PERSONAL COMPUTER USE IN NEONATAL INTENSIVE CARE UNITS - A FIVE-YEAR EXPERIENCE

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The need to adopt computer data systems for perinatal and neonatal care was first emphasized at the First National Conference on Perinatal Data Systems at the Medical College of Wisconsin in Milwaukee in September 1980. The subsequent increasing use of computers for assisting in neonatal care was not always easy for users. As with any new technology, some shortcomings appeared that had to be worked out. For example, problems regarding costs, inefficient use of time, staff compliance, as well as the possibility of detrimental effects on patients had to be recognized and dealt with.

Selecting the proper type of system also posed somewhat of a predicament. In the beginning, advocates of the advantages to be gained from centralized systems, requiring bulky equipment, enormous capital investment, and standard form, were in the majority.

This paper was presented at the First World Symposium on Computers in the Care of the Mother, Fetus, and Newborn in Wien on March 8-11, 1987.

More recently, those in favour of more decentralized systems with more flexible programs, more adaptable to single-unit needs, have come to the fore. Arguments for and against these two types of systems can make choosing equipment rather confusing. One must take into account the number of machines available on the market, recommendations by various institutions, as well as the abundant information in print regarding the equipment. With a little research, one will soon find that facilities exist that, at various levels, offer custom-tailored solutions to a wide range of clinical areas in need of assistance.

Until recently, microcomputer systems were characterized by annoying limitations, due to their restricted data storage capacity, limited speed in data processing on cassettes or diskettes, and by their inability to communicate with larger (mainframe) computer systems. These limitations and inconveniences have been practically eliminated over the last 5 years due to the availability of new widely-marketed commercial products which are now used in the hospital ward.

Main Areas of Use

Harris (1) has identified four main areas for computer use in neonatology:

1. DATA ANALYSIS or SIGNAL PROCESSING
2. INTERACTIVE
3. THERAPEUTIC INTERVENTION
4. CLINICAL INFORMATION STORAGE/RETRIEVAL

An example of the first area is real-time trend analysis, which, through reading several clinical variables relating to the patient such as respiratory rate, heart rate, or blood pressure, and by processing these data enables us to predict in good time incipient patient deterioration, and thus to start preventive measures, or to reduce the treatment, if necessary, if the patient is shown to be improving. Similarly, it is possible, through continuous monitoring of drug levels in the blood, to study pharmacokinetics, to optimize drug dosage, or through the processing of multidirectional x-ray data, to obtain picture images of various parts of the body (C.A.T.). The benefits to the newborn arising from the use of imaging are indisputable. However, the monitoring system based on computerized data analysis are not always helpful. Furthermore, this approach may require bulky equipment, a full-time programmer, and other facilities that not everybody can afford.

Harris' second area, the dialog between users and computer is frequently used in literature search, in professional teaching, learning, and updating; in differential diagnosis; in the rapid interpretation of the ECG; and so on. This aspect of computer application has not been used extensively in practice of neonatology. In fact, this procedure is not without risk: It may increase dehumanization of the relationships between patient and doctors; it may also give rise to misinterpretations of patient data due to the wide variability of factors depending on how the neonate adapts to the extrauterine environment, or when clinical situations involve diverse organs.

Moving on to Harris' third area of use, the computer has been more frequently used to direct modify patient treatment in specific fields such as adjusting the oxygen concentration in inspired air according to the variations of partial arterial oxygen pressure, or regulating the environmental temperature and the nutritional intake on the basis of continuous monitoring of certain vital signs (heart rate, respiratory rate, skin and core temperatures and so on).

The final area of computer utilization in neonatology, that is, patient information storage and retrieval of perinatal data has become more and more important during the last 10 years.

Less then 10 years ago, Jennet (2) and Janik (3), working independently, reported the first results of the computerized gathering of obstetrical and neonatal data. Today, most obstetric units collect and process data, on a day to day basis, using programs with various levels of complexity.

Staff Acceptance

Many factors justify an increasing acceptance of computer-based data systems in this field, on the part of the staff:

(1) Increasing amount of data in every perinatal chart, mainly in patients at high risk;

(2) The need to capture instrumental and laboratory data;

(3) The need to evaluate cost, working hours, effectiveness

and efficiency, follow-up data and so on.

In short, the collection of all factors concerned with the so-called quality assurance audit can be enhanced through the use of personal computers.

Several major goals are suggested by the many reports on the features that are common to most computer systems in perinatology: 1) To promote the standardization of data recording and reporting; 2) To improve the quality and accuracy of data gathering, thus decreasing the work load of physician; 3) To obtain a continuously increasing acceptance of the new method by users, through the evidence that gathering and processing data is very useful in improving patient care and in reducing costs, work times (particularly those hours dedicated to less rewarding activities such as writing discharge reports, physical examination findings, follow-up recording data, etc.; 4) To enable individual neonatal intensive care units to compare their activity with those of other centers, or to enable the regional neonatal experience to be compared with that of other regions.

Before data gathering and computer utilization are accepted by the staff, a "cultural revolution" will be needed. This will not be easily attained, unless the following favorable conditions are present:

1. Progressive and continuous involvement of clinical users in all phases of programming and hardware selection, as well as in the purpose, design, and content of the programs.

2. Gradual introduction to the computer, via simple and rapidly executed programs that do not discourage users during their first experience with the computer;

3. Involvement of staff at all levels (nurses, physicians, office staff, etc.) through the use of simple instructions to arouse the users' interest as early as possible, principally in terms of time saved, reduction of tedious tasks without detriment to real work satisfaction.

4. Trial period during which users may propose changes based on their previous experience.

5. Limitation of overdesigned programs (excessive number of questions or too detailed questionnaires) which may lead to loss of accuracy and a shortfall in information, themselves signs of poor compliance.

Data Collection in Italy

During the 1970s in Italy, the data available on natality, perinatal and neonatal morbidity and mortality were inadequate because the main source of these data were birth certificates, death certificates, and reports of infectious diseases.

An example of data items from birth certificate is show in Table 1.

TABLE 1: DATA ITEMS IN BIRTH CERTIFICATE

1 - Date of birth
2 - Viability
3 - Mode of delivery
4 - Length of gestation
5 - Filiation
6 - Order of parity
7 - Date of parents' wedding
8 - Date of birth of parents and brothers
9 - Mother's residency
10 - Parents' occupation
11 - Position within a profession
12 - Non-professional occupation (unemployed?)
13 - Instruction to parents
14 - Place of birth
15 - Congenital malformations of the newborn
16 - Presentation and birth weight
17 - Consanguiniety of parents

These birth certificates were short on detail, lacking the main internationally adopted data, for example gestational age, presentation at delivery, type of delivery, and so on. The death certificates and the diagnosis records were compiled according to chapter 14 and 15 of the manual of International Classification of Diseases (8th ed. 1985) and thus were far from thorough. The list of infectious diseases to be compulsorily reported did not include many conditions frequently found among neonates. In all certificates, the answer "other" was to be found in a very large number of cases, thus rendering detailed analysis impossible.

The information flow from each local area (communes and provinces) was based on a system full of defects:

1) Lack of involvement of clinical staff and thus little active participation in complete and reliable gathering of data at source.
2) Poor evaluation of the accuracy and the thoroughness of the material, collected and processed by office staff, lacking critical criteria.
3) Very long intervals (2 to 4 years) between the gathering of data regarding a cohort and making available these data, leading to unavailability of vital statistics and increasing scepticism as to their value.

The lack of regional programs, the shortage of resources for gathering and processing data analysis, and the lack of interest expressed by the clinical staff worked against accepting the need for quality assurance, to improve the use of scarce economic resources.

In the presence of these shortfalls in utilizing computer data systems, the needs of the technical staff, already skilled in dealing with computers, were growing day by day, pointing to the need for comparative investigation of data with regard to use of resources and level and quality of treatment.

In this state of affairs, physicians and nurses tended to maintain traditional professional attitudes; nobody considered himself a member of a coordinated and integrated system; all displayed poor compliance with scientific evaluation methods and revision of work performances. Given these difficulties, the introduction of a computerized data evaluation system regarding neonatological activity with the purpose of evaluating efficiency and efficacy and therefore modifying procedures would have seemed a "cultural revolution" for the clinical staff.

Since 1981, we have dealt with this problem through a new system of data gathering. It was originally limited to basic data (perinatal and neonatal mortality and diagnosis of pathologic neonates, general procedures analysis, etc.), and later, we collected more detailed data. During the first 2 years the program was phased in gradually to enable the users to get to know it and use it, and thus not reject it, and to enable updating on the basis of preliminary experience.

The difficulty involved in gaining access to large computer systems and utilizing previous experience, as well as having limited financial and professional resources induced us to adopt a personal computer for direct use in the department, to obtain progressive information storage and retrieval.

From September 1981 to March 1983 hardware comprised a personal computer: Hewlett-Packard HP 85A. Patient records, collected on patient file cassettes, were able to include up to 1200 bytes of information. One cassette contained up to 125 patient records.

TABLE 2: HARDWARE

	H.P. 85	H.P. 86
RAM	64 K	64 K
MASS STORAGE	TAPE CASSETTE	ONE 5" DISC
M.S.U.S. capacity	256 K	256 K
SCREEN (rows x columns)	16 x 32	24 x 80
PRINTER	chemical paper 32 columns	common paper 80 columns

Initial hardware costs in 1981 were in the range of \$10,000 and maintenance, support, and supply costs did not exceed \$2,000 per year. Since March 1983, to improve data gathering, processing and speed of data retrieval, we have been utilizing a HP 86 system with a standard screen (80 columns by 16 by 24 rows), a single disk drive, a low-speed 80 columns standard printer. Mass storage was om a 5" floppy disk with a capacity of 256 Kbytes each (cf. Table 2). The additional costs in 1983 were in the range of \$5,000, and the maintenance, support and supply costs were unchanged, or even reduced, in comparison to HP 85 costs.

Since June 1986 a new IBM XT system has been in utilized (cf. Table 3).

TABLE 3: HARDWARE IN USE SINCE JUNE 1986

COMPUTER:	IBM XT
MASS STORAGE:	10 MB DISK AND ONE 5" DISK
CAPACITY:	SEVERAL THOUSAND PATIENTS
OUTPUT:	SINGLE ITEM, WHOLE PAGE, OR OTHER DIFFERENTLY ARRANGED GROUPS OF ITEMS.

Physicians and nursing staff had no experience in the use of computers; this was the first experience in the health sector for both the coordinator and the programmer.

The design criteria for our neonatal database system included the following:

1. Convenience of use in comparison to traditional system.
2. Acceptance on the part of all the staff, persuaded of the usefulness in continuous, more objective assessment;
3. Improvement in work standards at all levels (physicians, nurses, technicians, etc.);
4. Efficiency of use of disk space, memory and computer time;
5. Flexibility and ease of modifications;
6. Flexibility of selection and retrieval of data;
7. Ability to promote active collaboration with other Italian neonatological groups to achieve homogeneity in the evaluation of each individual activity and, therefore, in care and treatment;
8. Possibility to deal with a large amount of data gathered

in collaboration with other centers, but leaving ample space (about 40% of the program potential) to the discretion of user for his or her own personal requirements.

To achieve these goals, in particular, the active and constant participation of almost all the staff concerned with care and treatment, since January 1983, we have gathered data without modifying the patient's clinical chart. Instead, we included the "pleated" form (which we call the accordion, because of its shape) for the collection of data, before entering them in the computer mass storage. In other words, data aren't directly entered in to the computer by physicians, nurses, and clerical-secretarial staff, but indirectly via worksheets, which are the link between the clinical chart and the computer. Physicians, and nurses were able to utilize an instruction manual showing how to transform the clinical data into computer language. No data were introduced directly into the computer, but all was collected on the pleated form before being typed in.

Every pleated form contained 33 pages corresponding to several groups of data, adding up to a total of 486 data items. Some of the data were arranged in chronological order, other data were arranged according to quality criteria: socio-economic, pharmacological, cardiological, and so on (cf. Table 4).

TABLE 4: PLEATED FORM DATA

Generalities (name, birthdate, ...)	p. 1,2
Pre- and postnatal growth parameters	p. 3
Maternal and pregnancy data	p. 4,5
Delivery data	p. 6,7
Exam and clinical data at admission	p. 8
Instrumental and laboratory findings	p. 9-21
Prenatal orthopedic deformit. and malf.	p. 22
Drug administration and plasmatic levels monitoring	p. 23-27
Food administration and nutritional data	p. 28
Parental and professional personnel attitudes monitoring	p. 29-30
Discharge and follow-up recording data	p. 31-33

Answers to the questions contained in the root data file can be expressed in different ways, including multiple-choice, floating decimal, date, time, alphabetic characters and so on, and include most of mother and neonate data, laboratory data, diagnoses, follow-up, etc. Certain forms are designed for the final evaluation, others to evaluating medical staff attitudes towards the infant, and so on. The data were collected gradually, during the patient's stay in the hospital, with particular regard to certain stages, for example transport, admission, and so on. Particular attention was paid to the diagnoses. A list was made up of about 200 of the most common diagnosis, grouped into major categories.

The diagnostic list for every patient was divided into primary and secondary groups, according to their relative importance. Essentially complete data (root data file) were entered for any neonate admitted to the Neonatal Intensive Care Unit (NICU) about 700 patients per year). The cumulative time required to collect data for each single patient was three to five hours, depending on the seriousness of the clinical situation and on the duration of the stay in the hospital. The time required to enter data was about 15 to 20 minutes per patient. Subsidiary files were left free for the collection of other data, according to the users' necessities. The final goal was the progressive collection of data, as exhaustive and continuous as possible, to be processed. These data represented the type and the level of care and treatment within the NICU, and enabled us to perform a permanent evaluation in order to induce a gradual and continuous change in attitudes and performances.

At the 9th European Congress of Perinatal Medicine in Dublin, in September, 1984, we presented the results of our preliminary experience. We emphasized the benefits gained during the utilization of the "UDINE/83" program, analyzed the possible disadvantages attached to this new program, and discussed a number of problems still existing in the application of the program itself. At the time 6 other Italian NICUs had joined the project.

The main benefits gained from the application of the "UDINE/-83" program were:

1. Avoidance of reexamination of clinical charts after the

patients' discharge;

2. Feasibility of the single and progressive gathering of data;
3. Continuous and repetitive analysis of data gathered according to statistical criteria;
4. Comparison of old and new data in the light of new approaches or changes in work systems;
5. Awareness of the real conditions in which research is to be carried out, or in which follow-up is performed;
6. Evaluation of the work burden (number or tests, examinations, consultations);
7. Recording of the admission patterns and, more generally, the frequency of admissions and discharges, the length of hospital stay;
8. Attempt at cost/benefit analysis.

The data system's acceptance by users was not totally satisfactory: After 2 years, only one third of doctors collaborated actively and on a daily basis in the collection of data; another third collaborated sporadically, and the remainder displayed poor compliance, as evidenced by incomplete and inexact responses as well as delays in the compilation of the pleated forms.

Results of Data Collection

Figure 1 shows the distribution of patients admitted to our Department, divided into three main types: the neonatal intensive care unit, the mild pathology unit (nursery) and the older patients' admissions (day hospital, readmission, etc.). The year by year trend can be seen: In the last 3 years, the number of admissions has been decreasing, except for those in the neonatal intensive care unit, who depend on physicians' individual decisions to a lesser extent than other types of admissions. The least serious problems are now dealt with without admission, while the baby is in the neonatal section of the obstetrical ward, and an increasing number of instrumental tests are performed on a surgery basis (whenever possible) in older patients after first discharge.

Figure 1 - Different types of admission.

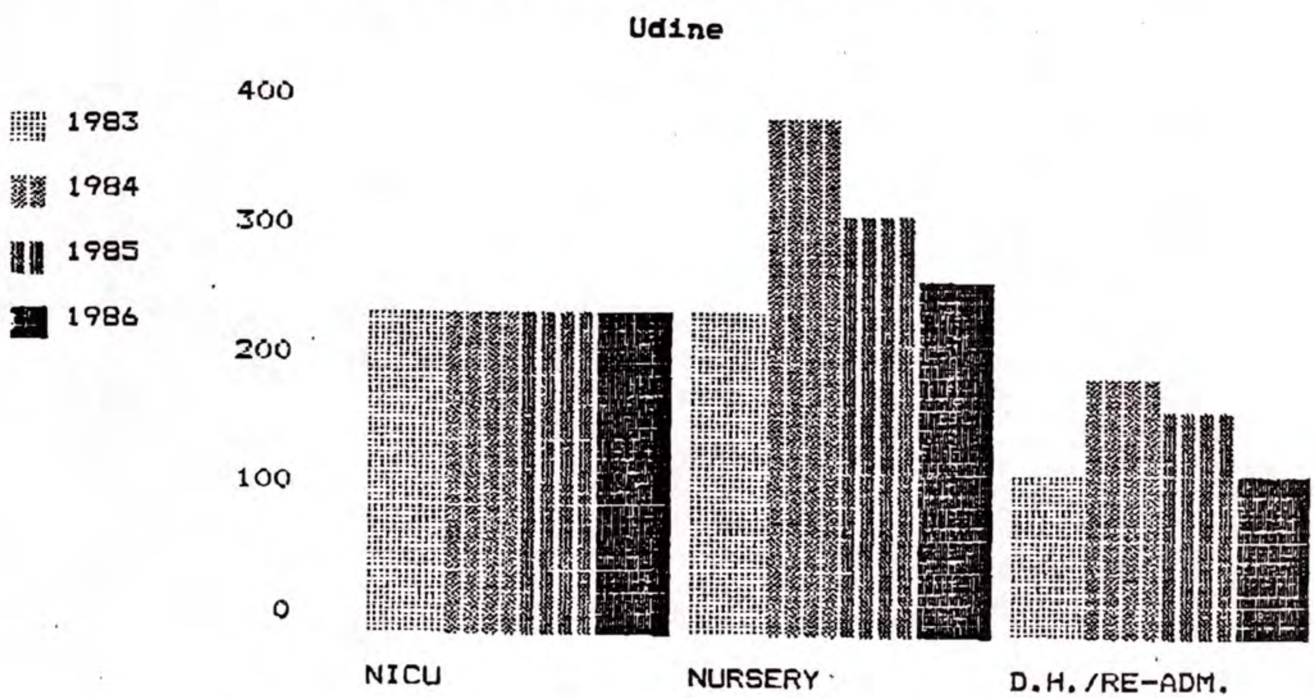
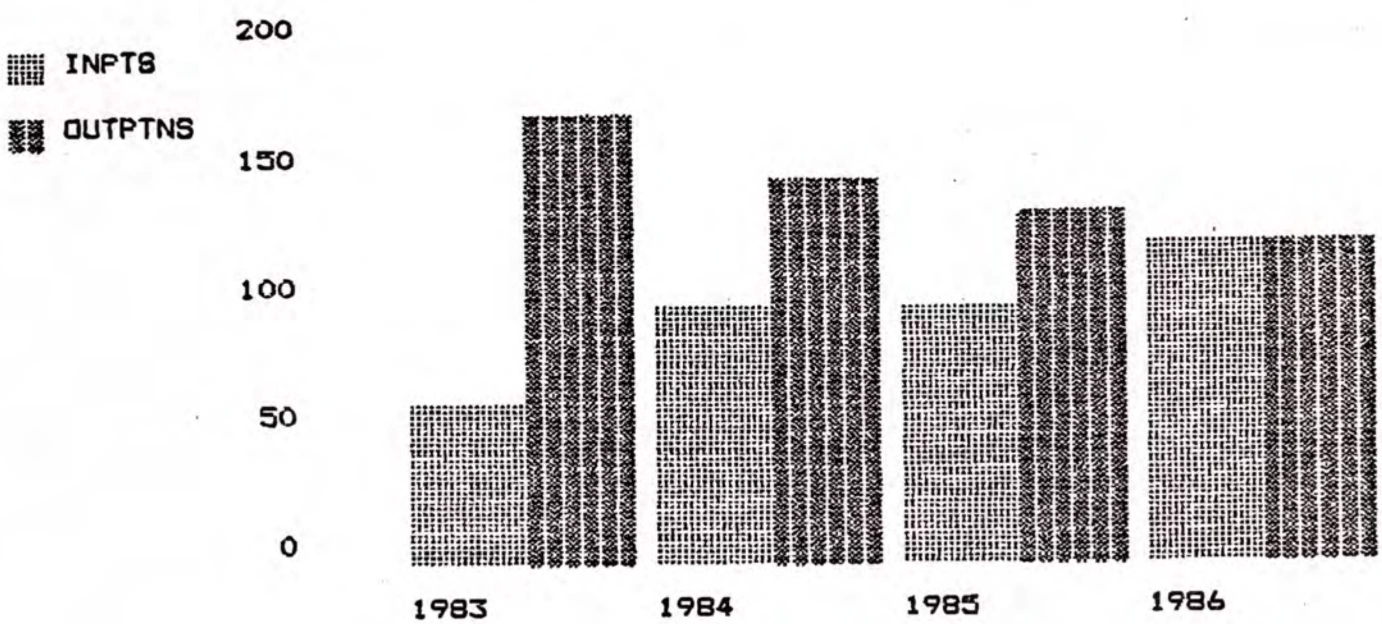


Figure 2 shows the number of admissions in the neonatal intensive care unit, divided into inpatients (born in our hospital) and outpatients (born in other hospitals, and transferred by ambulance): The trend in the 4 years is a constant decline in outborns, and a corresponding increase in inborn babies: The total number is almost the same from 1983 to 1986. We have attributed this trend to an increasing prenatal transfer of pregnant women at risk from outlying hospitals.

Figure 2 - N.I.C.U. Number of Admissions (INPT/OUTPT).

Udine



As a consequence, Figure 3 shows that the difference in the sum total of patient hospital days between inborn and outborn patients is narrowing year by year.

Figure 3 - N.I.C.U. Sum Total Patients' Hospital Days.

Udine

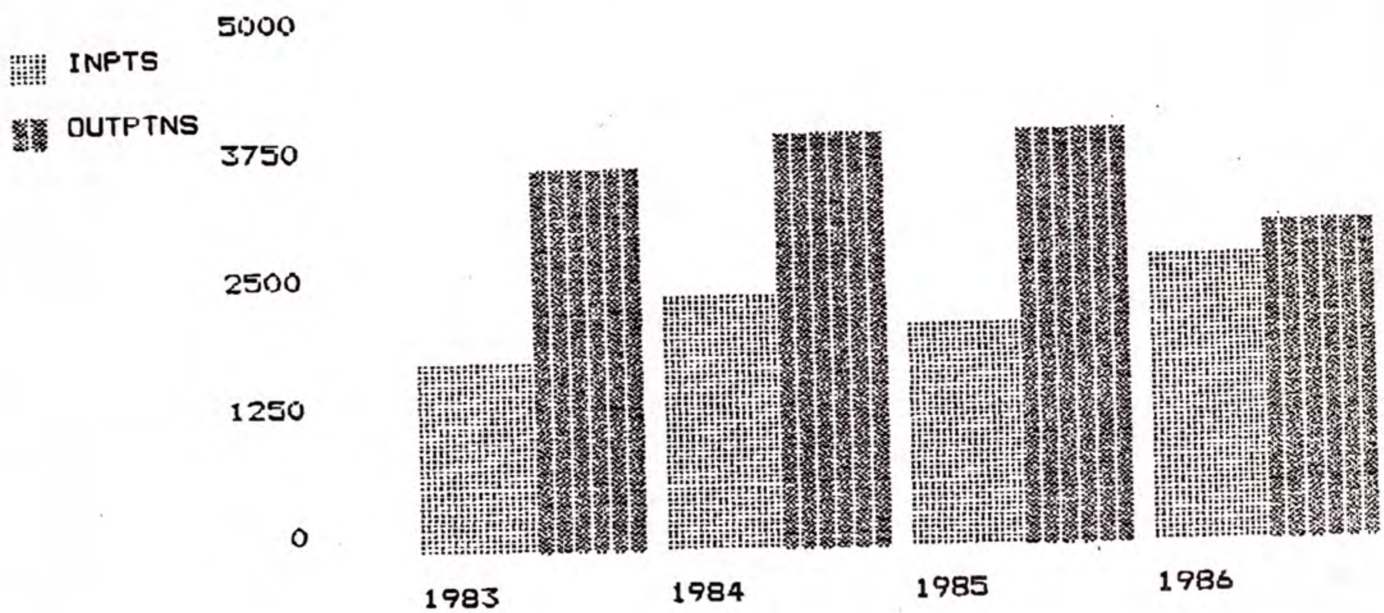
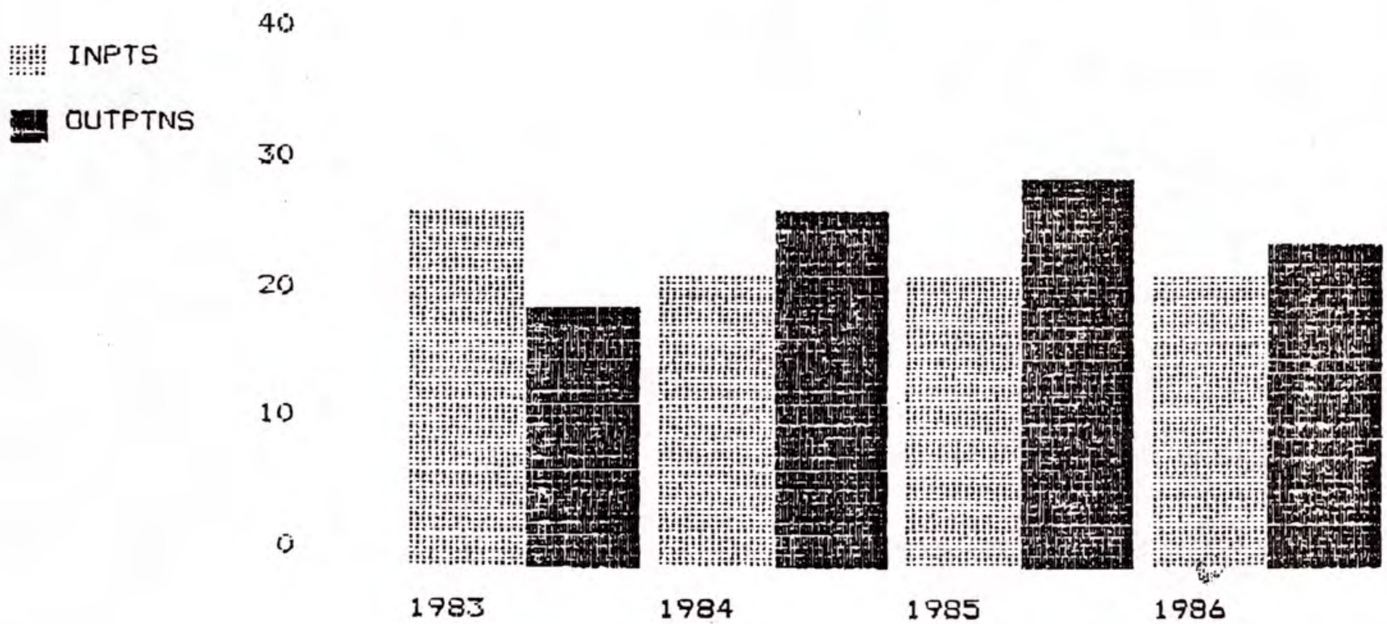


Figure 4 shows the mean hospital stay in inborn and outborn babies: There is no statistically significant difference, but the hospital stay is slightly longer for outpatients, in spite of the back transfer to the referring hospital of several newborns in a later stage of recovery. This policy is aimed at encouraging a binding of the babies with their parents and relatives, when only an increase in weight is required before discharge.

Figure 4 - N.I.C.U. Mean Hospital stay (INPT/OUTPT). Udine



Figures 5 through 7 show that no differences in our admission criteria were introduced in the period considered, because no statistical difference exists, year after year, in mean gestational ages (Figure 5), mean birthweight (Figure 6), and mean Apgar score at first minute (Figure 7).

Figure 5 - N.I.C.U. Mean Gestational Age (INT/EST). Udine

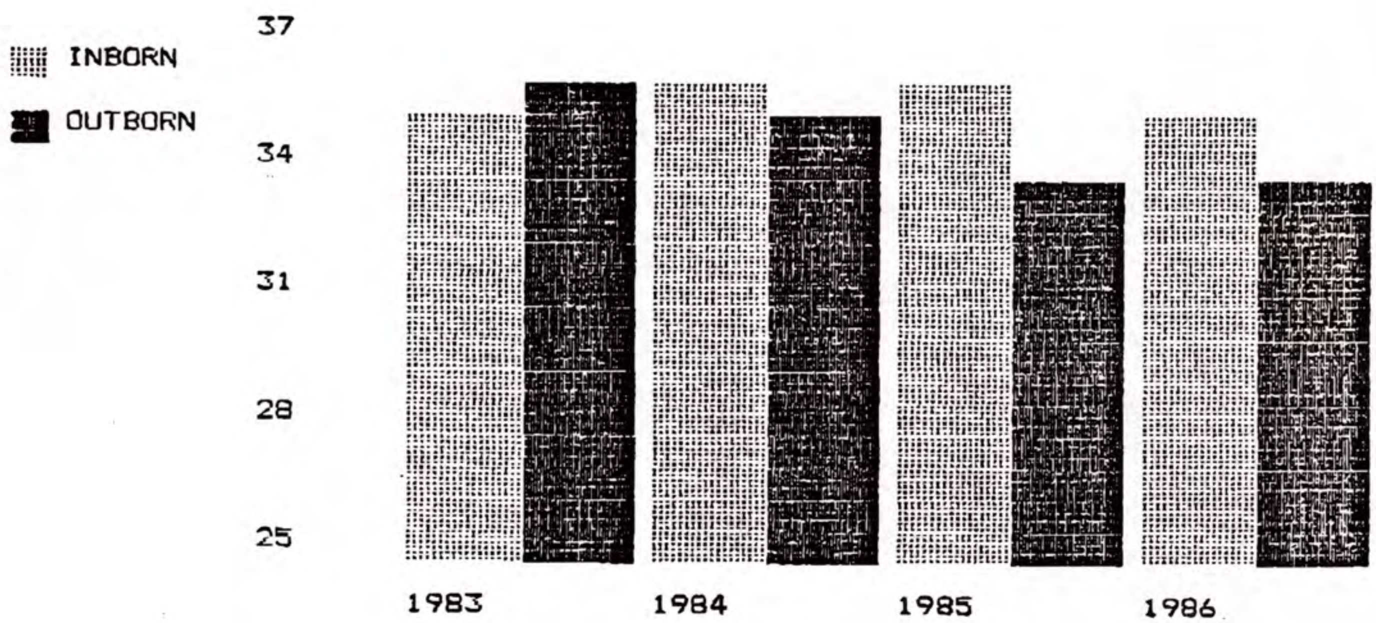


Figure 6 - N.I.C.U. Mean Birth Weight. Udine

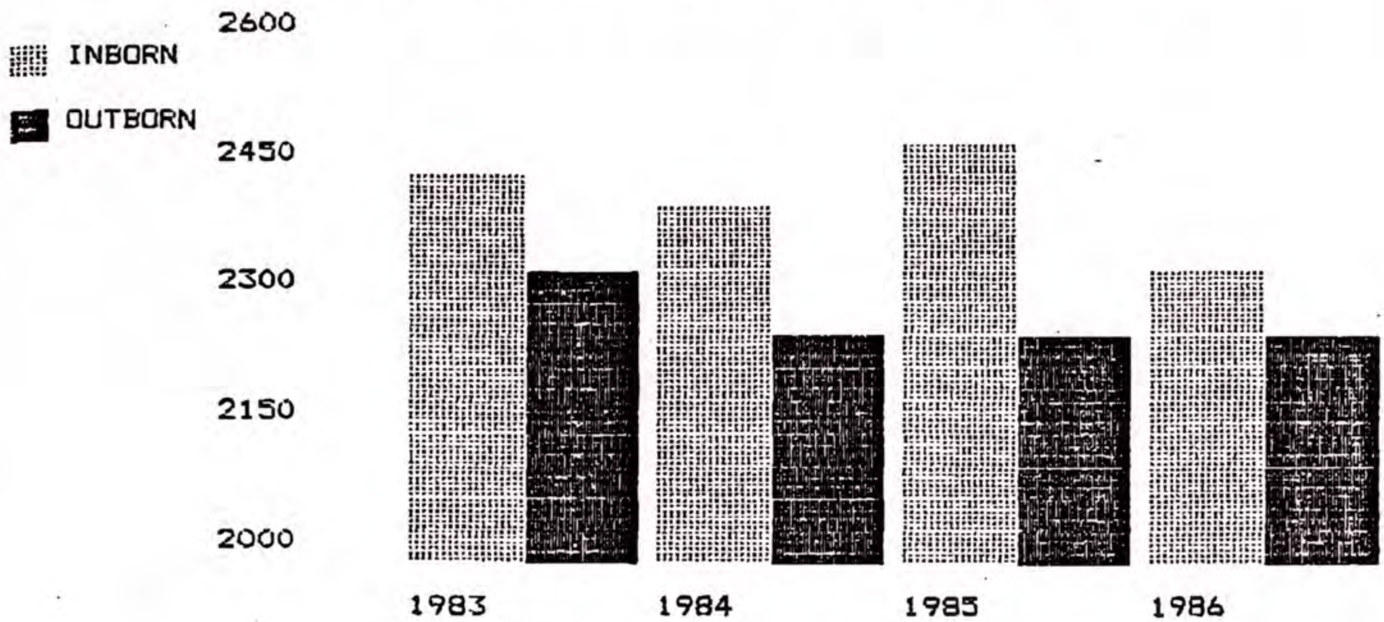
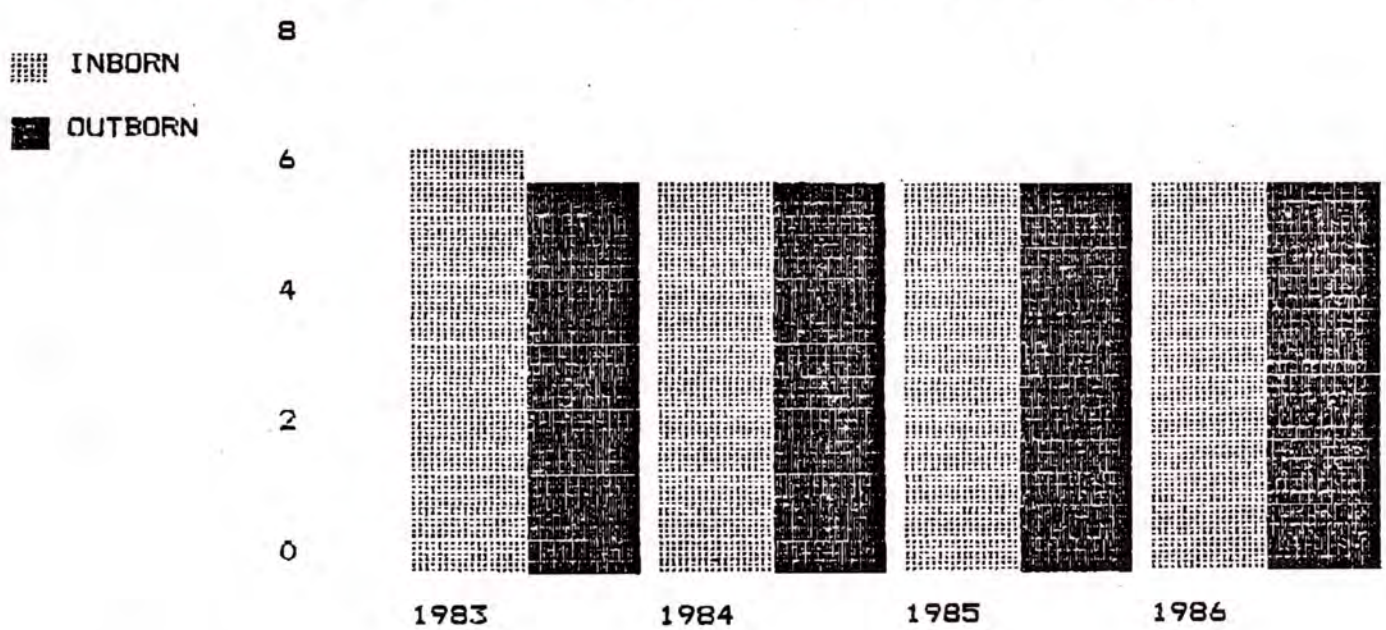


Figure 7 - N.I.C.U. Mean Apgar Score (N.I.C.U.). Udine



A favorable trend has been found in the improvement of the acid/base status at admission. No difference exists between inborn and outborn in the first 2 years; in 1985, an improvement is found only in the inborn patients.

Once we were aware of the lack of improvement in outborn patients, we made an effort to further ameliorate our transport by ambulance: The result was satisfactory in 1986.

The difference between inborns and outborns is statistically significant in 1985 for the incidence of both mild ($p < .02$), and severe ($p < .01$) acidosis at admission. Similar figures are attained in the year-by-year differences.

The next figures show the year-by-year trend of some indicators of intensive care activity: We realized that our policy toward mechanical ventilation and oxygen administration for long periods was increasing from 1983 to 1985, so we made an effort to wean the babies from the respiratory support earlier, as may be seen in 1986 (Figure 8: Oxygen Therapy; Figure 9: tracheal Tube Mean Hours). A low statistical significance is attained ($p < .05$).

Figure 8 - Intensive care (Oxygen Hours/Pt.) Udine

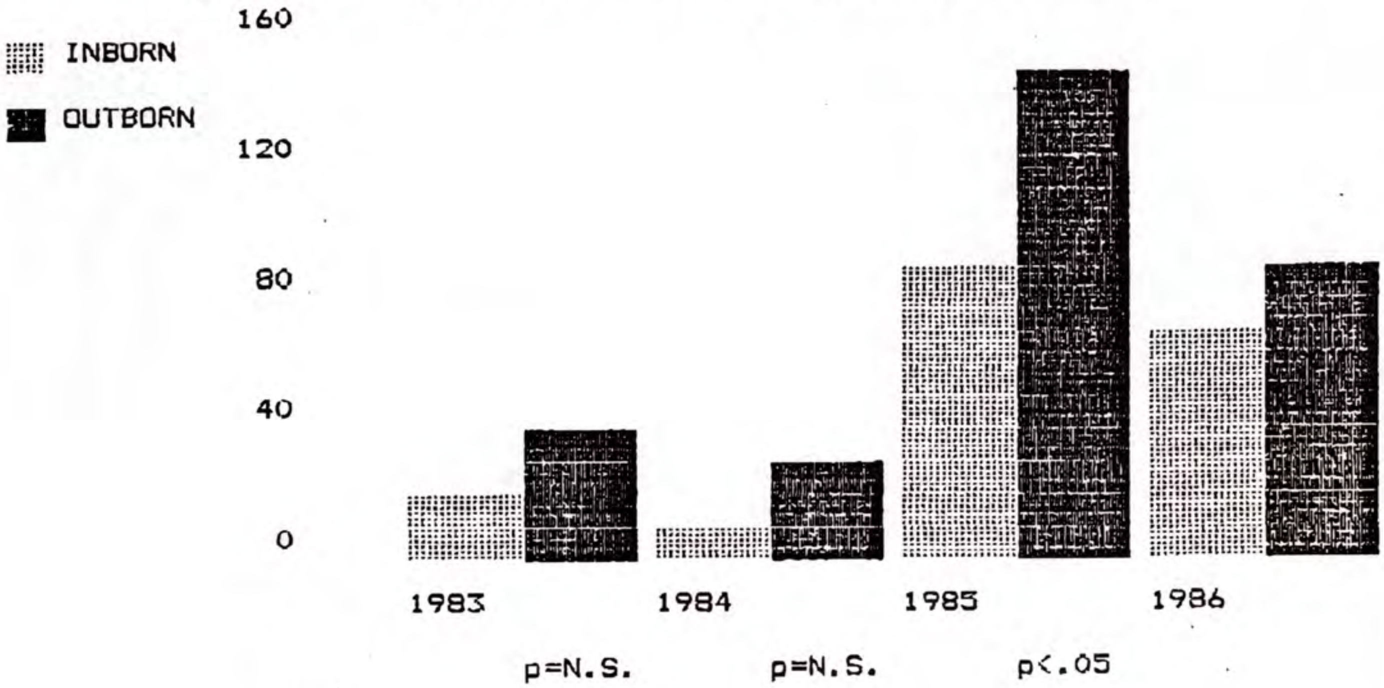
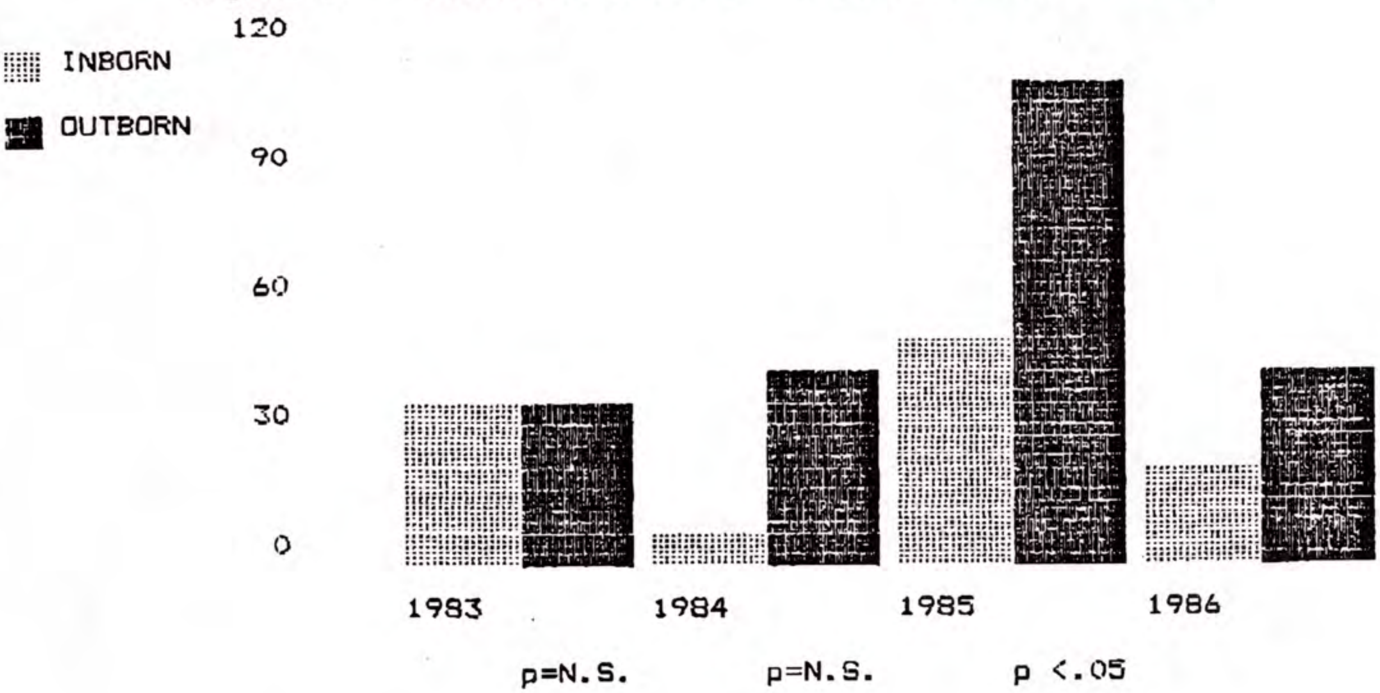


Figure 9 - Intensive Care (Tr. Tube Hours/Pt.) Udine



A similar trend, but with no statistical difference from 1983 to 1986 was found in the average time of: mechanical ventilation (Figure 10), continuous positive airway pressure (Figure 11), and umbilical artery catheter (Figure 12).

Figure 10 - Intensive Care (IPPB Hours/Pt.) Udine

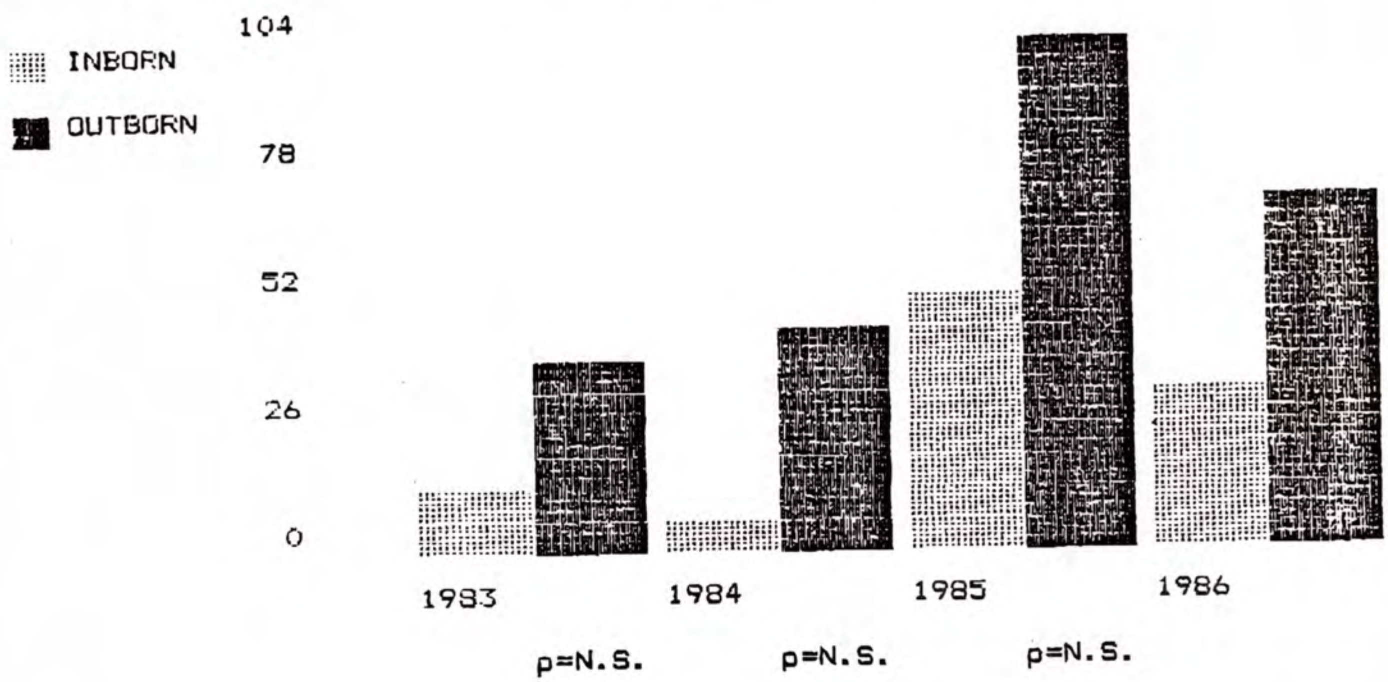


Figure 11 - Intensive care (CPAP Hours/Pt.) Udine

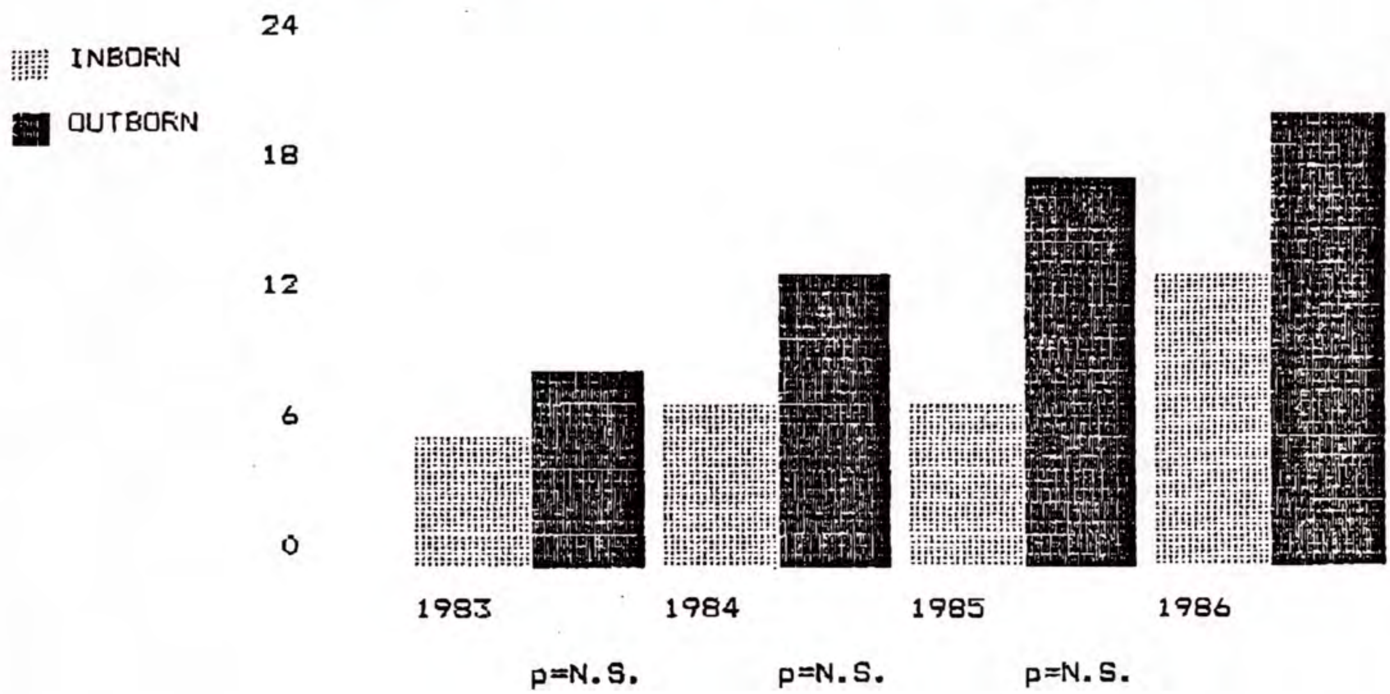
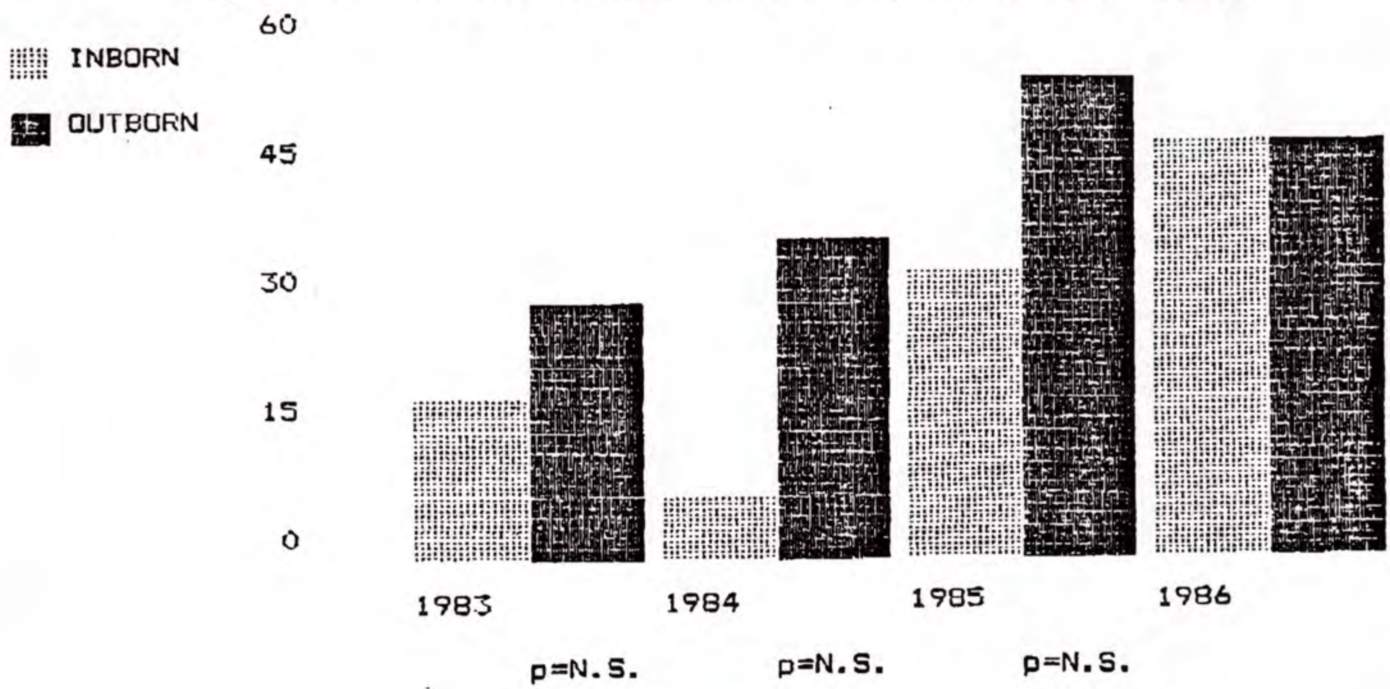
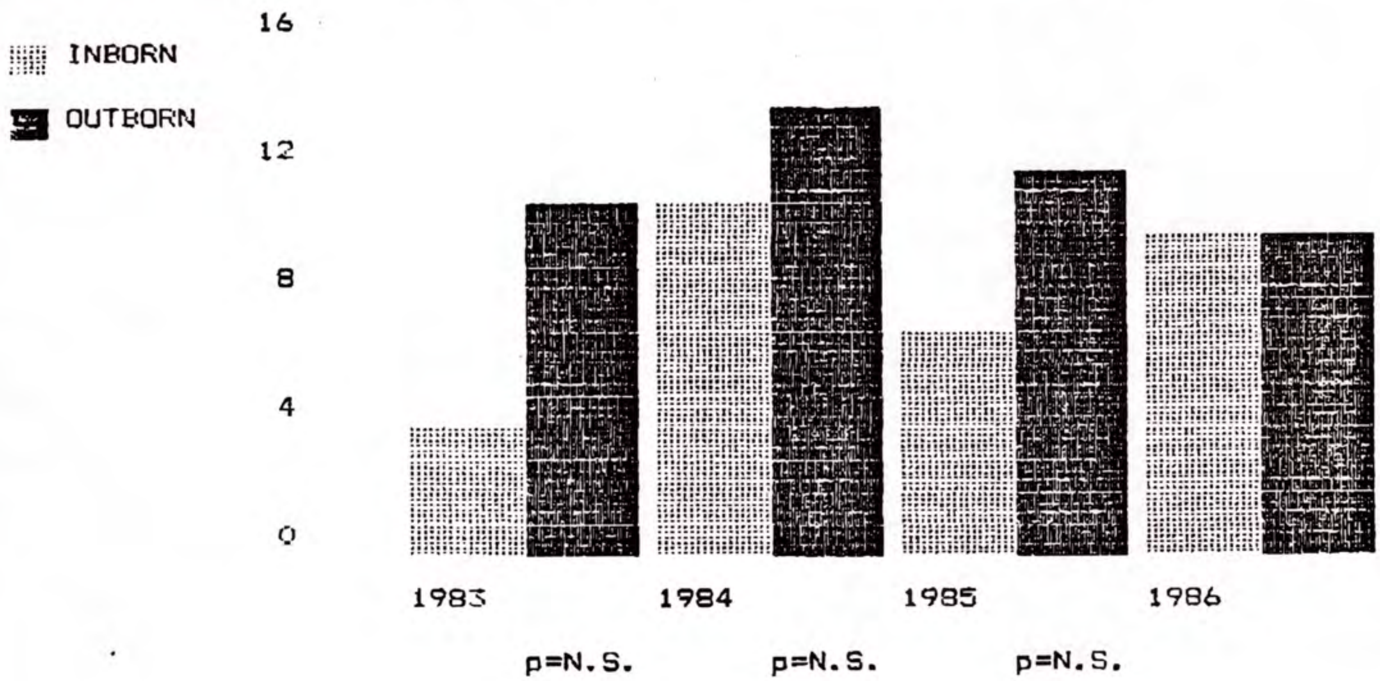


Figure 12 - Intensive Care (Art. Cath. Hours/Pt.) Udine



The overall mortality rate is shown in Figure 13: No statistical difference exists, and a favorable trend is barely distinguishable. So, we can assume that shortening average time of oxygen administration and tracheal tube was not detrimental to our patients.

Figure 13 - Mortality Rate in the NICU. Udine



Data from patients who died show that the mean gestational age is increased in 1986 only in outpatients ($p < .05$); all other differences are not statistically significant (Figure 14); the same is seen in birth weight (Figure 15) and Apgar scores (Figure 16).

To date, we are not able to explain why a larger number of neonates died in 1986 among outborn patients. But the characteristics of patients who died are fairly constant during the period considered, and no important differences are found between inborns and outborns.

Figure 14 - Deceased Patients (Gestat. Age). Udine

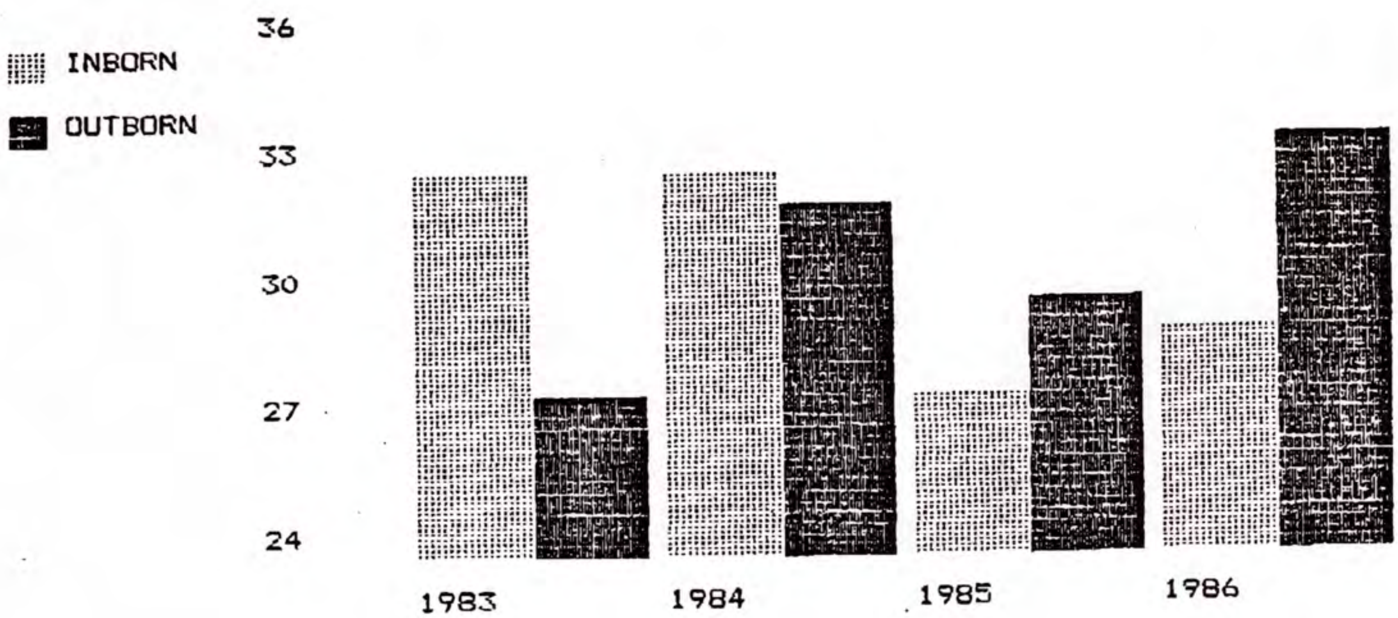


Figure 15 - Deceased Patients (Birth Weight). Udine

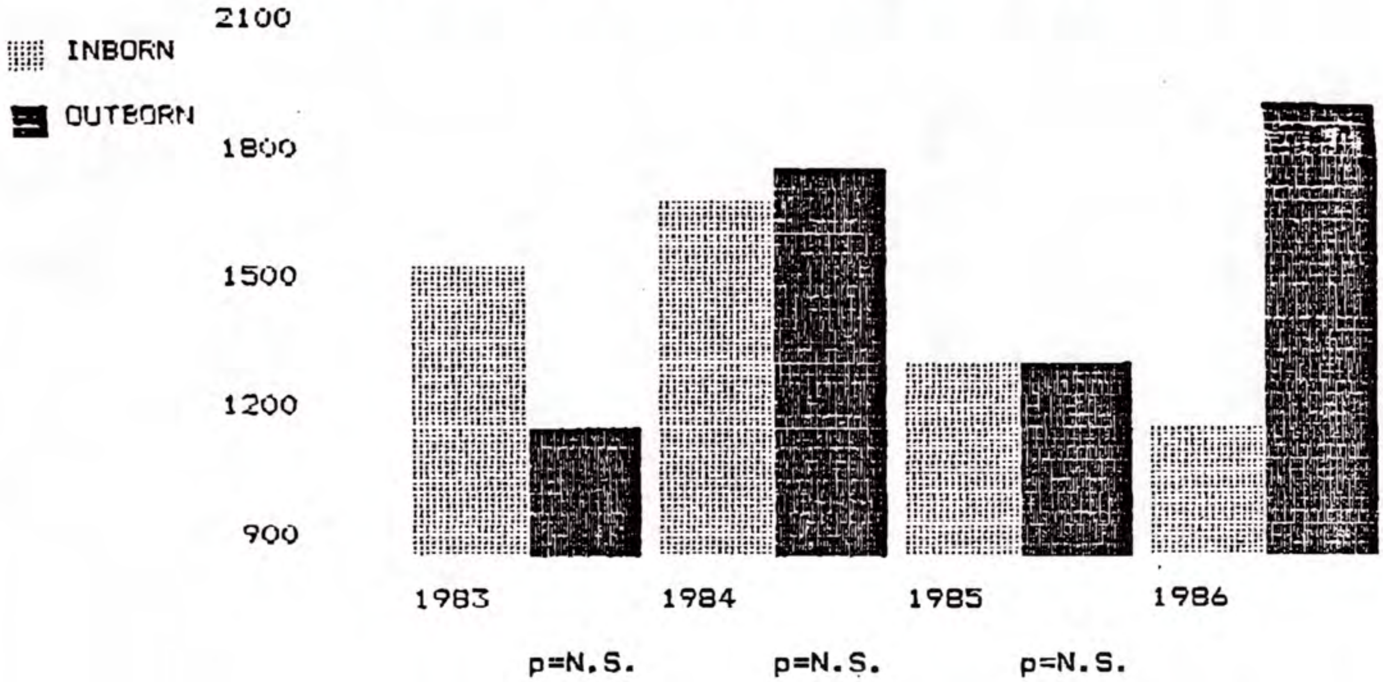


Figure 16 - Deceased Patients (Apgar Score). Udine

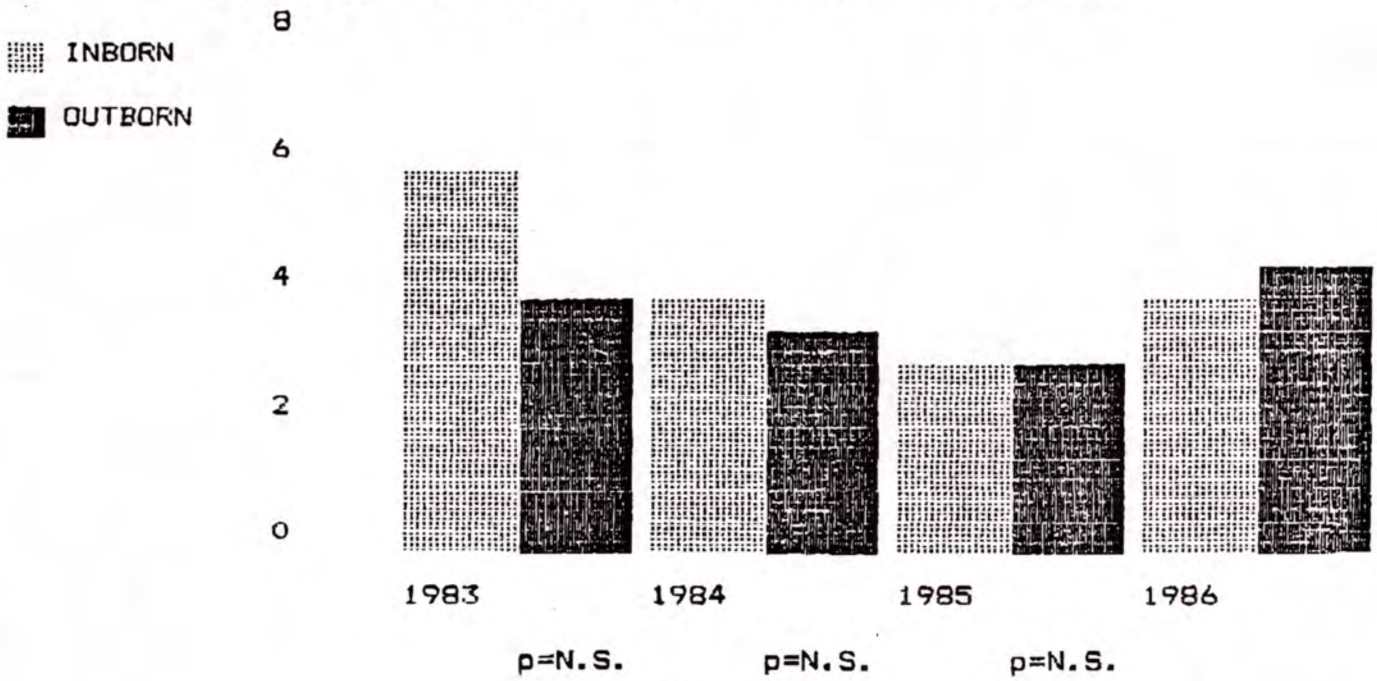


Figure 15 - Deceased Patients (Birth Weight). Udine

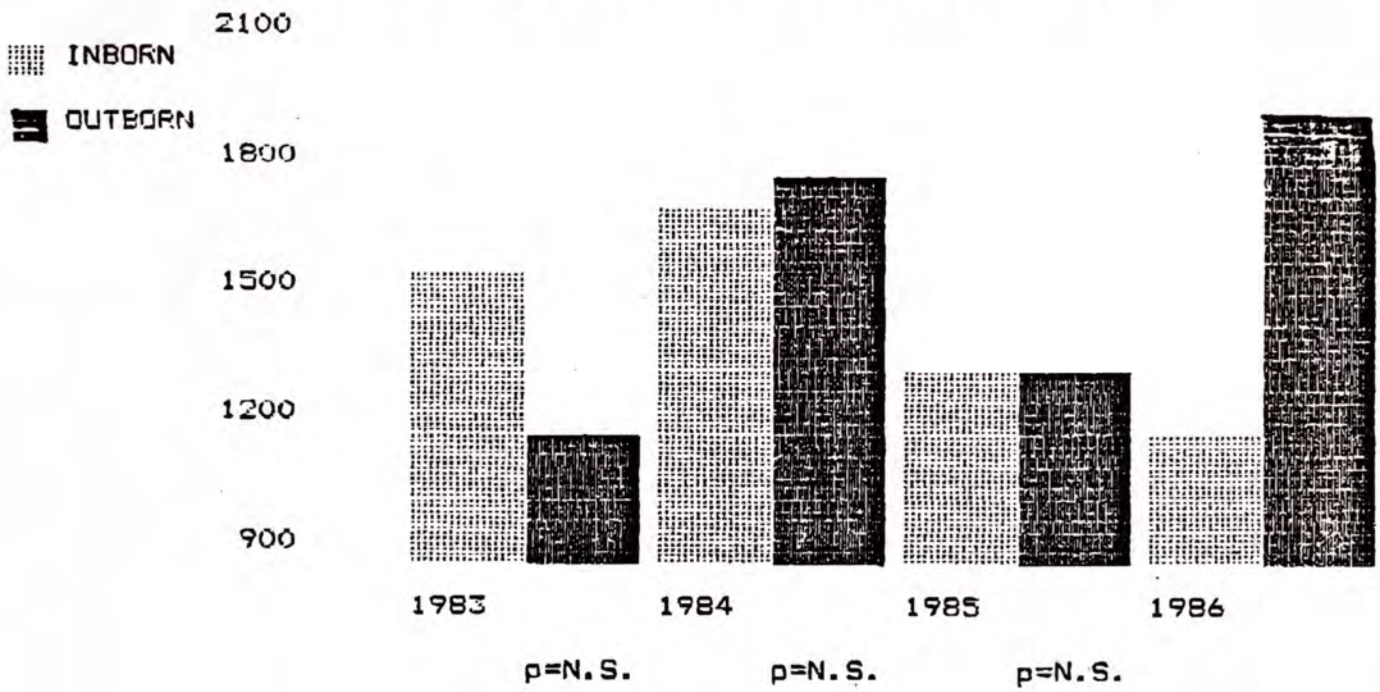
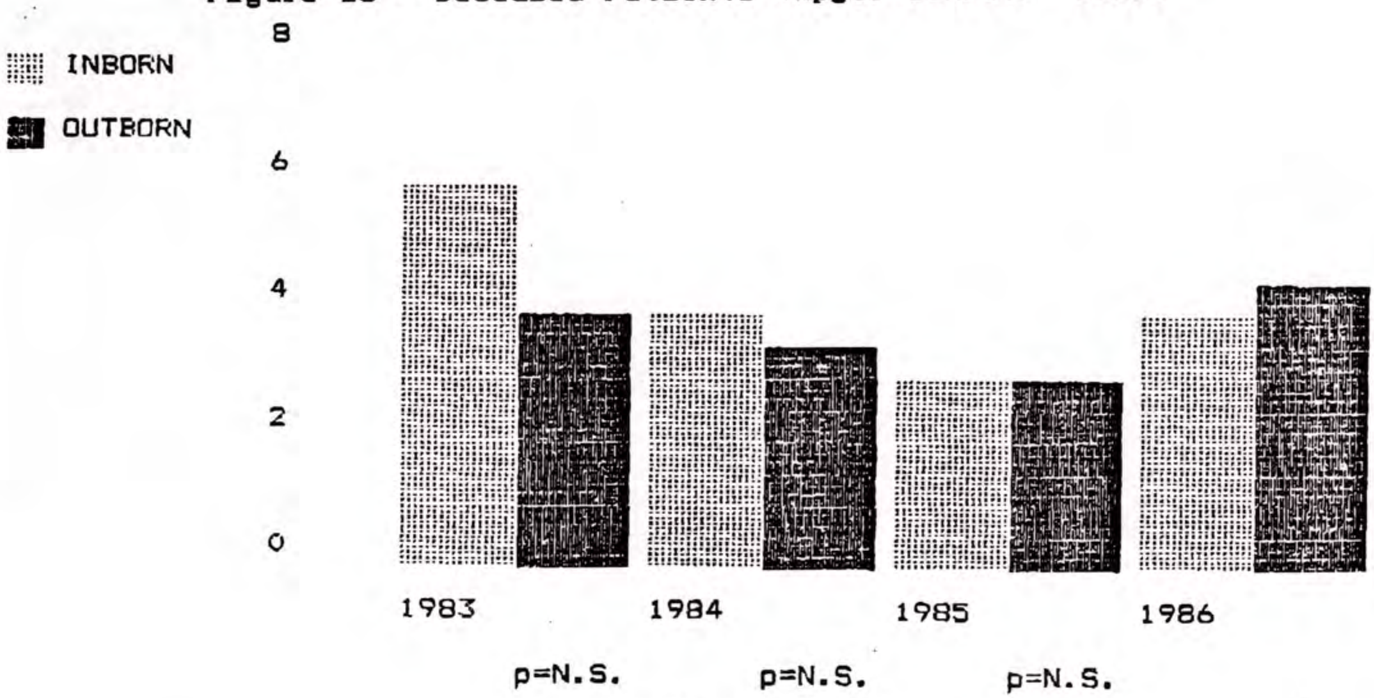


Figure 16 - Deceased Patients (Apgar Score). Udine



Data from several hospitals participating in the collaborative project are studied below.

Six main groups of diagnoses have been considered: birth asphyxia, hyaline membrane disease, other respiratory problems, intraventricular hemorrhage, post-hemorrhagic ventriculomegaly (requiring surgical treatment or not) and central nervous system malformations (Table 6).

Table 6 - Different Incidences of Six Main Diagnoses

Diagnosis	Northern H. (percentage)	Southern H. (percentage)	P
Birth Asphyxia	22.9	11.4	<.001
HMD	6.7	8.2	<.05
Other respiratory problems	11.5	9.8	<.05
IVH	2.9	0.4	<.001
Post-hemorrhagic ventriculomegaly	1.0	0.1	<.001
CNS malformation	2.7	1.4	<.001

The distribution of these diagnoses in each individual hospital has shown a sharp difference between northern and southern hospitals with respect to birth asphyxia: In northern hospitals "Birth Asphyxia" was diagnoses in 22.9% of patients, whereas it was diagnosed in only 11.4% of patients in southern hospitals:

This difference has statistical significance ($p < .001$).

In fact, the analysis of Apgar scores of the two groups shows a small difference (without any clinical relevance), but this difference attains statistical significance because of the very large population investigated (Figures 17, 18).

Figure 17 - Apgar Score at 1st min (% of Pts.)

Northern hospitals

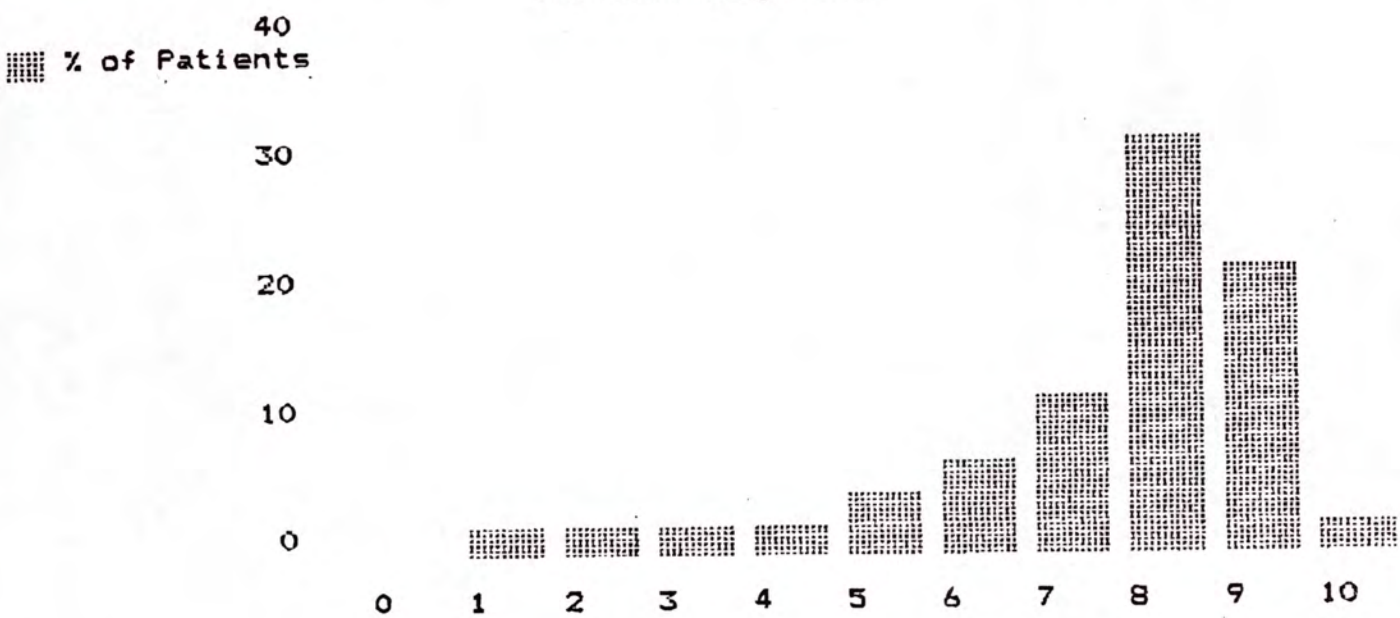
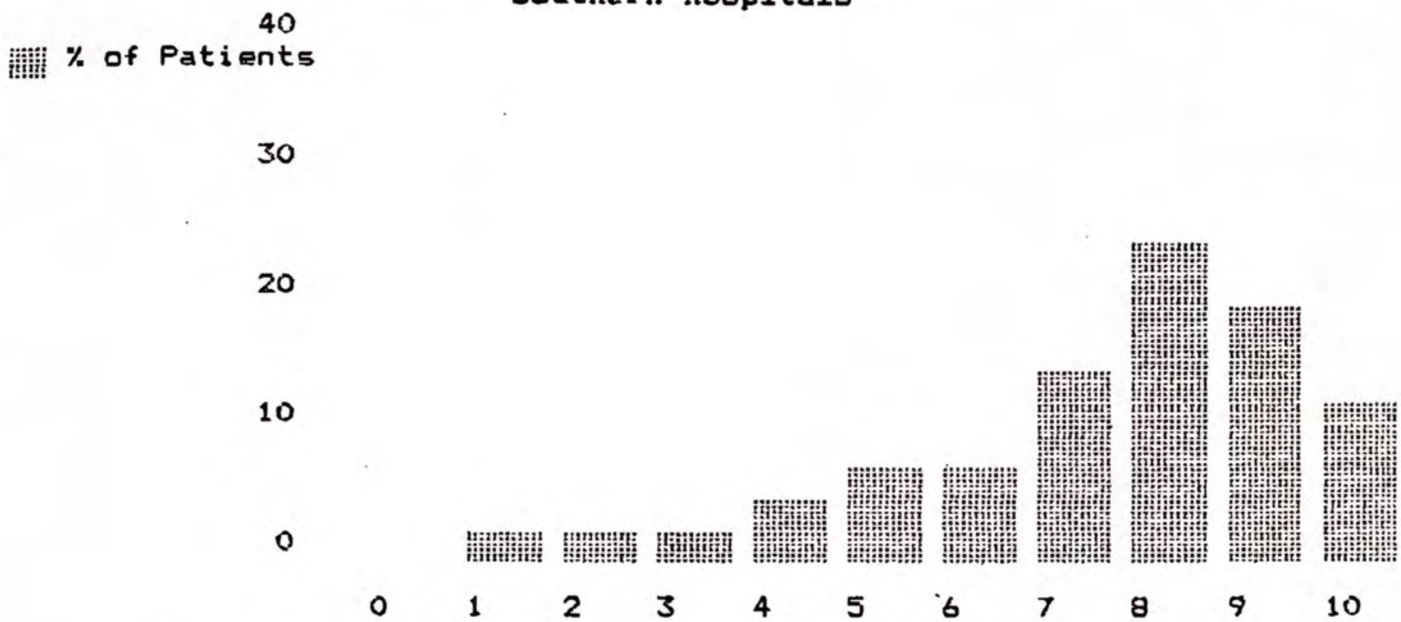


Figure 18 - Apgar score at 1st min (% of Pts.)

Southern hospitals



Another, less striking difference between northern and southern hospitals has been found in the frequency of hyaline membrane disease (HMD) and moreover, a different approach to the treatment of respiratory problems. The total incidence of respiratory problems HMD and others is nearly the same, and the mean duration of oxygen therapy per patient is not different in the two groups, but the number of patients receiving oxygen therapy is far greater in the southern group: This could involve some risk (Table 7).

Table 7 - Respiratory Problems and Oxygen Therapy:
A Different Approach Between North and South

	North	South	P
Respiratory pathology: % of patients	18.2	18.0	N.S.
Oxygen therapy: % of patients	15.7	28.6	<.001
Hrs. of oxygen: mean/patient	181	172	N.S.

Even in the case of nurses, compliance was not as great as expected: Involvement was irregular and attention to the problem had to be continuously reinforced.

In spite of the fact that the "UDINE/83" program was designed exclusively for the collection of pathological neonate data and for the requirements of a single neonatal unit (that is, Udine), it met with the approval of other groups of Italian neonatologists with the same needs. Some of the latter collaborated in the perfecting of the program and began to apply it later in their own neonatal units. This initial experience showed that the method was a valid attempt to obtain better individual performances and, above all, a more homogeneous, safe, and controlled work standard. In addition, it enables us to effect a double control on the quality of the system, that is, the ability to identify deviations from the norm and the ability to correct the tendency on the part of the staff to consider certain procedures sacrosanct, and thus unalterable.

What were the main disadvantages or failures and how could they be rectified?

1. The inevitable expense of time and money: the hardware and software were inexpensive but a great deal of time was required, considering the initial poor response, to gathering and processing data by users, generally neonatologists without any previous experience with computer systems;
2. The need to rigorously control data before feeding into the memory and to recontrol the computer's stock prior to any analysis, and the consequent need to study security sequences which may limit more common errors or save all data recorded;
3. In some way the collection of data could be considered twice the effort with respect to the traditional method, which was based on the clinical chart, or to more modern methods, which eliminate the clinical chart and the work-sheets by inserting data in the computer directly;
4. Reduced compliance of the staff members produced serious wastes of time, and errors that are not always easily detectable;
5. Sometimes the staff may refuse to change their attitudes following the results emerging from the analysis and, in

consequence, difficulties and disagreement may arise between the members;

6. Another disadvantage might be a negative conditioning of individual performance, a product of a sense of obligation toward the system itself, which leads to a diminution of freedom of decision at a particular time, and/or in the case of a particular patient.

A little more than a year after the language of the "UDINE/-83" program, certain problems were pointed out and discussed with users of our group and other groups utilizing the program.

Among these problems, the following seemed the most important:

1. Evaluating the real advantages and disadvantages of the application of the program in the health services;
2. Improving staff involvement in the management of data;
3. Modifying work procedures to obtain new benefits;
4. Deciding whether this program should be further extended to other services, given that it was processed by beginners in the epidemiologic and evaluation sector and based on our local neonatological experience;
5. Improving the cost/benefit ratio by such methods as using the computer directly at the newborn's bedside, improving the monitoring of vital parameters, of mechanical ventilation, etc.; and
6. Deciding which criteria should be followed to obtain new

guidelines for diagnostic procedures, for treatment plans etc.

In an effort to solve at least in part, these problems, the initial program was adapted to satisfy the needs of the whole work group. At that time, five additional hospitals joined the project. A new software was introduced, called "UDINE/85": main variations are listed in Table 8.

Table 8

Main Differences Between "UDINE/83" and "UDINE/85" Programs

Characteristic	UD/83	UD/85
Number of items	486	147
Pages	33	6
Worksheet	"Accordion"	Single sheet
Time required to collect data	3-5 hrs	1 hr.
Time required to enter data	20 min	5-10 min
Data output	Single item	Whole page
Number of patients per 5" disk	125	500

The root data file was reduced: The number of items per patient dropped from 486 to 147, and consequently each 5" disk could store information for 500 patients; the data input, as the output, was quickened, because processing was carried out on groups of items instead of one item at a time. The new pleated form contains six pages, still corresponding to several groups of data, which are collected gradually during the patient's stay in the hospital by several physicians and nurses particularly interested in data analysis.

Employees' work load also is lightened, and the opportunity to compare data from different neonatal units is thus improved. Today, the cumulative time required to collect data for each single patient is about one hour or less, and time to enter data is about 10 minutes. This guarantees a larger space for subsidiary items to collect specific data according to individual needs of each single neonatological unit. Of course, the reduction of the number of items does not prevent each single neonatological group from maintaining the previous, more complete collection of data, from certain selected populations of newborns, for instance, the very low birth weight infants, or others.

The diagnoses are sequentially stored, according to their relative importance in the clinical course and prognosis of the baby. The list of diagnoses has been eliminated from the instruction manual, since they are now selected from the entire list of the International code of Diseases (9th edition), with an additional figure as well as the official code, to allow further detail, as suggested by the British Pediatric Association; 6 digits have been reserved for each diagnosis, up to 10 diagnoses per patient.

Since January 1985, five hospitals have been gathering data according to a shorter list of 59 items specifically devoted to collecting data from the whole population of the newborns delivered in each hospital. This program is useful in the evaluation of perinatal care, with regard to an entire area population, and not only to the pathological cases: This universal data collection will enable statistical study on the incidence of various diseases.

Now, by way of example, we will present some results emerging from the processing of sample data from 14,053 newborns, 9,000 pathological and 5,000 physiological, from the Italian hospitals participating in the project. Main stages in the evolution of the project are summarized in Table 9.

Table 9

Main Stages in the Program's Evolution

1981	Launching of the program
1982	"UDINE/83" program
1983	Six hospitals join the project (Catanzaro, Reggio Calabria, Trapani, Trento, Siena, Genova)
1983	New hardware introduced (HP86 replaces HP85)
1985	New software introduced ("UDINE/85" program)
1985	further 5 hospitals join the project (Foggia, Brindisi, Torino, Treviglio, Brescia)
1985	Data collection regarding entire population commences (another 4 hospitals join this particular project: Gemona, San Daniele, Tolmezzo, Ancona)
1986	New hardware introduced (IBM XT replaces HP86)
1986	New software introduced ("UDINE/86" program)

A different distribution of gestational ages has been found in the hyaline membrane disease patients of the above two groups of hospitals (Figures 19, 20): The high frequency of diagnosing

HMD in newborns near term revels the use of different criteria for the diagnosis: This difference should be discussed and corrected.

Figure 19 - HMD (gestation, age)

Northern hospitals

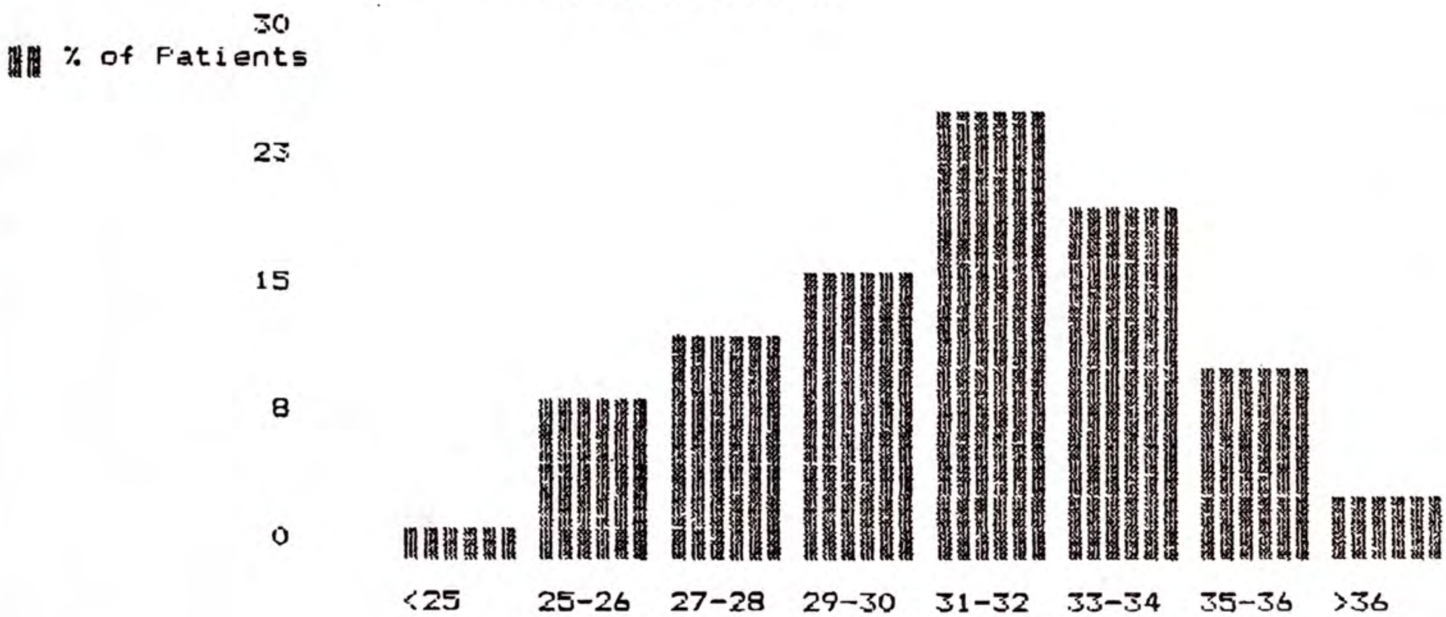
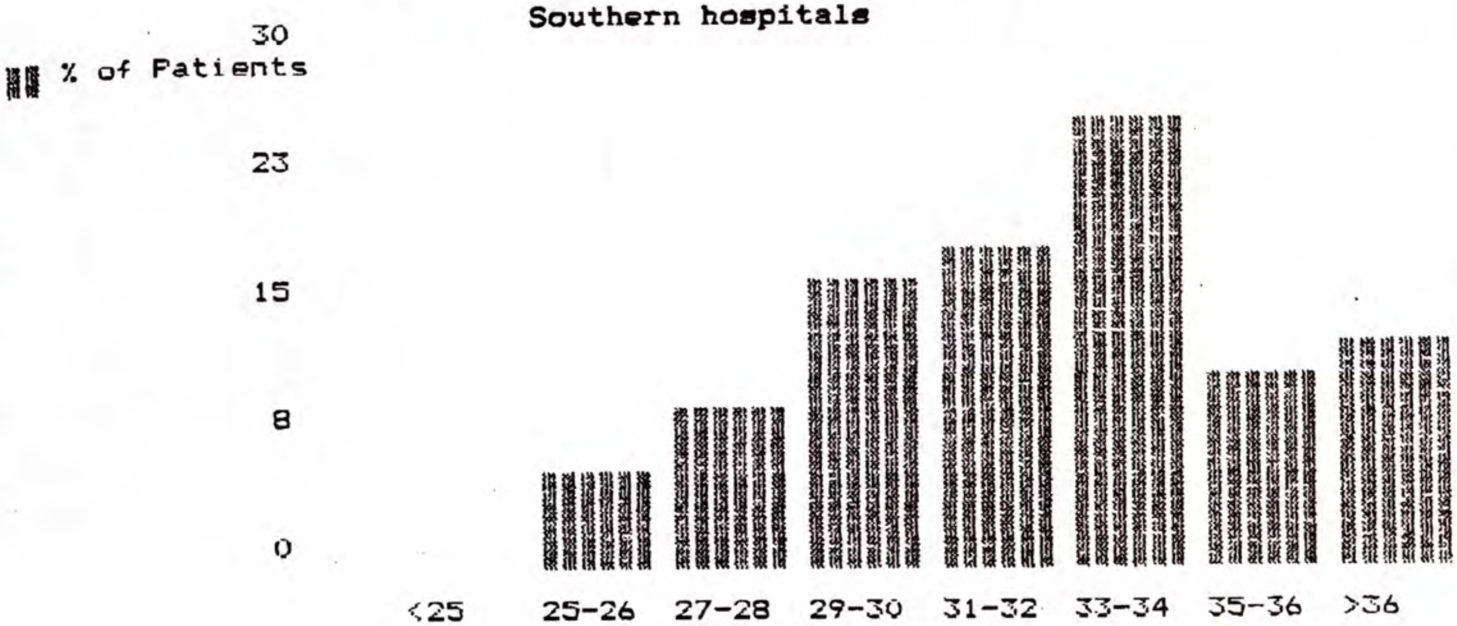


Figure 20 - HMD (gestation, age)

Southern hospitals



Other data analyses have shown differing behaviors of doctors in different hospitals: For instance, we have analyzed the rate of active resuscitation at birth (tracheal intubation and alkali administration): the distributions are shown in Figures 21 and 22.

Three hospitals have displayed a more active approach (Udine, Trento, and Trapani), and the three least active are Genova, Reggio, and Foggia. The differences between these two groups are highly significant ($p < .001$) for both the intubation and the alkali administration at birth.

Figure 21 - Tracheal Intubation at Birth (% of Pts.)

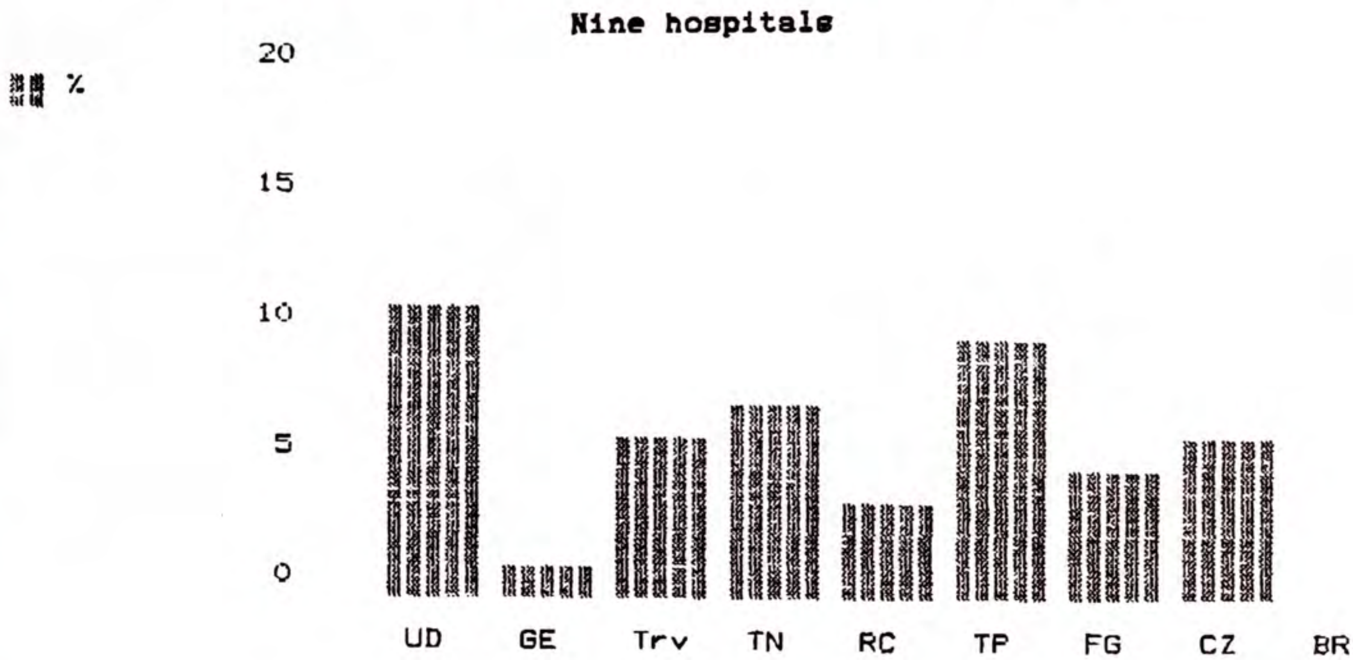
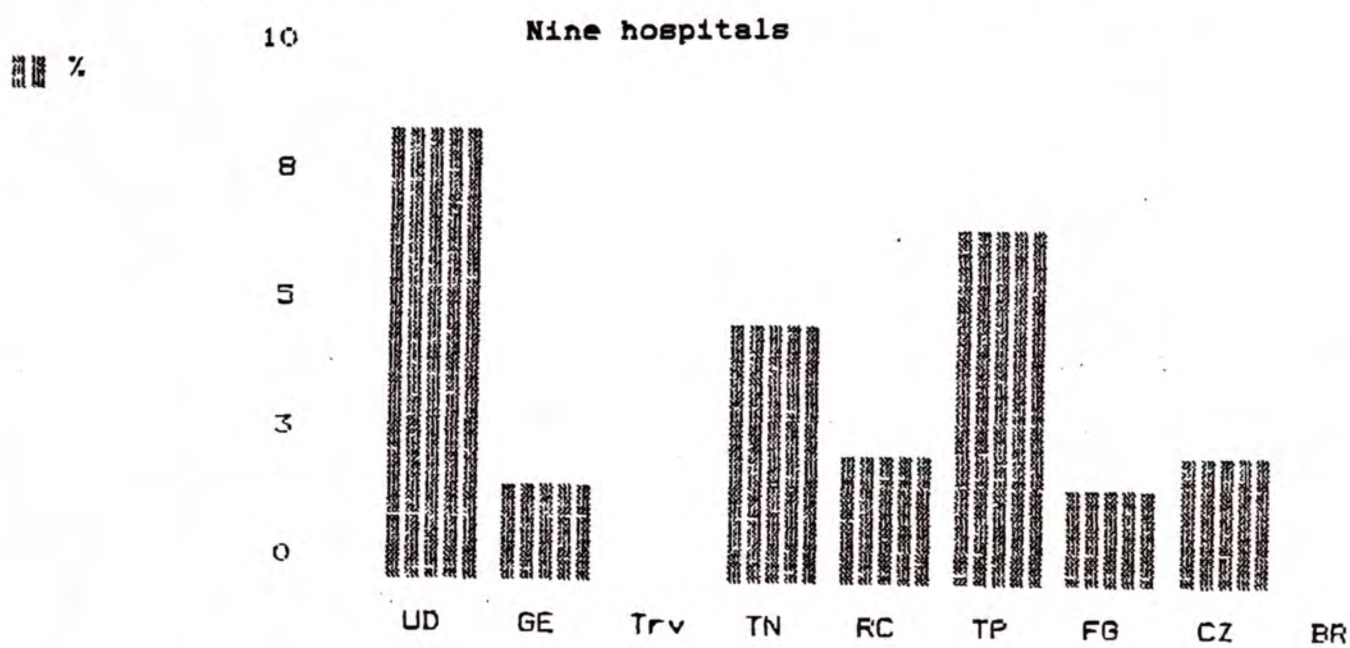


Figure 22 - Alkali Administration at Birth (% of Pts.)



To assess whether these different behaviors were based on different clinical conditions of the patients, the mean Apgar scores at first minute (that is, before reanimation) were studied; Surprisingly, the most active group had higher scores, (see Table 10).

Perhaps the decision to reanimate the newborn seems dependent on the personal attitude of the doctors toward asphyxia. This is later revealed by the higher frequency of the diagnosis "asphyxia at birth" by the more active group, (see Table 11).

Table 10 - Mean Apgar Score at 1st Minute in Two Groups of Hospitals

Hospital	Mean Apgar Score
Udine Trento Trapani	7.00 (Most active group)
Genova Foggia Reggio	6.40 (Least active group)

$p < .001$.

Table 11 - Relative Incidence of the Diagnosis "Asphyxia" in Two Different Groups of Hospitals

Hospital	Relative Incidence of Asphyxia
Udine Trento Trapani	20.2% (Most active group)
Genova Foggia Reggio	16.4% (Least active group)

$p < .001$.

The same difference as at first minute is found at fifth minute Apgar scores (Table 12) and the score gain after reanimation is nearly identical in the two groups (1.59 vs. 1.63).

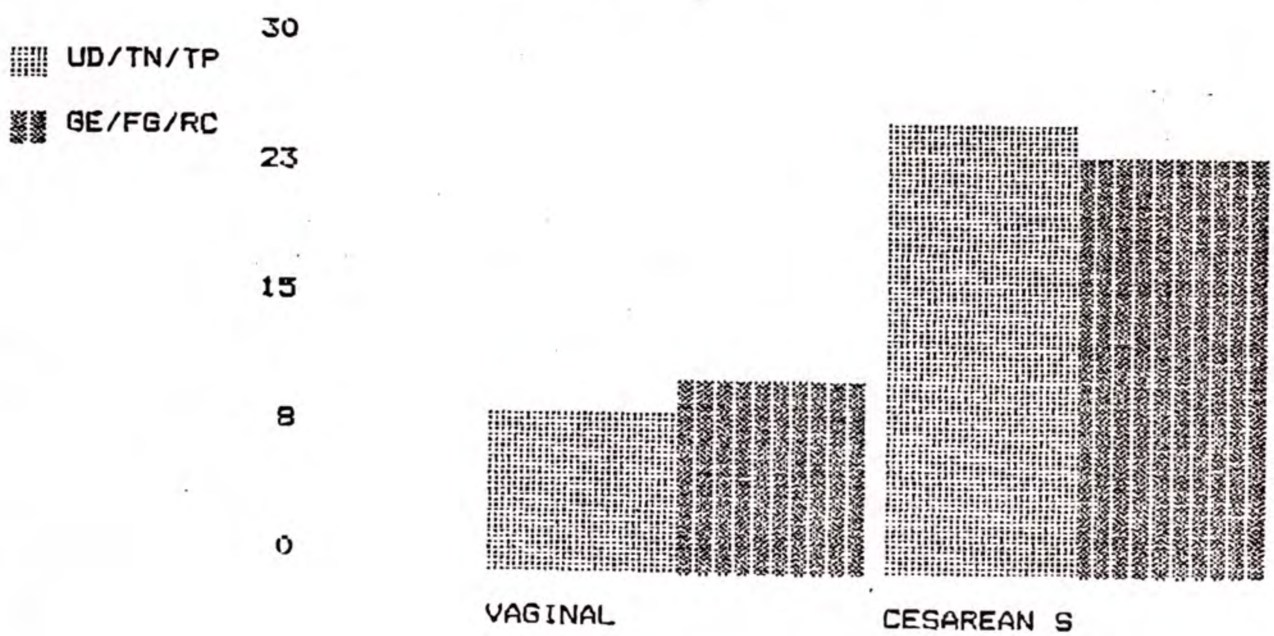
Table 12 - Mean Apgar Score at 5th Minute in Two Groups of Hospitals

Hospital	Mean Apgar Score at 5th Minute
Udine Trento Trapani	8.59 (Most active group)
Genova Foggia Reggio	8.03 (Least active group)

$p < .001$.

The incidence of operative deliveries is the same in the two groups with regard to both vaginal and cesarean deliveries (Figure 23).

Figure 23 - Operative Deliveries in 2 Groups of Hospitals
% of deliveries



The mortality rate in the two groups is shown in Table 13. The difference has statistical significance.

Table 13 - Mortality Rate
in Two different Groups of Hospitals

Hospital	Mortality Rate
Udine Trento Trapani	3.15% (Most active group)
Genova Foggia Reggio	5.89% (Least active group)

$p < .001$.

Of course, a lot of factors may have influenced this final outcome, and the mortality rate is a most inadequate index to assess care quality: Further studies are warranted to assess whether the better outcome might be influenced by a more active reanimation at birth; furthermore, the use of more subtle indices to assess well-being of the newborn is mandatory.

Conclusion

In conclusion, the lack of satisfactory state-wide computerized perinatal record systems, and the limited resources, led us to this program.

Its main advantages are:

1. Low initial costs, and minimal running costs;

2. The opportunity for every hospital to join the project without any specific skills or other facilities required;

3. The data processing and their comparison between different hospitals might disclose unsuspected differences in patient management: These will be discussed, and an improvement in treatment is likely to occur.

The necessity of mailing disks to exchange data among different hospitals has not proven, in our experience, to be a serious disadvantage, provided that it is done on a regular basis. Furthermore, this provides an excellent opportunity for better communication between participating hospitals.

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COMPUTERIZED DISCHARGE SUMMARIES:
A NEW WINDOW FOR
PATIENT CARE MONITORING

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(1) The Hospital's Patient Chart

In the traditional hospital setting, the attending physician documents clinical findings, decisions, and events regarding a certain patient on that patient's medical record. The resulting chart becomes a sort of diary, with interspersed medical and nursing notes, reports of various diagnostic studies, and a variety of other notes and records. The main purpose of this diary is communication of health professionals who deal with the patient. In addition, reviewing the medical record provides a means for carrying out various other functions, some of which are assessing quality of care, conducting risk management, or obtaining data for billing. This is where the traditional patient chart fails. Because of variations inherent within the style of narra-

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tive text and differences in organization of reports, only an unhurried, careful chart review by a knowledgeable clinician can result in a cohesive reconstruction of a patient's hospital course. Significant data may be buried and overlooked. Information may be obfuscated because of concern about the confidential nature of the illness, or for medico-legal considerations. Understandably, this antiquated patient hospital chart does not conform to the structural format that is a prerequisite for computerization.

(2) Hospitals' Use of Computers

During the last decade, the United States has experienced a growing need to contain health care cost and yet maintain quality of care. These two issues alone have forced hospitals to reexamine their methods for recording and retrieving patient care management information, and to find a cost-effective way for better access to patient care-related data. Computerization of patient data has become a necessity.

Blum (1) proposed that the general objective such for data computerization may be either gathering primary data, that is uninterpreted items; or collecting information, that is sets of interpreted data-cum-meaning.

In the early days of clinical computing in hospitals, the data system designers' main emphasis was on acquisition of primary data. It was expected that timely acquisition of these data would increase clerical efficiency and intra-hospital communications, and even facilitate cost analysis. However these computer-based hospital information systems failed to get closer to the actual clinical care and its methods, rationale, and appropriateness. The systems were often of limited help in direct patient-dependent cost analysis.

A number of vendors offered improved hospital information systems during the 1970s. Young et al. in a recent review, compared the systems of 12 major vendors (2). Although several good accounting, laboratory, radiology, and pharmacy systems are now available, information on the patient's illness and the clinical care rendered is still not computerized (1). Instead, manual methods for chart reviews are widely used by utilization review committees, professional review organizations, (PROs) and others in order to monitor efficiency, appropriateness, and quality of clinical care. These manual chart reviews are labor-intensive, inefficient, error-prone, and certainly not cost-effective.

(3) <u>Reasons for Automated Analysis Of Discharge Summaries</u>

Analysis of discharge summaries, through the capabilities of high technology, provides a new way to access information contained in the patient's chart. This preliminary report presents our initial experience with automated discharge summary analysis as a new, efficient method for clinical care studies.

a. <u>Traditional Discharge Summaries</u>

The medical record contains both the chronological documentation of events and findings and the discharge summary, which is compiled after the patient has left the hospital. In the body of the chart the chronologic notes are prospective, made by the attending physicians, consultants, nurses, social workers and other allied professionals concurrent with the patient's clinical course. Therefore, these records often contain speculation and predictions of short-range value. In contrast, the discharge summary is retrospective, selective, and prepared and interpreted by a single physician who has usually followed the patient from admission to discharge. Thus, the discharge summary data are much more reliable. Therefore, we chose the discharge summary for computerization.

The discharge summary evolved gradually as a summary document for a number of purposes. It is used as a way to inform the referring physicians, and to help in post discharge care management. In teaching hospitals, compiling discharge summaries is a valuable educational exercise. Discharge summaries also serve as documentation for Board requirements. Further, a good discharge summary is often used as an expeditious alternative to reading a voluminous, disorganized patient chart.

b. Fact Extraction

In terms of clinical informatics, the discharge summary is an aggregate of facts, selected and ordered in a logical sequence by an expert. The elementary unit is the fact, which may be a datum provided by the patient (historic), an observation made by a physician, a laboratory or x-ray report, a significant diagnostic or therapeutic reasoning, or a therapy. _A priori_, one could assume that all data in the discharge summary are significant because they were included by the physician. Thus, the difference between uninterpreted prospective data in the patient's chart and facts extracted from the discharge summary is that the latter facts are the results of a clinical evaluation process, carried out by the physician when formulating the discharge summary. The challenge of informatics is to find all the facts nested in the narrative, interpret them, and tabulate these facts in a cost-effective manner.

Full use of current computer technology should make fact extraction cost-effective. The computer could process large volumes of discharge summaries at a low cost. However, this required a complex computer software able to process unrestricted medical text. To accomplish this, a lexicon-driven software was designed. The major supporting lexicons are shown in Table 1. These lexicons enabled the parser, the heart of the software for text analysis, to recognize and segregate the facts in the narrative by means of looking up the meaning and syntactic value of the words and phrases (3).