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A PRACTICAL NICU COMPUTER SYSTEM—THE CETUS SYSTEM 100

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HISTORICAL REVIEW AND INTRODUCTION

In 1978, Janik et al.[1] described a computer-assisted system for data collection and reporting in a neonatal intensive care unit (NICU). This system, developed at Loma Linda University Medical Center, used computer cards keypunched from a specially designed data collection form and submitted daily to a large hospital financial computer. Outputs generated by the system included patient discharge summaries, letters to referring and follow-up physicians or agencies, and completed California infant transport forms. Among the problems eventually encountered with this system was a relatively high (10 percent) data error rate associated with the keypunching and computer processing.

For this and other reasons, a large, on-line, time-sharing system was developed using a remote computer terminal connected by cable to the large University computer.[2] The approximately 130 items of demographic, historical, medical care, social, and public health data could then be entered directly on the terminal screen by physician or nurse coordinator, using a combination of keyboard and light pen, in response to questions presented by the computer just as they ap-

peared on the forms. Outputs from this system included those listed above, plus data abstracts generated from a single, generalized QUERY program. The latter permitted abstraction of patient information without the need for constant reprogramming. Further development was prompted by delays experienced during peak hours of computer usage, dependence on an outside and expensive computer facility, and the need for several specialized programming languages.

In 1980, less than 2 years after reporting the first successful version, Janik et al.[3] described an on-line, dedicated microcomputer system for recording, reporting, and abstracting data on NICU patients. This work, conducted at the University of Utah Medical Center, provided fundamental experience toward more recent production of the relatively inexpensive, semicustomized CETUS System 100 now available commercially.[4]

After presenting a brief discussion of the problems commonly faced in developing medical computer systems, this chapter focuses on the CETUS System 100, describing in detail its basic design features, hardware components, programs and their outputs, specifics of operation, and assessment of results.

PROBLEMS IN MEDICAL COMPUTING

Medical care documentation, evaluation, communication, and research are increasingly important, yet complex, time-consuming, and costly tasks for referral medical centers. Various centers have attempted to address these problems through use of computers in clinical settings. Medical computer systems, however, must operate within stringent technologic and monetary limitations of medical departments or hospitals. Consequently, clinicians and hospitals look increasingly toward small, inexpensive, dedicated, locally owned and operated, stand-alone computer systems.

Yet while microcomputer systems appear an obvious choice, such systems often entail irritating limitations. Microcomputer technology is still quite young, and with very few exceptions, microcomputers are only now beginning to be introduced into the clinical arena. Although the hardware technology has improved dramatically with each passing year, software associated with such systems has not generally kept pace. With the possible exception of Massachusetts General Hospital utility multiprogramming system (MUMPS), microcomputers have lacked even a basic medical programming language. Microcomputer systems also tend to be limited by small working memory of 10-64 kilobytes (KB), small data storage capacity of 10-256 KB on cassettes or diskettes, and single-user applications. Rarely do microcomputer hardware or software permit integration into larger hospital information systems.

On the other hand, medical records tend to be exceptionally large but relatively few in number, compared with the elements comprising more traditional accounting or financial computerized systems. Medical data systems require provision for extended data collection, manipulation, sorting, "browsing," or query capacity and reporting, rather than traditional aggregate number processing capabilities. In addition, medical computer systems must be oriented to a highly specialized, inflexible user who is not likely to be experienced in or tolerant of computer technology, procedures, or jargon. Finally, a medical computer system must accommodate a variety of question types and allow for extensive narrative and textual information.

SPECIAL DESIGN FEATURES

Among the special design features incorporated into the CETUS System 100 for neonatal intensive care unit (NICU) application are the following:

Simple entry of data by medical, nursing, or clerical personnel, either directly into the computer or indirectly via site-specific forms

Data base, including diagnoses, customized to site's teaching and research needs

"Secretary" quality admission/discharge summaries in traditional hospital-approved, seminarrative medical style, computer-generated directly from the data base

Single, prewritten, table-driven query program that allows for selection and reporting on all data items without need for programmer support

FORTRAN IV applications programs fully documented and supported worldwide

Standard vendor-supported operating system

Industry-standard Digital Equipment Corporation hardware that is compact, easily moved, and capable of being operated in an environment independent of other computer systems, or that can communicate with most other industry-standard systems or special devices.

HARDWARE

The CETUS System 100 is comprised of a single Digital Equipment Corporation DEC LSI-11/2 or LSI-11/23 processor, VT-100 video-display terminal(s), standard typewriter-like keyboard, dual 500-KB floppy disk drives, and a Xerox Diablo 630 printer.

Patient records, recorded on patient file disks (see below), can include up to 5000 characters of information each. One disk (or diskette) will accommodate up to 200 discrete patient records. Applications programs (see below) reside on separate program disks. Back-up copies of disks are generally made weekly. Initial hardware costs in 1981 were in the range of $15,000, and maintenance, support, and supply costs did not exceed $6000 per year.

SOFTWARE

The CETUS System 100 uses the DEC standard RT-11 operating system to provide underlying file structure and system capability. The user, however, neither interacts with the operating system nor requires any knowledge thereof. Applications programs are well documented and written in FORTRAN.

Patient Files

Patient files are functionally divided into ACTIVE, ARCHIVE, or "other." Each resides on a separate disk.

ACTIVE Patient File

A single ACTIVE patient file disk is used to record data on infants during residence in the NICU. Approximately 500 items of referral (pretransfer), transport, admission history, admission physical examination, discharge history, discharge physical examination, diagnostic/procedural, and follow-up information are recorded either directly into the computer or onto nonrepetitive, sequentially structured, site-specific data entry forms (Figs. 9.1-9.5). Each item of information is assigned a unique, clinically meaningful "name" highlighted within each question. The worksheets are constructed in modules in the above-listed sequence to permit stepwise entry of data by medical, nursing, or clerical personnel onto the forms or directly onto the computer in identical format. ACTIVE patient file disks are able to function with INPUT/UPDATE, PRINTOUT, COPY, and QUERY programs described below.

ARCHIVE Patient Files

Inpatient records are moved from the ACTIVE onto serial ARCHIVE patient file disk(s) after discharge from the NICU. ARCHIVE disks function with PRINTOUT, COPY, and QUERY programs only; patient records must be transferred back to an ACTIVE disk before alterations can be made.

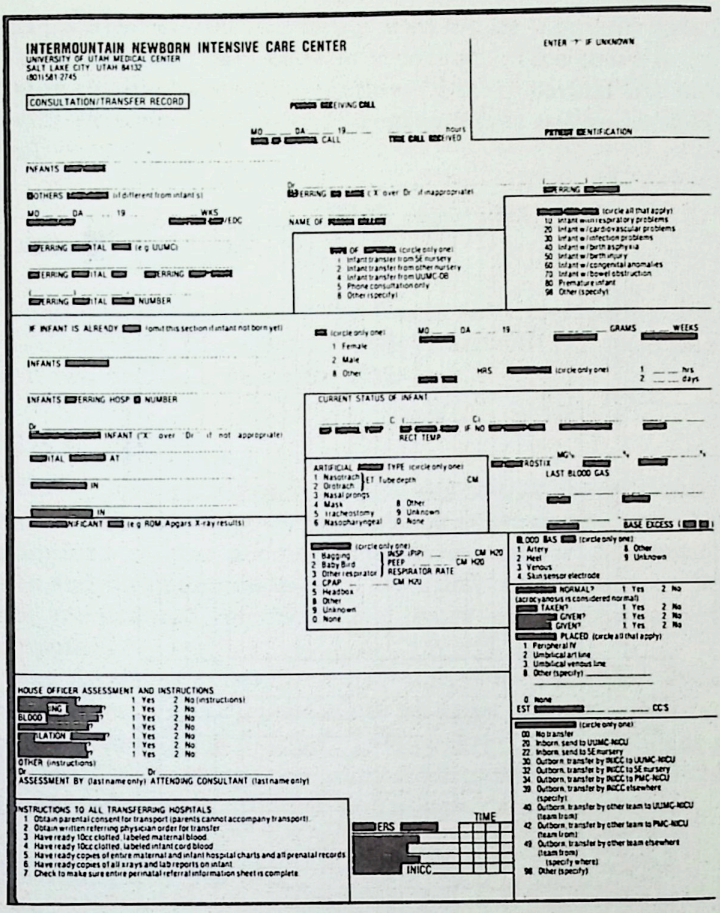


FIGURE 9.1. Consultation/transfer record worksheet in use at the Intermountain Newborn Intensive Care Center (INICC) in Salt Lake City, Utah. As with all these worksheets, illustrated in Figures 9.1-9.6, key items of information or "names" for computer input are highlighted by darkened background within each question. Unfortunately, most of these names are no longer visible, showing up as black blocks in these greatly reduced illustrations.

"Other" Patient Files

"Other" patient file disks can be created from time to time in conjunction with special projects, such as clinical research involving a sizable number of patients. Also, CONSULTANT/TRANSFER patient file disks can be created to record data on patients with whom staff members had some involvement (e.g., provided consultation or transport to another hospital) but who were not admitted to an INCU in which

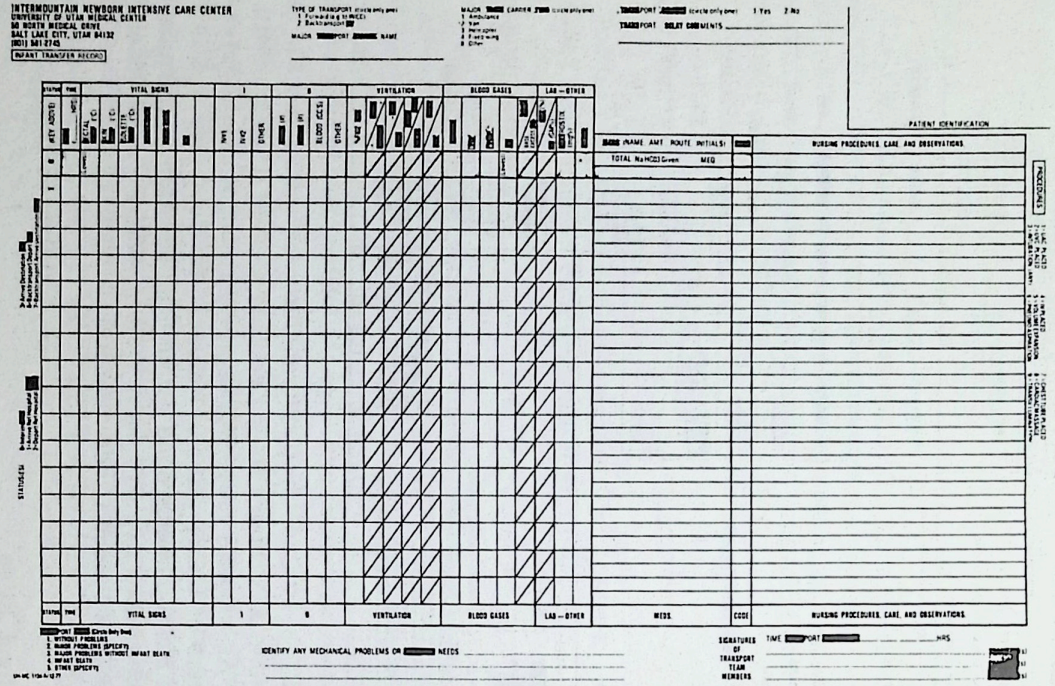


FIGURE 9.2. Infant transfer record worksheet in use at INICC. This form is completed by members of the newborn transport team. It folds out to be equal in size to two $8\frac{1}{2}$ X 11-inch sheets of paper.

the CETUS System 100 was being used for its inpatient data processing. An abbreviated data base is recorded, since there is no NICU admission or discharge information. "Other" patient file disks can work with various applications programs (see below) as specified by the site.

Applications Programs

Applications programs are functionally divided into PRACTICE, INPUT/UPDATE, PRINTOUT, COPY, and QUERY programs, each of which resides on a separate disk.

PRACTICE Program

The practice program enables unfamiliar users to gain experience with medical computer systems in general, and with this system in particular. This is accomplished through direct interaction between the user and the machine under controlled circumstances. No patient records are created, so one cannot "hurt" either data, programs, or the computer.

The program consists of 12 practice questions reviewing the five kinds of computer questions to be expected and eight basic system commands that will be needed. This program is available at any time, day or night, without special help. Additional help can, however, be obtained from a project coordinator during regular hours.

INPUT/UPDATE Program

The INPUT/UPDATE program is designed to capture, review, update, or edit patient information. Patient records are created, reviewed, or altered and therefore require an accompanying ACTIVE patient file disk. To update a patient record on an ARCHIVE patient file disk, the patient record must first be transferred onto the ACTIVE patient file disk using the COPY program (see below).

The INPUT/UPDATE program consists of nine modules, corresponding to the nine data-entry forms or worksheets. Questions are presented one by one by the computer as they appear on the worksheets. The last three modules (i.e., discharge physical examination, discharge diagnoses, and follow-up) are specially designed to encourage direct entry of data into the computer by physicians.

Upon entering the diagnostic module, "pages" of 15-30 diagnoses are presented as they appear in an accompanying Diagnostic Workbook. Approximately 400 common or important teaching or research diagnoses, grouped into 10-15 functional categories, including syndromes, multisystem diseases, organ diseases, and finally abnormal physio-

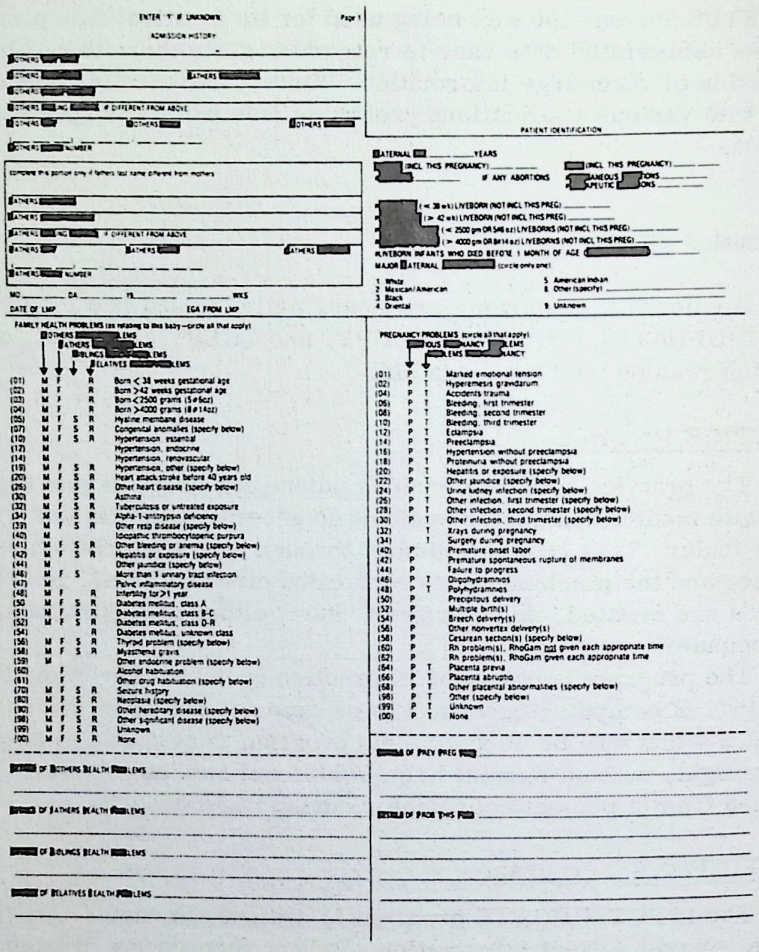


FIGURE 9.3a. Admission history worksheet in use at INICC, listing demographic data, information on family health problems, and maternal pregnancy problems. This form is initially addressed by the transport team and is completed by the admitting physician or resident.

chemical characteristics in that preferred order, are determined depending on site preferences. Diagnoses within each functional category are then further organized into primary, secondary, and occasionally tertiary groups according to the site's special therapeutic, teaching, or research interests. Each end diagnosis is then assigned a unique four-character identification code. Out of a group of 21 diagnostic qualifiers, such as the age at onset of disease, type of surgery performed, and the maximum oxygen concentration used, several can

then be linked to each diagnosis. Finally, up to 80 characters of additional comment are available for each diagnosis at the discretion of the physician to allow unrestricted diagnosis qualification. Figure 9.6 illustrates one page from the Diagnostic Workbook currently in use at the Intermountain Newborn Intensive Care Center, Salt Lake City, Utah.

PRINTOUT Program

The PRINTOUT program automatically generates patient admission and discharge summary notes and letters to referring and follow-

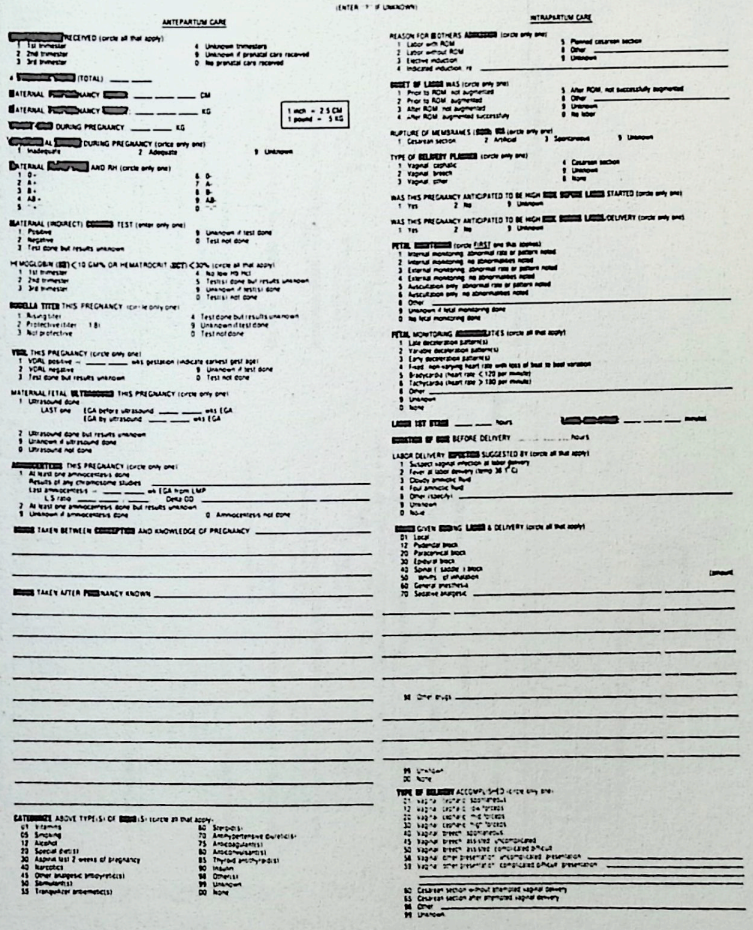
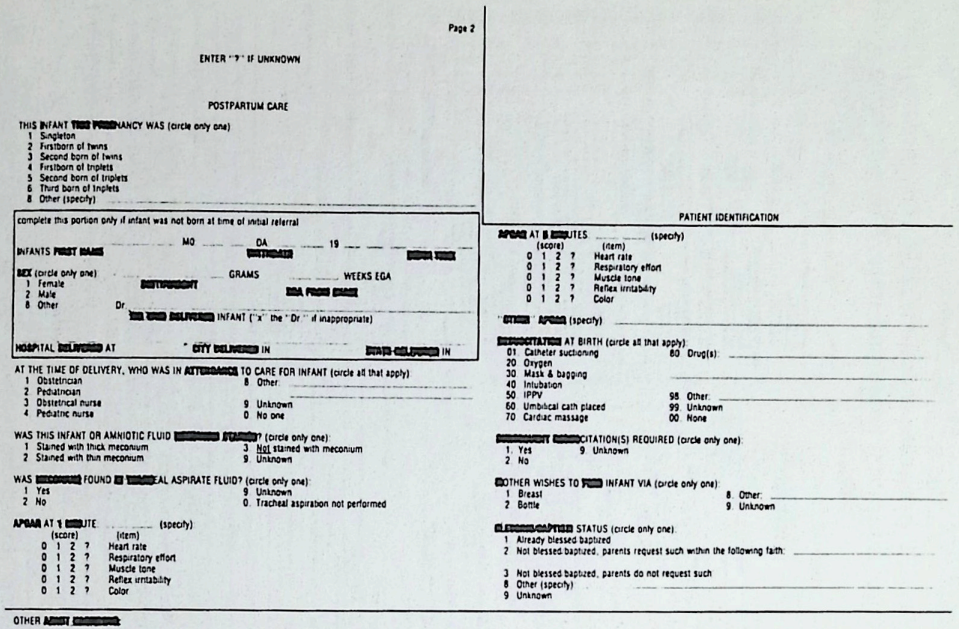


FIGURE 9.3b. Admission history worksheet, back side, in use at INICU, listing information concerning antepartum and intrapartum care. This form is likewise initiated by the transport team and completed by the admitting physician or resident.



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ENTER "?" IF UNKNOWN

POSTPARTUM CARE

THIS INFANT [redacted] PREGNANCY WAS (circle only one)
1 Singleton
2 Firstborn of twins
3 Second born of twins
4 Firstborn of triplets
5 Second born of triplets
6 Third born of triplets
8 Other (specify)

complete this portion only if infant was not born at time of initial referral

INFANTS [redacted] MO DA 19

SEX (circle only one)
1 Female
2 Male
8 Other

GRAMS WEEKS EGA

Dr

[redacted] INFANT ("x" the "Dr." if inappropriate)

HOSPITAL [redacted] AT CITY [redacted] IN [redacted] IN

AT THE TIME OF DELIVERY, WHO WAS IN [redacted] TO CARE FOR INFANT (circle all that apply)
1 Obstetrician
2 Pediatrician
3 Obstetrical nurse
4 Pediatric nurse
8 Other:
9 Unknown
0 No one

WAS THIS INFANT OR AMNIOTIC FLUID [redacted]? (circle only one)
1 Stained with thick meconium
2 Stained with thin meconium
3 Not stained with meconium
9 Unknown

WAS [redacted] FOUND [redacted] TRACHEAL ASPIRATE FLUID? (circle only one)
1 Yes
2 No
9 Unknown
0 Tracheal aspiration not performed

APGAR AT 1 [redacted] MINUTE (specify)

(score)	(item)
0 1 2 ?	Heart rate
0 1 2 ?	Respiratory effort
0 1 2 ?	Muscle tone
0 1 2 ?	Reflex irritability
0 1 2 ?	Color

PATIENT IDENTIFICATION

APGAR AT 5 [redacted] MINUTES (specify)

(score)	(item)
0 1 2 ?	Heart rate
0 1 2 ?	Respiratory effort
0 1 2 ?	Muscle tone
0 1 2 ?	Reflex irritability
0 1 2 ?	Color

"OTHER" APGAR (specify)

[redacted] AT BIRTH (circle all that apply)
01 Catheter suctioning
20 Oxygen
30 Mask & bagging
40 Intubation
50 IPPV
60 Umbilical cath placed
70 Cardiac massage
80 Drug(s):
98 Other:
99 Unknown
00 None

[redacted] RESUSCITATION(S) REQUIRED (circle only one):
1 Yes
2 No
9 Unknown

MOTHER WISHES TO [redacted] INFANT VIA (circle only one)
1 Breast
2 Bottle
8 Other:
9 Unknown

[redacted] STATUS (circle only one)
1 Already blessed/baptized
2 Not blessed/baptized, parents request such within the following faith:
3 Not blessed/baptized, parents do not request such
8 Other (specify)
9 Unknown

OTHER [redacted]

FIGURE 9.4a. Postpartum care worksheet in use at INICC, listing events surrounding infant's delivery and treatment during immediate newborn period. Additional space (shown only in part in this illustration) is available to record events before arrival of the transport team or admission to a newborn intensive care unit.

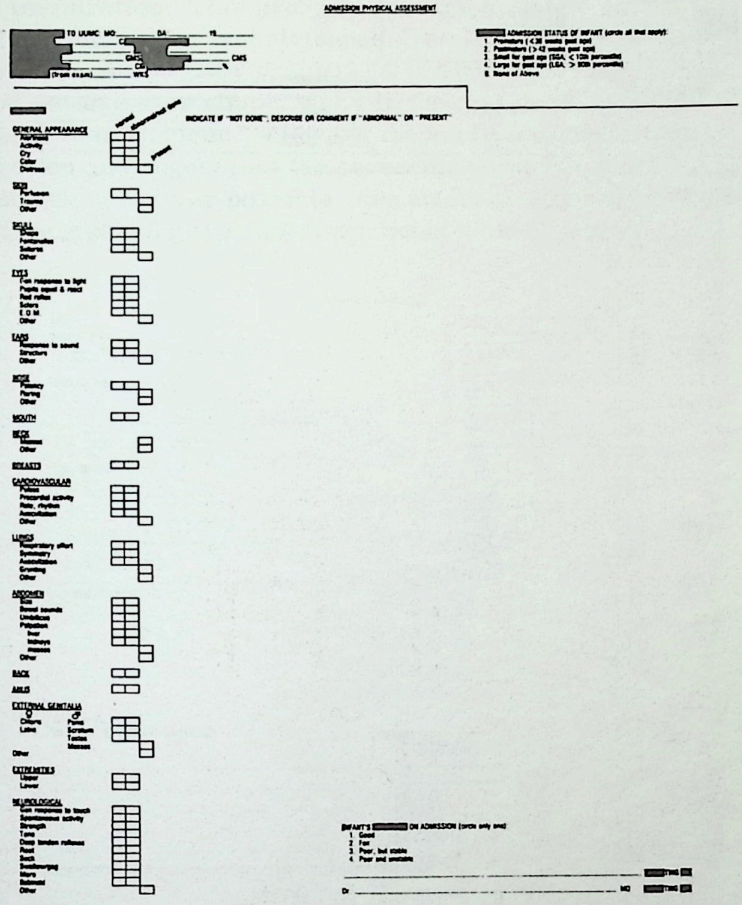

FIGURE 9.4b. Admission physical assessment worksheet, back side of the postpartum care worksheet. Included are checkboxes to record the presence of normal or abnormal findings on admission physical examination, and abundant space is available for comments or detailed description of abnormalities. This form is completed by the admitting physician or resident.

up physicians or agencies on the basis of data recorded in patient files. The program operates in conjunction with either ACTIVE or ARCHIVE patient file disks. At most institutions where the system is in use these notes and letters are hospital-approved, taking the place of dictated admission notes, discharge summaries, and letters to referring physicians, and thus become part of the permanent hospital patient record.

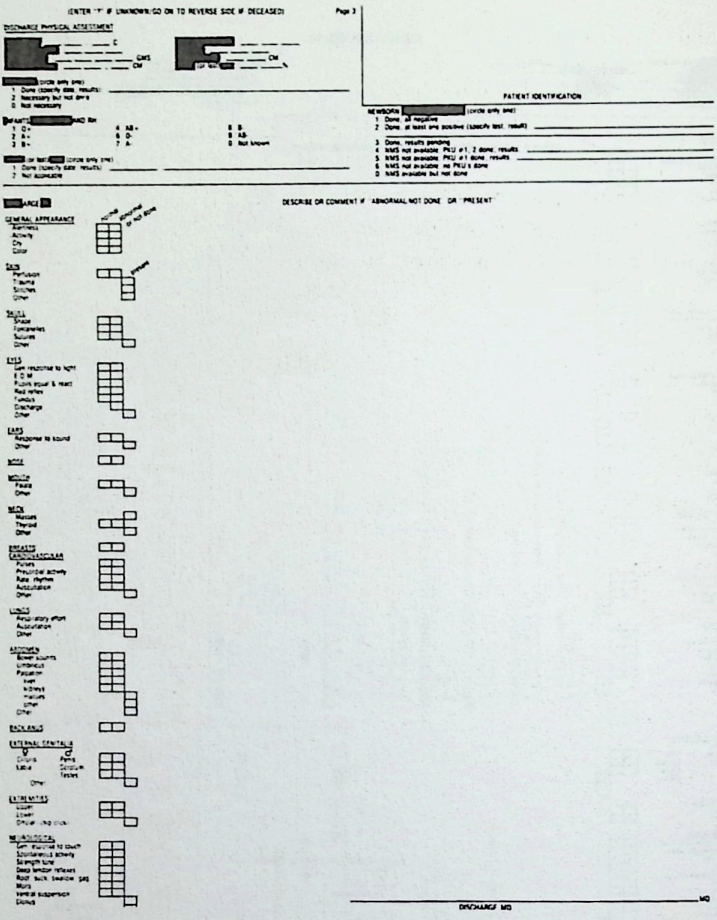

FIGURE 9.5a. Discharge physical assessment worksheet in use at INICC. This form is nearly identical with the admission physical assessment worksheet (Fig. 9.4b), except that it also requests information regarding screening procedures performed before the infant's discharge. This form is completed by the discharging physician or resident.

Data are reported in constructs similar to the questions used (on the worksheets) to solicit the data. Unknown data, including "?" answers, are treated by the system as valid responses to most questions, and are translated into words expressing this response. Lack of an answer, however, is considered by the system to be a recording error. In such a case, the system interrupts note, letter, or summary generation; skips two lines; centers and surrounds the item name with question marks; skips two more lines; and then continues with the docu-

ment preparation. This procedure makes for rapid visual inspection of all documents for completeness. To correct this situation, the user can either use the INPUT/UPDATE program and regenerate a corrected document or simply write in the change on the original computer-generated document, allowing the nurse coordinator to enter the correction and regenerate the corrected document at a later date. Diagnoses, whenever possible, are automatically computed-reported with accompanying ICD-9 (International Code of Diseases, 9th edition)

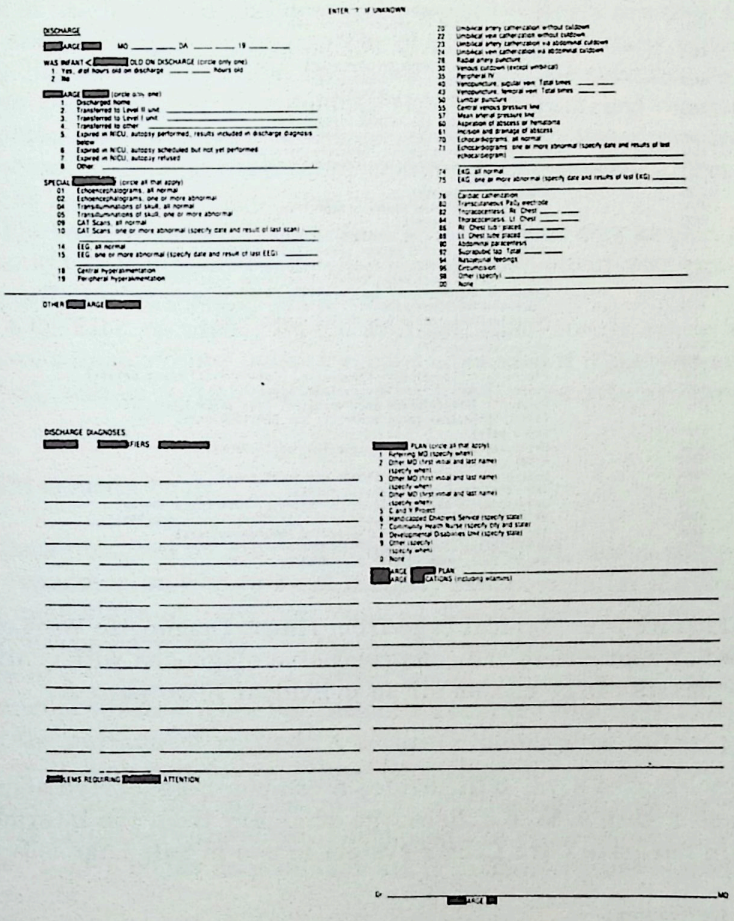

FIGURE 9.5b. Discharge worksheet (back side of discharge physical assessment worksheet) in use at INICC. It is designed for documenting disposition, special procedures performed while in the NICU, discharge diagnoses, follow-up plan, and discharge medications. At the bottom is space for comment on problems still requiring attention after discharge.

INICC DIAGNOSTIC WORKBOOK Page 2
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SYNDROMES

CHROMOSOMAL SYNDROMES

A010	Turners (XO; specify if mosiac)
A060	Trisomy 13 (D-Patau; specify if mosiac)
A120	Trisomy 18 (E-Edwards; specify if mosiac)
A180	Trisomy 21 (G-Downs; specify if translocation or mosiac)
A290	Other chromosomal syndromes (specify)

NON-CHROMOSOMAL SYNDROMES

A300	Achondroplasia
	Addison (see METABOLIC/ENDOCRINE)
	Adrenogenital (see GENITOURINARY)
	Albinism (see METABOLIC/ENDOCRINE)
A320	Apert (acro-cephalo-syndactyly)
A340	Arthrogryposis multiplex congenita
A360	Beckwith-Wiedemann (hypoglycemia, macroglossia, visceromegaly)
A380	Carpenter (acro-cephalo-polysyndactyly)
A400	Cockayne (wasted disproportionate dwarf)
A420	Conradi (dwarfism, stippled epiphyses)
A440	Cornelia de Lange (mental retardation, thickened eyebrows)
	Cretanism (see METABOLIC/ENDOCRINE)
A460	Crouzon (cranio-facial dysostosis)
	Cushing (see METABOLIC/ENDOCRINE)
A480	Cutis laxa
	Cystic fibrosis (see METABOLIC/ENDOCRINE)
A500	Diastrophic dwarfism (disproportionate)
A520	Di George (absent thymus, hypoparathyroidism)
A540	Ellis-Van Creveld (chondo-ectodermal dysplasia)
A560	Fetal alcohol
A580	Glaucoma, congenital
A600	Goldenhar (oculo-auriculo-vertebral dysplasia)
A620	Holt-Oram (hand-heart)
	Hemolytic-uremic (see HEMATOPOETIC/HEPATIC)
	Infant of a diabetic mother (see METABOLIC/ENDOCRINE)
A640	Infantile hypercalcemia (supravalvular aortic stenosis)
A660	Klippel-Feil (short neck, cervical vertebral dysplasia)
A680	Klippel-Trenaunay-Weber (angio-osteohypertrophy)
A700	Laurence-Moon-Biedl (obesity, retinitis pigmentosa, polysyndactyly)
	Mucopolysaccharidosis (see METABOLIC/ENDOCRINE)
A720	Oculo-dento-digital
A740	Oto-palato-digital
A760	Osteogenesis imperfecta
A780	Pierre-Robin (mandibular hypoplasia, glossoptosis, cleft palate)
A800	Poland (absent sternocleidomastoid, syndactyly)
	Polydactyly-imperforate anus-vertebral (see VATER syndrome)
	Potter (bilateral renal agenesis; see GENITOURINARY)
A820	Prune belly
A840	Reticular dysgenesis (complete immunodeficiency)
A860	Rubella, congenital
A880	Rubenstein-Taybi (broad thumbs and great toes)
A900	TAR (thrombocytopenia, absent radius)
A920	Thanatophoric dwarfism (disproportionate, restricted thorax)
A940	VATER (vertebral-anorectal-tracheo-esophageal-renal dysplasia)
A960	Von Hippel-Lindau (cerebello-retino hemangeomatosis)
A980	Von Rechlinghausen (neurofibromatosis)
A990	Wilson (hepato-lenticular degeneration)

FIGURE 9.6. Typical page from INICC Diagnostic Workbook from which appropriate and comprehensive diagnoses with qualifiers and comments can be chosen for an individual NICU patient.

numbers. Figure 9.7a, b illustrates a computer-generated admission note, and Figure 9.8a, b a discharge summary from the Intermountain Newborn Intensive Care Center system in use in Salt Lake City, Utah.

COPY Program

The COPY program permits the user to move patient records from one patient file disk to another, primarily transferring ACTIVE patient data, when complete, onto ARCHIVE disks. This particular function is protected by a "low-level" password. The COPY program also contains special patient record and file utility functions protected by a "higher-level" password available only to the project nurse coordinator.

QUERY Program

The QUERY program is designed to abstract patient data for analysis. Up to 10 characters of a group of infants to be researched or examined can be selected. These selection variables are specified by item name, identified to and by the computer through use of the preassigned, clinically meaningful "names" that appear highlighted within each worksheet question (Figs. 9.1-9.5). Selection variables can be further constrained by setting them at "equal to" or "not equal to" any range(s) of values recorded. Up to 20 items of data to be reported on each record that meets the chosen criteria are then specified to the computer by item name. The computer sequentially searches patient file disks for patient records satisfying the specified selection criteria and prints out in columnar format any recorded reporting item information for each patient record selected. Any items captured by the system, including diagnoses, comments, or narrative, can serve as either selection or reporting variables.

We have abandoned statistical processing of data as part of the abstraction process. Instead, we present the inquirer with raw data in an easily understood, traditional format.

A QUERY requires, on the average, 5 minutes to set up and less than 2 seconds per patient record examined if diagnoses are not searched, and up to 10 seconds per patient if diagnoses are involved.

SYSTEM OPERATION

Data obtained by clerical, nursing, medical, social or ancillary staff, depending on who is most directly responsible for the patient during each stage of care, are entered directly into the computer or indirectly via worksheets and the project nurse coordinator. Upon capture of admission data, a patient admission note is automatically computer-generated from the patient's recorded data base to become part of the permanent record. A separate letter to the referring physician or agency may be generated depending on the site. Upon capture of hospital course and discharge data, a patient discharge summary is similarly computer-produced. Diagnoses are reported with computer-assigned ICD-9 codes as a further aid in medical record and billing departments.

Permanent chart notes are available for visual inspection and signature by the admitting resident or attending physician pending introduction into the chart or mailing to the referring or follow-up physician or agency. Any errors noted can be corrected on the computer, and a corrected note, summary, or letter automatically can be produced to confirm the corrected data base.

INFANT ADMISSION NOTE

INTERMOUNTAIN NEWBORN INTENSIVE CARE CENTER
UNIVERSITY HOSPITAL
UNIVERSITY OF UTAH
Salt Lake City, Utah 84132
(801) 581-2745

#0000000
Jones, Baby Boy
INICU - 2 East
Birthdate: 01/05/80
Admit Date: 01/05/80

Referred by Dr. Scott Janik, Cottonwood Hospital, Salt Lake City, Utah, 801/581-2745

Patient Identification
Baby Boy Jones is a 01 day old male infant referred to INICC 01/06/80 for respiratory distress.

Parent Identification
Mother: Gerri Jones
1020 Sundown Lane
Magna, Utah 84118
801/218-0044
Father: Bruce

Family Health History
Father's health problems include special problems (deaf).
Siblings have no significant health problems.
Relatives have no significant health problems.

Antepartum History
Mother is a 22 year old white gravida 02, para 02, abortio 00, whose general health problems include special problems (deaf). Previous pregnancy history is not known. Prenatal care was received during first trimester, second trimester and third trimester. The number of prenatal visits is not known. Weight gain during pregnancy is unknown. Nutritional status was good throughout pregnancy. Drugs taken after knowledge of pregnancy included vitamins and iron. The following studies and their results were important to this pregnancy:
Maternal blood type: O positive
Indirect Coombs: unknown if test done
VDRL: unknown if test done
Rubella titer: unknown if test done
Hemoglobin/hematocrits: unknown if tests done.

Intrapartum History
Mother was admitted to Cottonwood Hospital, Salt Lake City, Utah in labor, with ruptured membranes. Labor began after spontaneous rupture of membranes. Labor was augmented. 22 hours elapsed between membrane rupture and delivery. Vaginal cephalic delivery was anticipated. No abnormalities were noted with external fetal monitoring. Labor and delivery medications included pudental block, epidural block and pitocin. First stage of labor lasted 21 hours. Second stage of labor

FIGURE 9.7a. Computer-generated infant admission note, page 1, in use at INICC. This note also serves as letter to referring physician to go out shortly after admission of the patient to the regional center.

To operate the system, a user inserts a patient file disk into the right disk drive unit and one of the six applications programs into the left disk drive unit. Disks and disk drive units are color-coded to enhance correct insertion. The system automatically self-initiates without need for special commands. Directions are displayed to enable the user to create or select a patient record. The system then begins to present, in scroll-like fashion, questions that mimic the worksheets both in order and in content. Security sequences may, if desired, be imposed.

No. 0000000 - Jones, Baby Boy Page 2

lasted 30 minutes. A spontaneous, vaginal cephalic delivery was accomplished.

Postpartum History
This 2863 gram male was born 01/05/80 at 1355 hours. The Apgar at 1 minute was 09. Infant and amniotic fluid were not stained with meconium. Resuscitative measures were not employed at birth. The Apgar at 5 minutes was 09. The infant's estimated gestational age on delivery was 35 weeks.

Infant Transfer History
INICC was consulted 01/06/80 at 1600 hours. The infant was transferred to INICC at University Hospital via ambulance by INICC. The transport team arrived at Cottonwood at 1700 hours and departed at 1805 hours after stabilizing the infant as much as possible for transport. The transport went without major problems and the infant was admitted 01/05/80 in poor but stable condition.

Additional Admission History
About 2 hours after delivery, baby began to have mild signs of RDS. During the following 24 hours, he required up to 70% O2 by headbox with rising CO2's. Was cultured and started on antibiotics; then transported here for more vigorous ventilatory support. PROBLEMS: (#1) Prematurity - 35 weeks gestation. (#2) RDS - R/O aspiration pneumonia vs. B. Strep pneumonia. Will follow cultures done at Cottonwood Hospital by Dr. Snarr.

Significant Physical Findings on Admission
Weight: 2800 grams Length: 47 cm Head circ: 34.5 cm
Admission examination was within normal limits for age except for the following: Has a jellowish conjunctival discharge. There are coarse rales and rhonchi heard; equal bilaterally, with severe substernal retractions.

Infant Admission Note Sent to:
Dr. Dr. Scott Janik, Cottonwood, Salt Lake City, Utah

Dr. David Pierce

Attending Neonatologist

FIGURE 9.7b. Computer-generated infant admission note/letter, page 2, to referring physician, in use at INICC.

Answers solicited might be categorical (single or multiple answer), short response (alpha numeric), or narrative in nature. The user can jump forward, backward, and review or correct the data entered and displayed at any time, using simple, one-key commands. Although normal exit occurs at one of several predetermined exit points, a simple two-key command (yellow "caution" key followed by a red "stop" key) can be invoked at any time, saving all data recorded and ensuring immediate exit from a program.

In a similar manner, the PRINTOUT program lets a user automatically computer-generate admission notes, letters, and discharge summaries from patient data bases. All output is "secretary" quality, in upper and lower case, using traditionally constructed English sentences, and is formatted in site-specific, seminarrative style familiar to medical personnel.

INFANT DISCHARGE SUMMARY

INTERMOUNTAIN NEWBORN INTENSIVE CARE CENTER
UNIVERSITY HOSPITAL #0000000
UNIVERSITY OF UTAH Jones, Baby Boy
Salt Lake City, Utah 84132 INICU - 2 East
801/581-2745 Admission date: 01/05/80
Discharge date: 01/11/80

Birthdate: 01/05/80 EGA from LMP/EDC: 35 weeks
Birthweight: 2863 grams EGA at initial exam: 35 weeks

Referred by Dr. Scott Janik, Cottonwood Hospital, Salt Lake City, Utah

Diagnostic Problem List

Y21 Prematurity, 35 weeks gestation
771.8
Septic work-up (infection not demonstrated, therapy aborted)
Cultures (-); antibiotics x 3 days.
Onset 01 day of life
Etiologic organism: None identified
Rx: Ampicillin and Gentamicin
769
Hyaline membrane disease Rx Bird respirator
Weaned to CPAP x 1 day then to head box. Presently in 26% FiO2.
Used 3 days
Highest FIO2 delivered: 100 %
Highest FIO2 delivered for <1 days
Highest pressure delivered: 23 cm water pressure
774.6
"Physiologic" hyperbilirubinemia, bililight required
Level 1/11/80 is 11.3.
Onset 01 day of life
Highest indirect/optical bilirubin: 11 mg%
Last indirect/optical bilirubin: 11 mg%

Special Procedures Done
Peripheral hyperalimentation
Umbilical artery catherization
Peripheral IV's
Transcutaneous PAO2 electrode used
47cc PRBC's given in 3 transfusions.

Discharge Narrative: Born 1/6/780 at 35 weeks gestation to a 22 year old deaf mother. Father is also deaf. Two hours after delivery, noted to have mild signs of RDS with increasing PCO2 by UAC blood gases. Required intubation and respirator support at about 40 breaths/minute and pressures of 23/4. Pavulon and phenobarb were used secondary to fighting respirator. Patient had good course of steady improvement and

FIGURE 9.8a. Computer-generated infant discharge summary, page 1, in use at INICC. This summary becomes a part of the official medical record, replacing the usual transcribed version of an individually dictated discharge summary.

EVALUATION

The CETUS System 100 NICU data recording, reporting, and research system described above incorporates more than 6 years' experimental systems research and more than 8 years' field research experience. On the basis of extensive field evaluation studies,[3] this system can be expected to:

Reduce physician and nursing admission/discharge paperwork up to 80 percent. Required admissions paperwork averages 20 minutes

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on 1/10/80, was extubated and did well on decreasing FiO2's per head box.

Status and Disposition at Discharge: Infant transferred to Cottonwood Hospital, Salt Lake City.
Significant Physical Findings:
weight: 2170 gms length: 48 cms
head circ: 35.0 cms temp: 36.8 deg Centigrade
heart rate: 150 resp rate: 50
blood pressure: 70
Discharge examination was within normal limits for age except for the following: Baby is lethargic after feedings.
Significant Lab at Discharge:
Newborn Metabolic Screen done but results pending
Last hematocrit: 51 % (Infant is O positive)
Discharge retinoscopy (date and results): 1/10/80: Normal exam, no RLF
Discharge CXR (date and results): 1/10/80: Improving HMD

Feeding Plan: PO EFP formula (gavage prn)

Discharge Medications: IV Hyperal (formula C) at 12cc/h; decrease rate as feedings are increased.

Problems Requiring Further Attention: (#1) Hyperbilirubinemia - follow levels and begin phototherapy if T. Bili >15. (#2) Wean off O2 as tolerated. (#3) Needs second newborn metabolic screen. (#4) Parents are congenitally deaf; we feel that by our tests, the child will need further evaluation at 2-3 months for brainstem studies. Here there was +/- response to 100 DB noise.

Followup Appointments
Referring MD, Dr. Dr. Scott Janik - upon transfer
Utah Div of Family Services, Children & Youth Project (C & Y # unassigned)

Discharge Letters Sent to:
Referring MD Dr. Dr. Scott Janik
Dr. Anna Bodner, Medical Director, C & Y Project, Utah State Department of Public Health

Dr. D.R. Beach

Attending Neonatologist

FIGURE 9.8b. Computer-generated infant discharge summary, page 2, in use at INICC. A copy of this summary is sent as a letter to the physician identified to provide follow-up care for that patient after discharge.

or less for transported patients, with no extra time spent in generating an admission note or letter to referring physician. Discharge paperwork averages 15 minutes or less, with no extra time spent to produce the multiple discharge outputs.

Improve completeness and reduce errors of commission of the medical data base by more than 10-fold combined.

Reduce time from patient discharge to receipt of patient care information within the referral community by up to 96 percent. Discharge summaries can be expected to reach the referring physicians within an average of 5–7 days after patient discharge, rather than the more usual 2-month wait experienced with traditional systems.

Reduce time and cost of data abstraction substantially, depending on the size and nature of the data abstraction job involved.

Temporary system failures over the first year of operation of the dedicated on-line microcomputer predecessor were few and minor (blown fuse, dirty air-intake filter, dirty diskette head) and never resulted in a delay of greater than 4 hours.[3]

Sites requesting installation of the new CETUS System 100 are required to provide a systems advocate—usually an interested NICU nurse who will also serve as discharge coordinator and follow-up liaison person.

CONCLUSION

A practical, microcomputer-based data recording, reporting, and research system has been described. It was designed to address documentation, communication, evaluation, and clinical research needs of most neonatal intensive care units. The CETUS System 100 is relatively inexpensive both to acquire and maintain. In 1981, acquisition costs were approximately $38,000 including hardware, site-specific software, installation, and personnel training; maintenance costs were generally less than $6000 per year. The system will operate, if necessary, in an environment independent of other computer facilities, is easily moved, requires only a desk-size area and conventional power, and meets the time and processing constraints of a medical facility. The system uses familiar, industry-compatible hardware, operating system, and high-level programming language suitable to this and other microcomputer-based clinical applications.

The appeal of the CETUS System 100 goes beyond its apparent low cost, accessibility, easy maintenance, and independence. It represents a well-planned, intelligent application of computers in neonatal medicine in tandem with the needs of each individual end user and need not suffer compromise arising from local political, communication, or experience liabilities.

REFERENCES

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3. Janik DS, Sharp EM, Forbush L, et al: Computerized newborn intensive care data recording, reporting, and research. III. A practical microcomputer system. J Pediatr 97: 497-500, 1980.

4. CETUS Systems Corporation, P.O. Box 8624, Salt Lake City, Utah 84108. Telephone: (801) 350-8731.