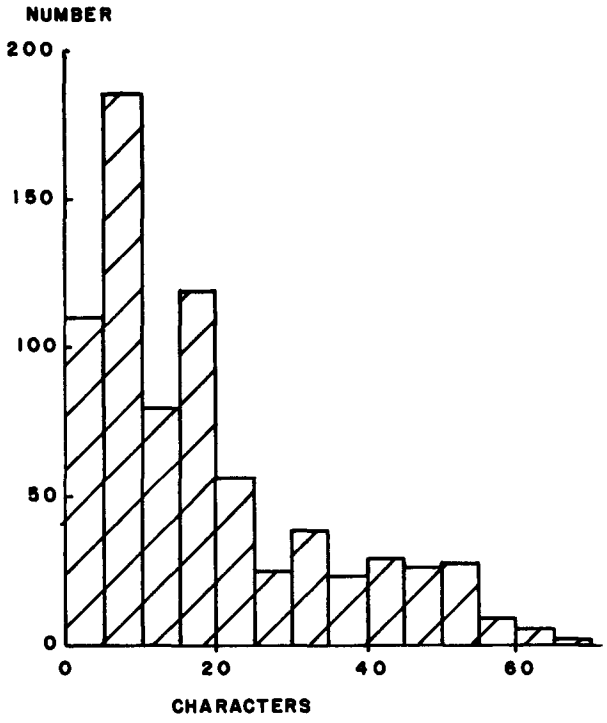

FIGURE 19. Frequency Distribution of Number of Characters per Line Used for Patient History Displays

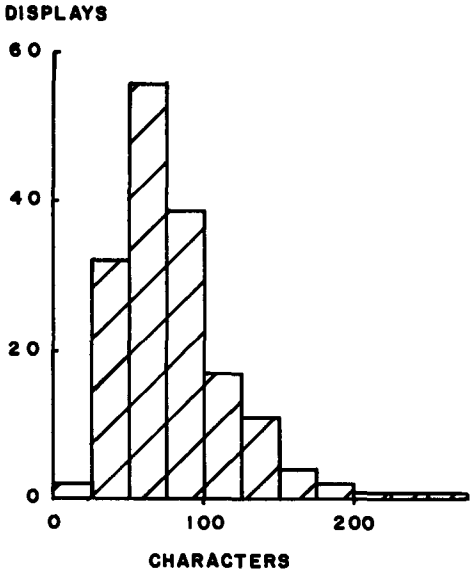

FIGURE 20. Frequency Distribution of Total Number of Characters per Display for Patient History Displays

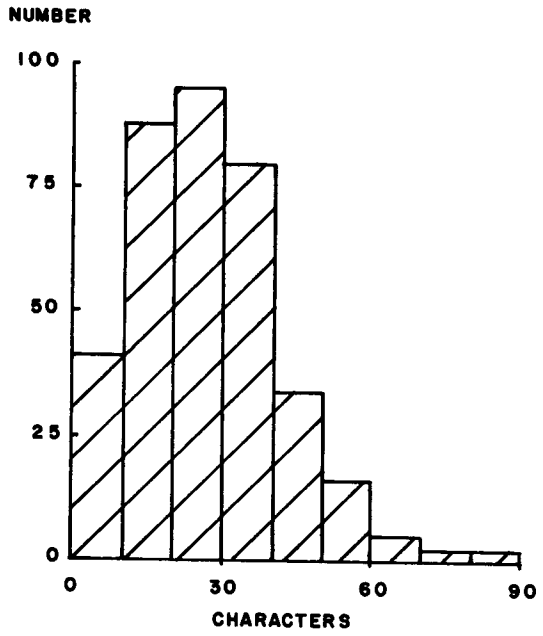

FIGURE 21. Frequency Distribution of Number of Characters Generated in the Patient File per Datum Entry for the Patient History Displays

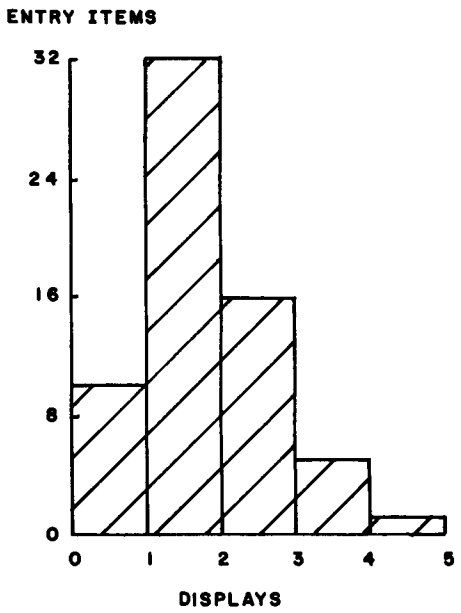

FIGURE 22. Frequency Distribution of Number of Displays Required to Enter an Item of Information for the Physical Examination Displays

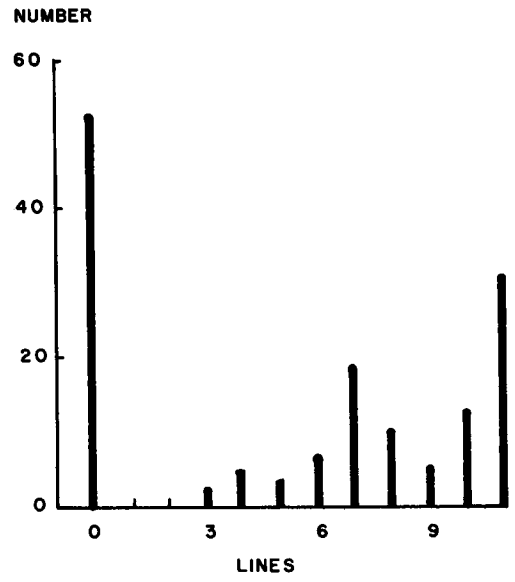

FIGURE 23. Frequency Distribution of Number of Lines Used for the Physical Examination Displays

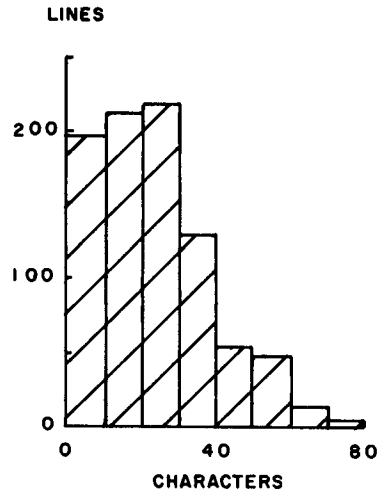

FIGURE 24. Frequency Distribution of Number of Characters per Line Used for Physical Examination Displays

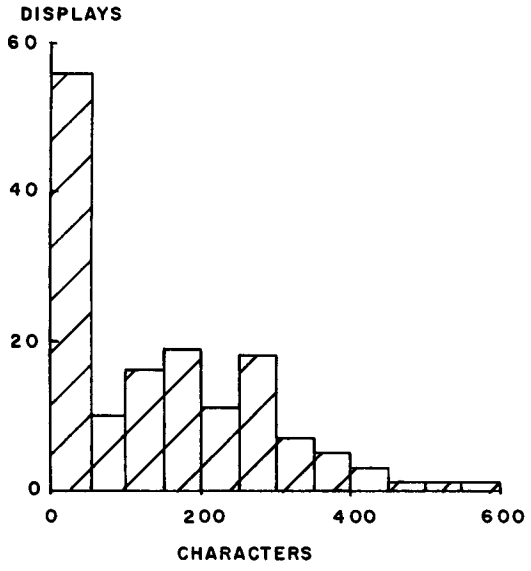

FIGURE 25. Frequency Distribution of Total Number of Characters per Display for Physical Examination Displays

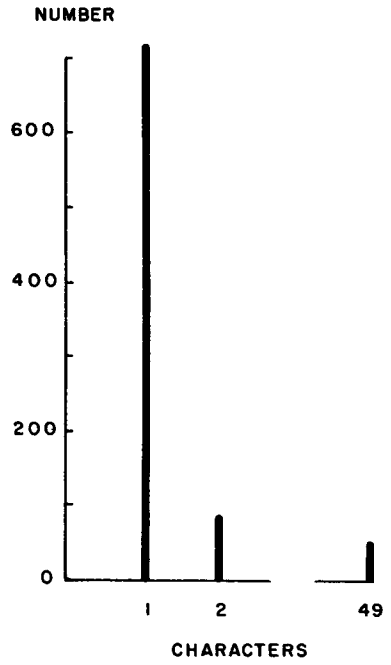

FIGURE 26. Frequency Distribution of Number of Characters of Data Entered per Display for Physical Examination Displays

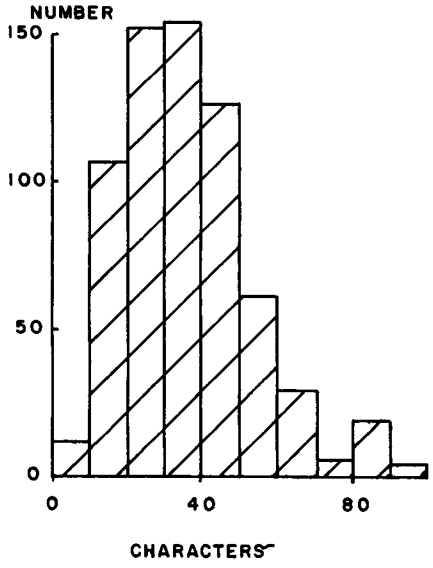

FIGURE 27. Frequency Distribution of Number of Characters Generated in the Patient File per Datum Entry for the Physical Examination Displays