Automated Information Handling in the Newborn Intensive Care Unit of the University of New Mexico Hospital

by

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Abstract

There are two sections to this paper. The first section briefly lays out the information handling needs of the Newborn Intensive Care Unit (NICU) of the University of New Mexico Hospital. The new computer system that we feel best meets our needs is also introduced. In the second section, the computer hardware is described and then, in some detail, our new software explained. Examples are given of the menu system, the Query by Example routines and the reports the software can generate.

I. Introduction to the Problem

The need to readily and rapidly access patient records, extract specific information, make comparisons and compile data in the Newborn Intensive Care Unit (NICU) at the University of New Mexico Medical Center led us to investigate computerized data processing and records management. After reviewing the literature (1,2,3) and systems in use at other NICU's we opted to design and implement a system specifically tailored to our unit and needs. The result is a menu driven, user friendly software package installed and running on a WICAT 150 multi user, multi tasking microcomputer. The choice of the WICAT system was prompted by fiscal restraint combined with a need for state of the art equipment. The WICAT system (M68000 based) we chose to purchase was just over $10,000.

Specific concern in developing our software included: 1) it had to be easily available to medical staff, clerical personnel and administrators not familiar with computer technology; 2) it had to be flexible, i.e., should clinical demands indicate need for changes in a menu or some other aspect of the system, it should be possible for those changes to be made by people with only rudimentary programming skills, and not require excessive down time or extensive reprogramming; 3) it must be more than a data collection device, rather a data management and research tool as well as an instrument which would improve health care delivery in the NICU; and 4) report generation and data investigation must be fast and readily available. To these ends we have implemented a Query by Example (QBE) routine which allows staff to search across all the collected records to determine important relationships in the data.

The software is written in the high level language Pascal and is easily transportable to any Pascal machine with random access to disk. The program, in its current state is a little over 100K in size in addition to, in packed form, patient records of up to 900 bytes each.

In an attempt to measure the effectiveness of our computer system in improving medical care delivery in the NICU, we have devised, with the help of a human factors consultant, a pre/post evaluation. The pre-implementation survey of user expectations and attitudes was given to key medical and support staff. There is also an on-going assessment of needs to gage actual use and effect of the system on medical care. Finally, the post implementation comparison and survey of attitudes, satisfaction, and use will be reported in full (6) when it has been completed.

II.A. Hardware Description

The hardware is the WICAT System 150 multiuser, multitasking microcomputer. As currently configured, we have 256K of random access memory, 10MB Winchester Hard Disk storage and a 5 1/4" floppy back up. Terminals are located in the NICU and the administration office. The computer is available 24 hours a day. The terminal in the NICU is linked to the computer by a phone line using a 1200 baud modem for rapid access to and input of information. A third terminal doubles as the hard copy printer, and is also connected at 1200 baud.

Should the need arise, the WICAT system can expand to 1mb RAM and to 30MB hard disk storage. The need for this extra processing power and memory seems unnecessary due to our ability to store the archival records of discharged patients on floppy disks, for access when needed. Records of approximately 250 patients can be stored on one 5 1/4" disk.

The hardware has been in place for approximately one year. While we have spent much time creating our software, we have also been able to evaluate the operating system and become aware of system weaknesses. While the WICAT is extremely versatile it does present some problems. Specific problems have been in the lack of operating system diagnostics especially for overflow and out of range errors. It is our hope that these problems will be overcome soon through our and other users' feedback to WICAT.

II.B. Software Description

The heart of our system is the software. It is menu driven and user friendly, leading the user, menu by menu, from admission of the patient to discharge. Diagnoses and procedure information is prompted for only after an admission has been made. Likewise, follow up menus are only available after a discharge has been completed. Each menu takes no more than one full screen of the terminal. This feature avoids the need of scrolling up and down to see all the fields. The admit menu, and how it is "called", is shown in Figure 1. When a specific field of a menu must be filled in, such as the patient number of Figure 1, it is printed with a special mark on the screen, and will not be integrated into the data base until this field is properly filled in.

When longer names, for a county, for example, or for a diagnosis such as pneumonia, must be entered, we have devised a series of codes that allow the information to be added in simplified form. After a menu has been filled out using these codes it is rewritten on the terminal in its full English form and the user is prompted to check answers and enter specific fields, if they have been neglected or overlooked. If specific information is unavailable the system will accept an incomplete menu, if the user so indicates. These fields can always be entered at a latter date if the information becomes available.

The program is menu driven in that the only way data may enter or leave the data files is through a fixed set of menus. This is an important approach to data storage and retrieval for several reasons (7,8,9). The most important is that the operator cannot alter or rearrange the file systems; he or she may only enter or change the data contained in the files. The files are thus said to be "hidden" from the operator. All that is seen is one of the set of menus on the screen asking for or displaying different bits of information.

For specific tasks such as changing data already entered in the data base or for actually changing fields of the menus themselves special passwords are required. This,of course, is necessary to protect the integrity of the data.

The menus are designed using a series of "tabs" and "new lines" on the CRT. With this approach, the questions are printed out on the screen with blank areas left for

responses to these questions. The set of "tabs" for each menu is arranged so that by touching the "carriage return" key, the cursor automatically skips to the appropriate location for the next response from the user.

The menu approach to data entry also provides a good deal of modularity for the entire system. For example, one nurse could be assigned to do admit and history information for each new child admitted. A physician may enter the daily diagnosis and procedure information, and a third person may handle discharge information and generate reports. The menus may be further used to protect the data base by allowing only certain people to use particular menus. This approach can also meet the privacy requirements for sensitive medical records by preventing unauthorized entry to restricted data.

The software we have developed is for general purpose information handling needs. It is only because of the specific requirements of the NICU that the particular menus were designed the way they were and their fields set to the values they now have. The number and content of the menu fields are variable and may be set to values appropriate to the application intended. Thus they might equally well be set for a doctor's office with the "admit" menu set for patients' personal history. the "daily" menu set for each office visit, the "discharge" menu set for summary information, and so on.

Especially critical in the design of any new computer system is the need to lesson the amount of time required to complete patient charts. Also, retrieval and review of information from hand written paper charts has proven a tremendous constraint on the time of the medical staff. We intend to demonstrate a significant improvement in accuracy and speed in data retrieval through our computerized system (6).

The data collection section of the program generates a number of automatic reports such as patient summaries (Figure 2, used with QBE), active patient lists, and code listings for all menus. Also, any patient record can be recalled for review and correction. The QBE allows for searches of all records across all fields in the top 9 menus and the 28 fields of the diagnoses and procedures. Sample questions might include: how many 1000g or less infants come from Rio Arriba County in 1982; how many Hispanic babies were admitted with IRDS; how many admissions were via the Newborn Transport Team? Specific medical research questions can also be tailored for search by the QBE routines. An example of a QBE run followed by summaries of patients meeting the constraints of the QBE may be seen in Figure 2.

The menu progression, as mentioned earlier, goes from admission to discharge and follow up. The top 9 menus are: 1) admission demographics, 2) mother physical/history, 3) baby physical/history, 4) transport menu, 5) discharge, and 6-9) 2 week, 5 month, 1 year, and 2 year post-discharge follow-up. After menus 1-4 are completed the program prompts for input of 1) referral diagnoses and procedures, 2) transport procedures, and 3) admission diagnoses and procedures. Space for additional admission diagnoses and procedures is also available. After the initial admission of a patient, the daily update menus allow specific daily procedures and diagnosis and other information to be added to the patient's permanent records.

We feel one of the most important changes brought about by the new system will be the overall consistency of the new data management regime. At the time of computerization the medical staff took many hours to overhaul and refine their own goals and needs in record keeping. Many of the forms that emerged from this rethinking of basic needs were more simplified and concise than the previous record forms. We feel that the longer, more involved report generation that makes up an important part of the administration of any medical clinic will be greatly simplified. With all records present on the computer, we feel that reports to government and other funding agencies that formerly took days will be accomplished in a matter of minutes.

Finally, we feel that the research abilities of the medical staff, both for present babies, and follow up studies across future years, will be greatly improved. In fact, the most important reason for the general query by example routines was to allow the medical staff to ask general purpose questions about the complete collected sets of medical data.

III. Conclusion

In this paper we have given a description and overview of the computerized information system that we constructed for the newborn intensive care unit of UNM Hospital. There are several additions we hope to include in the system in coming months. One feature would be the facility for real time monitoring where some data (blood pressure, temperature, and caloric intake) are taken directly from the infant's support system. This would require a small processor collecting data and periodically sending it to the larger system. Also, since many growth curves for normal children are fairly well understood, it would be nice to monitor changes in the patients' development, generating a warning, for example, of a too rapid cranial change, or when caloric intake is inappropriate to body weight. We would also like to improve the QBE routines so that any pediatric researcher could enter the data system and ask any question pertinent to his or her current research.

We also feel there are specific "human engineering" issues left to be resolved to make the entire data system more comfortable for the medical staff. If the information system becomes difficult or cumbersome to use, it will be a failure simply because it will not be used to its fullest capacity, or worse still, will be abandoned. All these issues continue to concern us and will be reported on by our group in due course.

Finally, although our program was developed for the Newborn Intensive Care Unit, menu access, the daily procedure and diagnosis routines, the query by example and report generation offer a general system for collection and manipulation of medium sized sets of medical data. Our general purpose information handling routines can be easily revised for use in other areas of the hospital as well as doctors' offices or clinics: wherever the smooth handling of medical information can improve medical care delivery.

Copies of complete menus, as well as the full tables for diagnosis and procedures, are available from the authors for anyone wishing to examine the system further. An agreement for using the software itself can be worked out with its authors.

Figure 1. An example run of the menu system, asking which menu the user would like to see. The infant admit and mother's history menus are shown together with the appropriate codes.

```
What would you like?

0 - Quit
1 - Admit new patient.
2 - See the Active Patient List.
3 - See a Patient Summary.
4 - Update or View an Existing Record
5 - Add a Social Services Menu to an Existing
    Record
6 - Print a Codes-and Meanings List.

ADMIT MENU

patient chart #          enter number
last name/sex(m/f)       ex. Smith F
race                     codes : 12345678
street                   ex. 9999 Campus NW
city                     ex. Albuquerque
county state zip         ex. Bern. NM 87106
telephone number         ex. 402-821-2013
other contact(name)      Jones
relationship             Grandmother
telephone number         203-435-2461
date/time of birth       ex. 021482 @ 0900
date/time of admit       ex. 021583 @ 2100
type of admit            codes:  1234567
unit of admit            codes:  12345

MOTHER PHYSICAL / HISTORY

mother chart number      enter number
age                      enter age
race                     codes:  12345678
marital status           codes:  123456
mult. birth? order       ex: yes 1 of 2
gravida/para/ab/sb       ex: 2/2/0/0
blood type               ex. O+
antibody screen          ex. + or -/rh or other
sts                      codes:  1234
delivery type            codes:  1234
delivery position        codes:  1234
maternal death           y)es or n)o
prom ( = 24 hrs          y)es or n)o
meconium present         y)es or n)o
maternal disease         codes:  12345
```

Figure 2. Query by Example is used to ask the collected set of data which children were a) born between 1 January and 28 February 1983, b) with mothers between 15 and 20 years of age, c) with birthweight between 1000 and 2000 g, d) were born before their due date, and e) had transient IRDS. Note that a summary is given of each patient meeting all these criteria. The user could have asked for the number of infants only. The ability to generate summaries of patients meeting certain criteria (for example, current active) demonstrates one of the report generation abilities of the program.

```
The following 3 chart(s) fit(s) the specified
criterion:

473138
Olivares f
Admit Date:  010583 @ 0612
Unit of Admit:  nicu
Discharge Date:  011283
Type of Discharge:  Home


473137
Olivares f
Admit Date:  010583 @ 0630
Unit of Admit:  nicu
Discharge Date:  011783
Type of Discharge:  Home


473213
Reese f
Admit DAte:  011683 @ 2106
Unit of Admit:  nicu
Discharge Date:  011883
Type of Discharge:  Other Hospital
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IV. References

(1) Janik, D., et al., Intermountain Newborn Intensive Care Center Computer System Users Manual, 1979.

(2) Shulthesis, D.C., and Norden-Paul, R.E., A Real-Time Patient Data Acquisition and Display System, 32nd ACEMB, 1979.

(3) Comerchero, H., et al., SOLO: An Interactive Microcomputer-Based Bedside Monitor, Third Annual Symposium on Computer Applications in Medical Care, Oct. 14-18, 1979.

(4) Roger, J., and Harig, O., The Impact of a Computerized Medical Record Summary System on Incidence and Length of Hospitalization, Medical Care, Vol. 17, No. 6, June 1979.

(5) Kaplan, B., The Context of Medical Computer Software Systems Development: Medical User Needs and Expectations, Third Annual Symposium of Computer Applications in Medical Care, Oct. 14-17, 1979.

(6) Stibbard, P., Luger, G., Lesser, D. & Alverson, D., Evaluating the Effectiveness of Computerized Medical Record Management at the University of New Mexico Medical Center, Department of Pediatrics, Division of Neonatology. Document in preparation.

(7) Slosarik, W., Luger, G., Kirkpatrick, J., Koffler, H., & Burstein, R. The UNMH Intensive Care Information System, Proceedings of Computer Applications in Medicine Conference, Washington D. C. (IEEE), 1980.

(8) Wiederhold, G., Database Design, McGraw-Hill, 1977.

(9) Copeland, J., Hamel, B., and Bourne, J., An Exploratory Data Analysis System for Support in Medical Decision Making, Vanderbilt University, 1979.