A COMPARATIVE STUDY OF CASE-MIX SCHEMES FOR THE NEONATAL INTENSIVE CARE UNIT

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INTRODUCTION

Research is currently under way to develop and select a valid prospective payment system for neonatal intensive care units (NICUs). It is imperative that any payment system reflect the unique care processes within the NICU in order to be used appropriately for reimbursement, as well as for research, quality assurance, budgeting, staffing, and other applications. Nursing plays a critical role in these care and administrative processes and, therefore, should be included in the development and evaluation of prospective payment case-mix reimbursement systems. This chapter discusses the significance of a prospective payment system for the NICUand the contribution of nursing to development of such a scheme.

The Diagnosis Related Groups (DRG) patient classification system is currently being used by some Medicaid programs as the basis for reimbursement in neonatal intensive care units. As a public health insurance program, Medicaid is a substantial source of reimbursement for neonatal hospital care. However, research has shown that the DRG groupings consistently underestimate the total number of days NICU infants use

(Poland, Bollinger, Bedard, & Cohen, 1985; Resnick, Ariet, Carter, Fletcher, Evans, Furlough, Ausbon, & Curran, 1986). In states that have instituted DRGs for Medicaid, there is evidence that perinatal programs, including NICUs, are being threatened financially (Friedman, 1985). Hospital administrators overseeing NICUs, therefore, are concerned that a valid prospective case-mix payment system be developed to encourage high quality, accessible neonatal intensive care.

Children's hospitals, many of which contain NICUs, were granted initial exemption from the Medicare prospective payment system (Stoltzfus, 1985). This exemption was granted because children's hospitals care for more resource intensive pediatric patients than do general hospitals; the latter served as the basis for derivation of the DRG system. Now the Prospective Payment System (PPS) legislation requires that the Health Care Financing Administration (HCFA) develop and evaluate a case-mix system for children's hospitals. Hence, a pediatric case-mix system would be a critical determinant of the quality of care, financial viability, and accessibility of NICUs.

Studies have found a high degree of variation in patient severity and resource consumption for children within DRG categories (NACHRI, 1985); such variation has

also been found for patients in neonatal intensive care units (NICU) (Resnick, Ariet, Carter, Fletcher, Evans, Furlough, Ausbon, and Curran, 1986 ; Poland, Bollinger, Bedard, and Cohen, 1985; Lagoe, et al., 1986).

Substantial variation in resource consumption within DRGs may create financial problems for institutions because the DRG classification system is based on averaging. Each DRG category is assumed to contain patients with similar overall resource consumption, and thus total hospital costs per case. Reimbursement based on estimated average costs should be adequate. If the groupings have a high degree of resource use variation, individual institutions may experience adverse or favorable selection and have wide discrepancies between incurred and reimbursed costs. They do not have sufficient numbers of cases in each DRG to stabilize this variation. Hospitals are at high risk of incurring either losses or profits. Such risks may be unacceptable to hospitals, even when there is an equal chance that they will be winners or losers.

NICUs carry a high risk of losses because they provide a high-cost mode of treatment. Infants requiring the most intensive, aggressive intervention will be placed in the NICU. This special care unit is responsible, therefore, for a disporportionate amount of

the cost, as well as the day outliers, among neonatal cases. Resnick, et al., (1986) reported total hospital charges of $118 million for 8,492 infants in their study. Pomerance, Ukrainski, Ukra, Henderson, Nash, and Meredith (1978) reported total adjusted costs for 75 infants requiring neonatal intensive care at $1,849,216, or average costs of $61,641 per survivor. Kaufman and Shepard (1982) reported average hospital costs totaling $102,944 for 10 very low birth weight infants.

A case-mix system should provide adequate reimbursement for services. Hospitals, in the long run, can only provide the level of care for which they receive adequate payment if they are to remain financially viable. Sustained underpayment, as projected by Resnick, et al. (1986) and Poland, et al. (1985), can lead to reduced availability of and access to neonatal intensive care services.

The majority of NICU patients spend their total length of stay within the NICU. Hence, there is no chance of cross-subsidization from lower cost forms of care for these patients over the course of their stays. To avoid incentives that could undermine the quality of care for NICU cases, the case-mix scheme should separate these cases and recognize their relatively higher costs.

Neonatal intensive care units have justified their high costs with a generally rising trend in neonatal

survival and improved prognosis for normal functioning after discharge. About 80% of two-pound, 27-week gestation babies born nationwide now survive (Davis, 1987). Ten years ago nearly all of these infants would have died. Infants weighing 1,000 grams or less had only a 10% survival rate, and survivors rarely escaped the sequelae of physical and/or mental handicap. Pomerance, et al. (1978) researched infants born at 1,000 grams or less. They found a 40% survival rate and 30% of the surviving infants had significant residual complications. Kaufman, et al. (1982) document survival rates that range as high as 65% for neonates weighing between 751 and 1,000 grams. Morbidity and mortality of infants with birth weights less than 1,000 grams have improved substantially as a result of neonatal intensive care.

Paneth, Kiely, Wallenstein, Marcus, Pakter, and Susser (1982) document a "dose-response" gradient of mortality with intensity of care in 1250 to 2250 gram infants. Kaufman, et al. (1982) propose that the cost of neonatal intensive care is reasonable in relationship to the health benefits provided. Comparisons with adult intensive care units have shown higher overall and functional survival rates for NICUs (Cullen, Fevara, and Briggs, 1976). McCarthy, Koops, Honeyfield, and

Butterfield (1979) report that 91% of NICU survivors can be expected to lead productive adult lives. In contrast with adult ICU survivors, only 42% could expect to return to productive lives (Cullen, et al., 1976).

Improvements in technology have played a major role in the increasing survival rates of very low birth weight infants. Extra corpuscular membrane oxygenation (ECMO), a form of heart-lung bypass in infants, is now producing increasing survival rates in near-term infants with severe conditions affecting the respiratory system (NACHRI, 1986). A classification system should encourage, rather than inhibit, technological progress.

Payers should only reimburse for the provision of appropriate, efficient, and technically progressive health care. A prospective payment system should encourage efficiency, while guarding against the funding of waste and uncontrolled, experimental care. It should also include incentives to change patterns of care in the direction of improved efficiency, as well as improved survival. A case-mix system, then, should give providers information regarding the level and mix of resources that NICUs and their patients should receive, while at the same time, providing incentives for clinicians and administrators to adopt effective new technology without wasting staffing and other resources.

Two case-mix classification systems have been developed for neonatal intensive care based on the DRG conceptual framework: Children's Diagnosis Related Groupings (CDRGs) and Neonatal Care Groups (NCGs). These systems were developed to improve the DRGs' ability to predict hospital resource utilization in children and/or neonates. They incorporate variables that have been documented as important determinants of hospital resource consumption in neonates but are not used in the DRG system. The CDRGs are being evaluated by HCFA for use in the Medicaid system, and thus, may have a great impact on reimbursement in all NICUs. The NCGs are currently being used for reimbursement in Florida's NICUs. Both systems purport to be valid and to improve prediction of hospital resource utilization in neonates. The comparative performance of these three case-mix schemes--DRGs, NCGs, and CDRGs--as prospective pricing systems for the NICU has not been examined.

These systems should be compared on their ability to place infants into clinically meaningful groupings. Prospective payment mechanisms are increasingly being used in the management, evaluation, and payment of neonatal intensive care (Lagoe, Milliren, and Baader, 1986). The degree to which these systems place infants into clinically meaningful groupings will determine their usefulness in quality assurance programs, research,

budgeting, staffing, analysis of nursing inputs and outcomes, and future policy issues.

Significance

The primary purposes of case-mix classification systems are reimbursement, quality assurance, and internal budgeting and staffing. Thus, a classification system should be valid and acceptable to everyone involved in the care process: clinicians, administrators, payers, and patients. For example, reimbursement of a flat amount per day creates an incentive to admit infants with less serious complications and to extend infant stays in the growth and recovery stages (Kaufman, et al., 1982). Under such a reimbursement system, lengths of stay will be unnecessarily extended and acutely ill infants will have less access to treatment. Reimbursement of a flat amount per day in all levels of care will also result in cross-subsidization between infants and various reimbursers (Kaufman, et al., 1982). It may also result in subsidization by other departments within the hospital. The National Association of Childrens' Hospitals and Related Institutions (NACHRI, 1986) found that nearly a third of children's nursing costs are subsidized by adult patients in general hospitals.

Cross-subsidies resulting from fixed per diem reimbursement also create economic incentives for

hospitals to behave in ways that are not optimal for either quality or cost. There may be incentives to admit borderline cases to the NICU unnecessarily or to prolong the recovery period at the end of an infant's stay where the excess of revenue over cost is greatest.

Appropriate incentives for efficiency are not included in a payment system that is based on incurred costs, i.e., services rendered, either in terms of the socially optimal mix of treatments or the least cost mix of inputs (Hornbrook, 1982). Reimbursement on a fee-for-service basis encourages waste and inefficiencies in the provision of care. Cost reimbursement encourages higher use and allows provider preferences to determine case mix and patterns of care. This type of reimbursement system captures only the care provided to a neonate, not the theoretically appropriate care for that neonate's age, birth weight, and clinical condition.

Kaufman and Shepard (1982) suggest that other methods of reimbursement for neonatal intensive care might be useful. One option is to reimburse on a fixed rate basis for each type of case and eliminate the incentive to prolong length of stay (LOS). Diagnosis Related Groups represent one system for defining case types for prospective payment. This method attempts to reimburse for the overall resource intensity of the

inpatient episode of care, in this case, the hospital stay. As a basis for NICU reimbursement, it should accurately reflect the differing levels of severity during a NICU stay, without requiring an internal cross-subsidy. Inaccurate payments produce incentives for hospitals to divert unprofitable cases elsewhere, thereby reducing access to care or reducing quality of care for low profit case types.

Case-mix classification systems can serve as a means of cost control and care refinement. They can be used to specify measurement of NICU costs, for example, in order to provide for a more valid and standardized comparison of inter-institutional costs, adjusted for differences in case mix and patterns of practice; this permits the comparison of different modalities of care (Kaufman, et.al., 1982). Valid case-mix classification systems can allow practitioners access to an enlarged clinical data base that will help them evaluate their own care practices and case-mix. In fact, entire quality assurance programs can be effectively generated from utilization data tied to an appropriate case-mix measure. Research can be done across facilities comparing outcomes and modes of treatment. Advances in technology and changes in care practices can be more effectively evaluated.

Prospective payment can provide facilities with a system for the analysis of their costs, thereby stimulating alternative, less costly programs. Hospital administrators can examine the services they provide from quality, cost, efficiency, and satisfaction perspectives. Administrators in the NICU can use this information to project staffing needs for their highly skilled personnel. Staffing patterns can be analyzed, as well as the skills required to care for a changing case-mix of infants. Budgetary requirements can also be forecasted based on this information. Nursing administrators and researchers can use this data base to assist them in analyzing the nursing contribution to NICU costs and outcomes per patient type. In this manner, practitioners and administrators can work together in providing high quality, efficient neonatal care.

In addition, the data base created by a case-mix system will likely be used in deciding future policy issues. For example, the success of new treatments and technology in improving the survival of very low birth weight infants could be analyzed in deciding what type of care to provide to this birth weight grouping. Survival rates per patient type and birth weight could be used in making decisions regarding what patient types would

receive neonatal intensive care. The quality of care and the effectiveness of NICUs could be analyzed in decisions regarding where to allocate health care dollars.

The Neonatal Intensive Care Unit

Neonatal intensive care is the highly technical medical and nursing treatment provided in a specialized unit to the most severely ill or premature subset of neonatal hospital populations. NICUs treat the sickest neonates and offer the most complex, sophisticated, and prolonged neonatal care. Most NICUs function as referral centers and many have capabilities for land and/or air transport.

NICUs are areas of high cost concentration. The technology, ancillary support, and skilled nursing and medical care required by these infants entail high resource utilization. Ethical issues regarding access, cost of care, and treatment decisions are also inherent in this milieu. Thus, it is important to develop a valid case-mix system specific to the NICU so that it can be used to study the case mix, quality of care, and accuracy of reimbursement, and to assist policy makers in decisions regarding efficacy of treatment to specified neonatal populations.

Infants admitted to the NICU form diverse patient types that require either intensive, intermediate,

recovery, or routine care. A small percentage of the population are very low birth weight infants (< 1000 grams). They consume a large porportion of hospital resources, as they are critically ill and stay in the hospital a long time to achieve growth and stability. On the other hand, the majority of infants in NICU patient populations have birth weights greater than 1500 grams. These babies are more mature and, primarily, less severely ill. They require less ventilatory support and fewer days of hospitalization. Some require surgery for congenital anomalies or complications of prematurity. A few are severely ill, usually with respiratory system disturbances. Most NICU infants are medical patient types.

Prematurity is not, strictly speaking, a disease. It indicates that an infant was born before the time when all body systems are sufficiently to assure life independent of the womb. Thus, the infant requires external support of varying degrees until his own systems can take over. Disease may complicate prematurity because the infant's immune system is immature and he is susceptible to complications from external support systems and treatments.

Neonatal intensive care should be separated from normal newborn care (level I) in a classification

system. A normal newborn can be defined as a full-term infant without disease. Normal newborn care focuses on the support of normal, physiologic processes within the infant and mother-infant dyad. Neonatal intensive care encompasses both premature infants and infants with disease processes and congenital anomalies. NICU care focuses on abnormal or immature processes and consists of intensive monitoring and aggressive therapy provided to neonates by a multidisciplinary team. It serves a set of patients that are differentiated not by diagnoses, but by birth weight, ventilatory support, and surgery status, and by mortality.

NICUs differ from other intensive care units in one other primary dimmension--the vast majority of infants admitted to a NICU will be discharged to home from the unit, while a small percentage of infants are discharged to another unit or hospital, before going home. In one study (Poland, Bollinger, Bedard, and Cohen, 1985), only 3% of the infants transferred to the neonatal unit were transferred back to the referring hospital for continued care before being discharged to home. NACHRI (1986) found that the majority of NICU infants are treated in the unit until discharge to home, although the percentage depends on the NICU case mix and type of referring institution.

Care regimens, and thus resource utilization, differ greatly between normal newborn nurseries and NICUs. Neonatal intensive care calls for a higher level of intensity and specification in case mix measurement, which will allow for better resource use prediction, more accurate groupings by clinically meaningful patient type, and greater utility to NICU managers. An improved system will also entail higher administrative cost, since equity would call for development of similar, more refined systems for other special care units.

NICUs need a classification system that will cover an episode of care which encompasses a variety of severity levels. Infants stay in the NICU during intensive, intermediate, and recovery stages of care. Different levels of hospital resources are utilized in each stage. A classification system must be able to account for all of these levels of care during an infant's hospitalization.

For example, ventilatory support in neonatal intensive care units is primarily of two types: mechanical ventilation and continuous positive airway pressure (CPAP). Administration of low pressure oxygen by means of a nasal cannula or oxygen hood is not considered to be ventilation. Mechanical ventilation actually performs part, or all, of the breathing

function. It provides neonates with forced inspiration. CPAP, on the other hand, provides pressure in the neonate's lungs to keep the airways open and stimulate his breathing mechanisms. In this study, forced mechanical ventilation is implied when the term "ventilation" is used.

The medical care in NICUs is given primarily by a group of neonatalogists, with minimal involvement from private, attending pediatricians. Some neonatal nurse clinicians may also be involved in giving medical care by making treatment decisions or performing certain procedures. The nursing staff is a fairly stable, highly specialized group of nurses who are intimately involved in the assessment, treatment, and evaluation of NICU infants. An NICU classification system should encompass both nursing and medical inputs to care delivery.

NICU Nurses and Case Mix

In the NICU, physicians and nurses function as a team. Nurses play a major role in making assessments and diagnoses, and in initiating treatment. Decisions are often collaborative, between the nurse and doctor, and sometimes with the family. However, nursing is the most continuous care provider, often rendering 24 hours or more of nursing care per patient day. This distinction may account for nursing care inputs tat are not always

parallel with medical inputs. Nursing contributions to treatment decisions tend to have more weight in the care of long-term infants than inputs.

In addition, nurses are primarily responsible for educating and supporting the family. This unique and vital role as a liaison between the intensive medical system and the family unit provides a unique perspective for development of a prospective NICU case. Nurses play a major role in a neonate's current and future care processes, and, therefore, have an important perspective about clinically meaningful patient groups.

Providers encompass different perspectives on NICU iso-resource groupings. Administrators are primarily concerned with iso-length of stay or iso-total charges. Clinical meaningfulness is not relevant directly, as long as the groupings are predictive of total hospital resource utilization. Physicians are primarily concerned with iso-treatment groupings. They focus on the medical care requirements and only indirectly address nursing requirements as support for medical treatments.

A nursing perspective incorporates all of the above and adds a clinical dimension: assessing the level of nursing skill required, monitoring and providing daily care requirements which are related to developmental stage and functional health status, and supporting

adjustment. Clinical homogeneity from a nursing perspective would incorporate both the resources required for ultimate survival, as well as the resources required for minute-to-minute continuous monitoring and support. Nurses are caregivers, problem-finders, and therapeutic interventionists. They see more of the overall care process than do physicians and also consider the resource implications of family structure and functioning. These factors are likely to be predictive of survival and long-term outcomes and complication rates. Iso-resource groupings that include a nursing perspective should be more clinically homogeneous, more useful for quality assurance programs, and more beneficial to hospital administrators than the current DRG system with its diagnostic perspective only.

To be sure, medical and nursing care given in the NICU is directed by a neonate's primary diagnosis; i.e. prematurity, 28 weeks small for gestational age, or respiratory distress syndrome (respiratory immaturity). As such, primary diagnoses are actually patient attributes. Diagnoses direct nursing and medical care regimens and are indicative of the level of maturity in all systems. They reflect clinical courses and indicate potential problems that medicine and nursing will be focused around. They are also predictive of neonatal outcomes.

A case-mix classification system that is based on nursing requirements, as well as medical treatments, will have other benefits. Such a system will be useful in budgeting resources to maintain appropriate staffing levels in NICUs. It will also be useful in justifying costly education and orientation programs for specialized NICU nurses. Moreover, it will be useful for assuring nursing quality such as in the evaluation of alternative modes of care and therapy, and in the comparison of nursing's expected outcomes. It will form a data base from which nursing research can be developed. A nursing perspective in the development and evaluation of neonatal case-mix systems is vital to the validity of the system and its usefulness for other purposes.

This research focuses on the comparative performance of three case-mix schemes--DRGs, NCGs, and CDRGs--as prospective pricing systems for the NICU. These systems will be compared on their ability to place infants into iso-resource groupings and clinically meaningful groupings. In the next chapter, a conceptual framework for this research will be developed. Case mix, in general and for the NICU, will be discussed. NICU patient types and the attributes that determine clinical meaningfulness will be explained. The criteria that will be used in this research to compare NICU case mix systems, and to establish their validity as prospective payment systems, will be outlined.

Chapter II

CONCEPTUAL FRAMEWORK

The comparative analysis in this research is based on a conceptual framework relating NICU case mix, clinically meaningful patient attributes, and criteria for a valid case-mix classification system. This conceptual framework is the basis for comparing and evaluating the appropriateness of all output classification systems within the NICU. This chapter will explain the conceptal framework guiding this research.

NICU Case Mix

Case-Mix Terminology Defined

A neonatal case-mix system attempts to measure the output of neonatal intensive care units. In the literature, the definition of output for hospitals is unclear, diverse, conflicting, and changes with the purpose of analysis or the ultimate objective of the system of measurement (Berki, 1972). According to economic theory, medical care output is best reflected by the satisfactions consumers derive from improved states of health. Medical care is only one input into health, however, and consumer satisfaction presents many obstacles to direct measurement.

Critical care output can be characterized along three fundamental dimensions: volume, quality, and case-mix (Hornbrook, 1982). These are intermediate concepts of output believed to be related to consumer satisfaction, but are more easily quantified than satisfaction per se.

Volume is defined as the number of patients treated per unit of time. The treated case is the preferred output measure because it recognizes that various clinical services are prescribed to achieve a particular objective, and that differences in patients' conditions require different inputs (Hornbrook, 1982). Patient days are not considered an output measure because days are actually inputs to the care process (Hornbrook, 1985).

Quality is defined as the likelihood of a successful outcome to the illness or problem episode, given the patient's condition prior to treatment and given the services provided (Hornbrook, 1985). Few attempts have been made to capture the quality dimension in a measure. However, it is recognized as an important dimension of output, both in terms of technical quality and medical appropriateness (Berki, 1972).

Case mix is defined as the vector of different products, i.e., case-types treated by the unit. Case mix has not been uniformly or adequately defined in the

literature. It is represented by such varied concepts as disease staging, physiological instability, treatment intensity, resource consumption, and disease episodes. Without a clear definition of this basic term, efforts to develop a useful case mix measure are limited.

Rafferty and Hornbrook (1979) recommend that case mix in general be defined in terms of the clinical attributes of patients that are relevant to all clinical decision makers, including the nurse. For this reason, NACHRI (1986) and Hornbrook (1985) both recommend that case mix for pediatric intensive care and intensive care, respectively, be defined in terms of diagnostic groupings. Hornbrook (1985) believes that the definition of case types via diagnosis is most appropriate because it presents the conceptual structure governing the actions of clinicians--assigning a diagnosis and initiating the appropriate therapy. Diagnostic groupings are also appropriate given the special characteristics of the NICU discussed earlier.

However, diagnosis is not sufficient by itself. The family's ability to care for the infant, the need to nurture the mother, and the need to establish bonding while the mother and infant are separated must be taken into account. In addition, discharge planning for certain patient types within the NICU is an extensive,

vital process. Infants discharged from the NICU have continuing requirements that may entail special care procedures, monitoring, and follow up. It is the nurses' role to prepare the infant's parents to provide this specialized care and monitoring.

NICU Case Mix Defined

For the purposes of this study, the following definition of neonatal intensive care case mix will serve as a basis for evaluation of empirical measures:

> Neonatal intensive care case mix defines the multiple outputs of neonatal intensive care units in terms of clusters of neonate attributes that were present just prior to initiation of the care process, that pertain to families' reasons for seeking care, and that pertain to physicians' and nurses' therapeutic objectives and capabilities.

This definition covers hospital care provided exclusively in a NICU. Infants discharged to other levels of care, should be classified into separate, distinguishable case-mix groupings. These infants require less intensive care, less case-mix specialization, and less resource utilization.

Case mix, as it is defined here, is not simply the mix of activities engaged in by NICU providers, does not

incorporate the process of care provided to a given neonate with respect to its quality or relative costliness, and is not merely an arbitrary taxonomy of cases treated. It is a classification of health problems presented to the NICU that is independent of providers' actual responses to those problems, but not of the theoretically appropriate responses (Hornbrook, 1985).

The incorporation of nursing and physician perspectives will ensure a better classification system. Medical treatments, surgery, lab, and radiology are important, but not inclusive. Nursing intensity and the factors used by nurses to identify when an infant requires more, less, or different care will add to the accuracy and appropriateness of the system.

Defining NICU patient groupings solely as cases with similar costs of treatment may result in confounding of inputs and outputs. Cost per case may vary with differences in efficiency of NICU production, quality of care, and case-mix of admissions. Rafferty, et al. (1979), are also cautious about defining patient groupings by cost since actual resource use is under the control of physicians. For example, defining groupings by length of stay does not account for different neonatal characteristics and conditions that may give rise to the same NICU length of stay. Nor does it account for the

appropriateness or efficiency of that length of stay for any given neonate. Groups of cases with similar resource intensity, or iso-resource classes, should be sets of well-defined outputs with similar unit costs under efficient conditions, and should not be sets of cost categories with undetermined heterogeneity of outputs and efficiency (Hornbrook, 1985).

Classes defining similar outputs should also require similar resource inputs. Resource utilization, for the purpose of this study, does not include overhead and indirect unit costs. These costs are assumed to be stable over the short run and do not affect homogeneity of NICU resource groupings over a given period of time. Here resource utilization should capture the aggregated, direct patient care resource consumption of a group of infants with similar characterisitics.

Output classification is a system of averaging. The goal is to classify infants in such a way as to provide incentives to hospitals for the provision of high quality, efficient, and accessible neonatal care. The goal is not to assist with direct clinical decision-making by clinicians, to predict mortality, nor to measure severity of illness. For example, severity of illness does not, and should not, always correlate positively with resource consumption. Infants who are

the presence of concurrent problems which may complicate an infant's course; e.g. growth retardation, infants of diabetic mothers. Birth weight is an indication of an infant's ability to fight infection and disease processes because it is reflective of the physiologic resources an infant has available for maintaining homeostasis and recovering from external insults.

Disruption or immaturity in the respiratory system's ability to function adequately is the most common medical problem treated in the NICU. Disruption in this system affects the functioning of other body systems, and thus, the infant's total plan of care. Body systems that are unable to receive adequate oxygenation can be permanently damaged. Respiratory disruption requires support in the form of oxygen administration or mechanical ventilation. The latter is indicative of severe respiratory disruption or immaturity. Infants requiring ventilation are more severely ill than those not requiring ventilation.

In addition, ventilated infants are prone to complications associated with this therapy. Therefore, they have similar care regimens and clinical courses. Because of the complications and disruptions associated with lack of oxygenation in long-term ventilation, length of therapy is a more accurate predictor of clinical course and care regimen than ventilation as a single factor.

Criteria for a Valid Case-mix Classification System

Classification systems should meet three sets of criteria to establish: content/construct validity; classification variable validity; and external validity. The following criteria were used in this research to compare the three NICU case mix systems' validity as the foundation for prospective payment systems.

Content/Construct Validity

Content/construct validity involves the following four basic criteria:

(1) Exhaustiveness: A classification scheme of the total output of the NICU should be exhaustive. That is, it should account for all cases treated in the NICU setting and every case should be classifiable. Patients treated outside the NICU should not be classifiable into these systems. A classification scheme that arbitrarily excludes some NICU cases is not useful and, more importantly, is misleading and biased--that is, some of the product of the NICU has been omitted.

(2) Mutual Exclusivity: This means that each treated case can be unambiguously classified into a particular product group and no others. One manifestation of mutual exclusivity, if cases are

classified according to factors that are related to resource use, is that classes tend to be nonoverlapping in observed resource use.

(3) Homogeneity: Each group should be relatively homogeneous with respect to the classification criterion so that cases in a given group are more alike than cases from different groups. In this research, groupings will be analyzed conceptually to determine if infants are grouped by clinically pertinent patient attributes, according to medical and nursing providers within the NICU. Ideally, documentation should be available in the literature that these variables affect neonatal resource utilization. Neonates within an iso-resource group should be identifiable as requiring approximately the same nursing and medical care regimens. Each grouping will also be examined empirically to determine their degree of homogeneity with respect to observed resource use. Different groups should have different levels of resource consumption within the universe of patients treated.

(4) Consistency: Each member of one group should bear the same ordinal relationship to a member of another group. The relative ranking of groups between systems should also be consistent.

Classification Variables' Contribution to Validity

Classification variables must meet certain criteria in order to sustain the validity of the resulting groups. The following established criteria were used to evaluate each variable's validity:

1) Reliability: Variables should be reliably measured and easy to audit; i.e., they should be clearly and accurately retrievable from the discharge abstract, NICU summary data form, or the physician's billing form. Unreliable variables will result in poorly distinguished groupings.

2) Stability: Variables should be reasonably stable over time in a given patient; i.e., they should be present long enough to influence nursing and medical care regimens. Stable indicators give better assurance that the classes are reflective of true, non-random differences among groups of cases.

3) Service orientation: Variables should not be direct measures of patterns of care or service. They should reflect patient, not provider, attributes. The greatest single threat to the validity of a case-mix measure is the inclusion of actual utilization variables as classification variables, such as ventilation or surgery. This is equivalent to retrospective cost reimbursement, where the provider is paid for use of inputs rather

than for producing outputs. These inputs are easily manipulated by providers. If utilization variables are used as classification variables, incentives should be present that will prevent overutilization and manipulation by providers.

External Validity

Finally, each classification scheme should be assessed for its ability to meet the established criteria for iso-resource groupings. The criteria are as follows:

(1) Generalizability: Iso-resource groups should be based on variables that are uniformly available across NICUs and are identifiable by practitioners; i.e., birthweight, mortality, ventilation, or surgical categories. The scheme should be generalizable to all NICUs.

(2) Administrative feasibility: Each group should have a reasonable percentage of patients. The system should consist of a manageable number of groups so that its administrative cpsts are acceptable.

(3) Minimization of negative impact: The system should be designed to minimize negative incentives and provider gaming. Provider gaming is the manipulation of the system for the providers'

financial gain. The goal of the groupings is to provide incentives for the provision of high quality, accessible, and efficient NICU care. It is also desirable for the groups to allow for comparisons between hospitals, regions, and modes of treatment. Where groupings provide opportunities for potential provider gaming and negative incentives, positive incentives should be in existence that discourage overutilization and manipulation.

The conceptual framework on which this research is based relates NICU case mix, clinically meaningful patient attributes, and criteria for a valid case-mix classification system. This framework is used in the following chapter to review case-mix schemes develop for adult, pediatric, and neonatal intensive care units.

CHAPTER III

REVIEW OF THE LITERATURE

Several prospective case-mix reimbursement systems have been developed for, or used in, intensive care settings. The DRGs have been used by Medicaid in intensive care settings, but documentation exists that this is not a valid system for the neonatal intensive care population. In addition, two case-mix schemes were developed specifically for adult and pediatric critical care. They will also be reviewed in this chapter and their applicability for NICUs discussed.

The NCGs and CDRGs were developed from the DRG framework. There is consensus in the literature that such a diagnostically based framework can represent the neonatal population from a clinical and resource use perspective. These modified case-mix schemes attempt to correct the flaws in the generic DRG system and expand on its classification variables.

Diagnoses Related Groups (DRGs)

Description

The DRG system was designed to categorize all hospital patients by major diagnostic groupings that would be predictive of hospital resource utilization.

The data base was constructed primarily from community hospitals. There was a strong emphasis on adult, rather than pediatric patients, with no specific effort to include such specialized centers as intensive care units (Pasternak, Dean, Gioia, and Rogers, 1986). DRGs are designed to classify the total episodes of hospitalization, and do not make distinctions between care provided in intensive care units and newborn nurseries. DRGs for newborns were developed to classify both normal newborn and neonatal intensive care patients. The newborn DRGs are primarily medical in focus. Infants with surgery or congenital anomalies are often more appropriately categorized outside the newborn DRGs.

The DRG system categorizes diagnoses into groups, each group entailing similar, expected hospital services and lengths of stay. Hospitals are paid a predetermined specific rate per patient discharge, rather than the traditional per diem rate. Patients ideally are classified into distinct groups that are homogeneous with respect to cost. A limited amount of additional reimbursement is provided for "outlier" patients whose stays are 1.94 standard deviations (SD) longer than the federal average. Additional payments are only received for days beyond the outlier threshold (1.94 SD) and amount to only 30% of the average per diem for the DRG.

The majority of neonates are classified into one of the following newborn DRG categories also diagrammed in Figure 1:

DRG 385-Neonates, died or transferred

DRG 386-Extreme immaturity or respiratory distress syndrome, neonate

DRG 387-Prematurity with major problems

DRG 388-Prematurity without major problems

DRG 389-Full-term neonate with major problems

DRG 390-Neonates with other significant problems

DRG 391-Normal newborns

The birth weights included with the DRGs in Figure 1 are not part of the DRG grouping definitions, but are included in the definitions of extreme immaturity and prematurity. A list of the diagnoses included under each DRG can be found in Appendix A. A small percentage of neonates, primarily those with surgical procedures, are classified into other non-newborn DRGs.

Evaluation

In analyzing the newborn DRGs, they appear much too broad to be predictive of resource utilization. The categories do not utilize variables important in predicting resource utilization and defining nursing and medical care regimens in a neonatal intensive care population. For example, two patient types are grouped

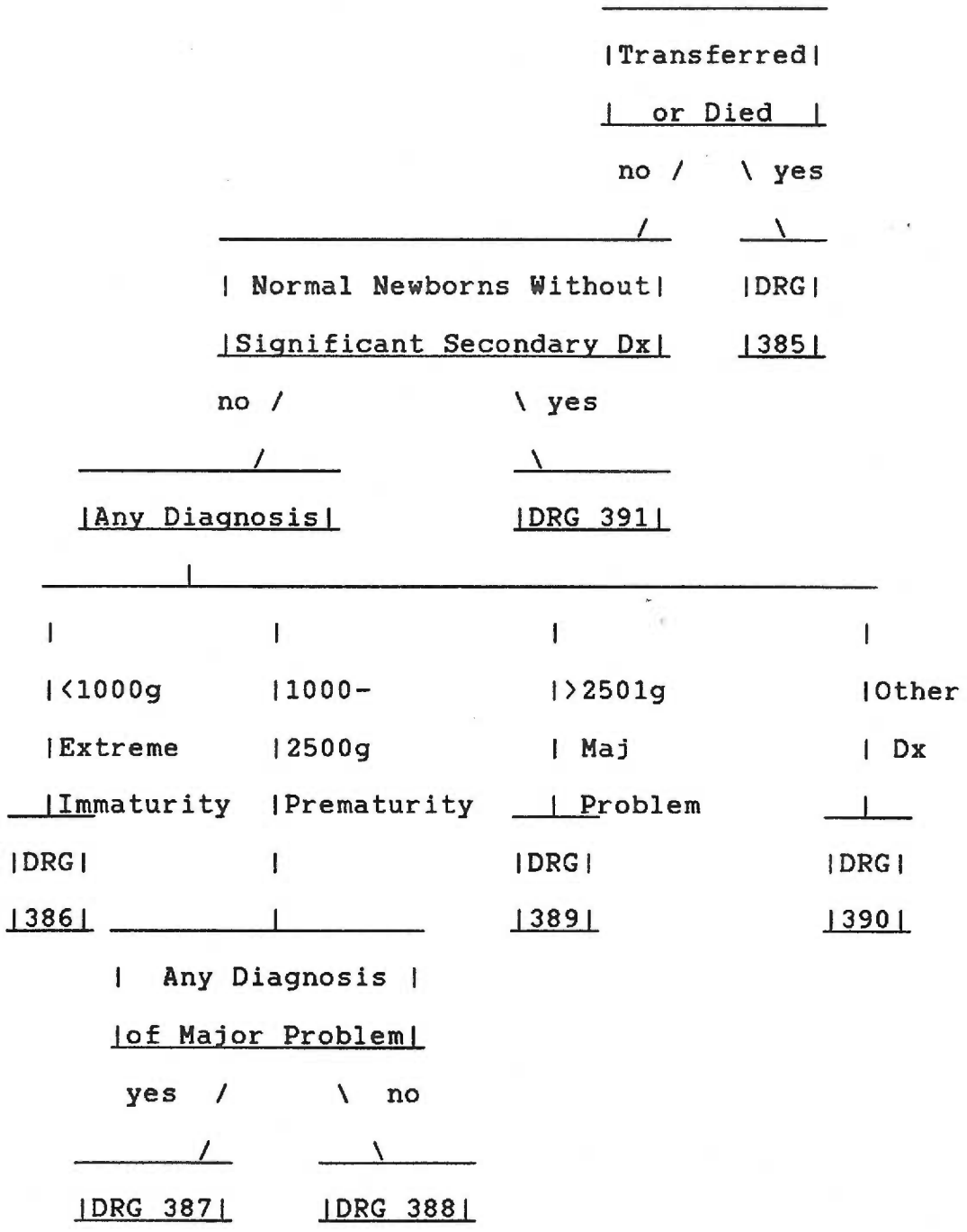

Figure 1. Diagnosis Related Groups pertaining to newborns.

together in DRG 385, infants who died and infants who were transferred. These are complex groupings that require very different care regimens and resource consumption needs within patient types. Infants who died and infants who were transferred need to be separated to form more homogeneous resource utilization groupings.

The DRGs justifiably use birth weight definitions, but they are much too broad to be predictive of resource utilization. Infants with birth weights of 1000 grams are more severely ill and require more supportive care than those infants weighing 2,500 grams or more. In order for DRGs to reflect clinical decision making, birth weight divisions need to be smaller. In addition, the DRGs need to incorporate other variables important in resource consumption in neonates; e.g., surgery and duration of mechanical ventilation. The DRG system does not contain enough groupings and the groupings are not appropriately divided to accurately capture resource utilization in neonates.

Over 350 diagnoses are included in DRG 387 and 389. Diagnoses range from jaundice (a physiological process requiring little intervention) to meningitis (an infectious process requiring immediate and intensive intervention). The diagnostic framework is appropriate, but the diagnoses used in the DRGs are representative of

the normal newborn population. Many of these diagnoses would rarely be seen in a NICU setting. Variables important in predicting resource consumption in neonates are not accurately or consistently captured by the DRG diagnoses. In addition, the diagnoses that capture some of these variables are all together and not divided into separate groupings. Diagnoses, used in this manner, will not be predictive of resource utilization within NICUs.

The DRGs also classify infants requiring normal newborn care and those requiring intensive care into the same categories. A classification system that does not distinguish between these two very different types of care can only form divergent, heterogeneous groupings. In addition, DRG 387 and 389 use the same list of diagnoses. Low birth weight infants (DRG 387) will have diagnoses/clinical conditions that are not adequately represented by this list of diagnoses. The DRG system was designed to capture the patient population within normal newborn nurseries, and is not appropriate for predicting resource utilization or reflecting treatment regimens in NICUs.

An analysis of DRG utilization by high-risk newborns admitted to a tertiary care, children's hospital unit, conducted by Poland, et al., (1985) established that DRGs did not take into account important influences on

hospital stays such as birth weight, surgery, outborn status, and mechanical ventilation. Length of stay data for high-risk newborn infants in a NICU were compared with mean and outlier lengths of stay. Findings showed that in every case, the DRG mean underestimated the total number of days spent in the hospital. This was attributed to DRG use of the geometric mean, which tends to reduce the impact of high values in a distribution. NICU patients are disproportionately likely to be in the outlier tail, so the geometric mean discriminates against these patients as a group. Also, the data represented a select population of newborns who were transferred from their hospital of birth to a tertiary care nursery. These infants tend to have longer lengths of stay in comparison with infants that could be treated at their hospital of birth.

Lagoe, et al., (1986) found that Level III, II, and I neonatal facilities produced markedly different hospital mean stays for patients in DRG 385 and 386, and to a lesser degree, in DRG 387. (Level I facilities are normal, newborn nurseries; Level II facilities can care for medium risk neonates; and Level III facilities are NICUs). In DRG 385 and 386, the federal geometric mean stays were comparable to the mean stay for Level I and Level II facilities, respectively. Under this system,

Level III facilities with longer lengths of stay would not be adequately reimbursed. Poland, et al., (1985) states that it is likely all tertiary care neonatal units will have a disproportionate share of outliers.

Resnick, Ariet, Carter, Fletcher, Evans, Furlough, Ausbon, and Curran (1986) analyzed NICU data from Florida's ten regional neonatal intensive care centers. They also found mean length of stays in those centers to be substantially longer that those reported from centers using federal DRGs. According to Resnick, et al. (1986), if federal DRG-based reimbursement was implemented in Florida's perinatal intensive care program, compensation would range from 9% to 56% of actual hospital care charges. Resource consumption in Level III, tertiary neonatal units is not accounted for by the DRG system.

Birth weight has been established as an important influence on hospital resource utilization in neonates. Birth weight is a critical variable because it reflects the maturity of an infant's vital systems, i.e., respiratory system, cardiovascular system, homeostasis control, etc. Birth weight is a critical variable in determining nursing care regimens. "Tiny baby" protocols are utilized for nursing and medical care. A very low birth weight infant requires constant monitoring and comprehensive care to address total system immaturity.

The more immature an infant, the more support that infant will need to survive until it can function on its own. Most authors recommend that birthweight be divided into 250 to 500 gram intervals (Resnick, et al., 1986; Poland, et al., 1985; Kaufman and Shepard, 1982; Pomerance, Ukrainski, Ukra, Henderson, Nash, and Meredith, 1978; Zarfin, Van Aerde, Perlman, Pape, and Chipman, 1986).

Only three DRG categories deal with prematurity: extreme immaturity--DRG 385 (by definition 1,000 gms or less); prematurity with or without major problems--DRG 387 or 388 (by definition 1,000-2,500 gms). NACHRI (1985) and Resnick, et al. (1986) found that these neonatal DRGs contained a high degree of variation in patient severity and resource consumption within diagnostic groupings, and were not homogeneous.

The DRG category, transferred or died, is particularly inapplicable to NICUs, infants may be treated for prolonged and intensive periods before death or transfer. It may be appropriate to cluster infants who died, but infants who were transferred form a divergent type of care grouping from infants who died. Additionally, reimbursement in this category is significantly inadequate for NICUs because its mean length of is only 1.8 days. Thus, the category creates incentives for NICUs to keep patients, rather than

transfer them to a lower care facility, and convert them to another DRG with higher payment. Reimbursement can be increased by keeping infants through their growth and recovery stages, and assigning other DRGs; e.g. DRG 386 through 390 have length of stay means of 17.9 to 3.4 days. The result could be crowding in Level III facilities and barriers to accessibility of care at this level.

In summary, the DRGs were found not to be predictive of hospital charges in Level III NICUs. They did not take into account important influences on hospital resource consumption. They substantially underestimated the length of stay for infants in tertiary centers, creating adverse incentives for these facilities in the admission and treatment of certain patient types. The groupings were also found to be heterogeneous from a clinical perspective. Factors important in determining care regimens and in clinical decision-making were not present. Finally, the DRGs do not allow for the formation of a data base for in-unit and across unit analysis of deaths per birthweight, diagnosis, or treatment modality.

Physiologic Systems for Severity of Illness Measurement

Case-mix measurement studies of several systems have been conducted in adult and pediatric intensive care

units to assess severity of illness of patients and patient groups, primarily for mortality prediction and the comparison of treatments. They have also been used with the Therapeutic Interventions Scoring System (TISS) to correlate severity of illness with resource utilization. This section will evaluate these other case-mix systems for their relevance to the NICU.

Acute Physiology and Chronic Health Evaluation (APACHE) Description

APACHE and APACHE II are disease severity classification systems that are used in adult intensive care units. Their purpose is primarily to stratify patients prognostically by risk of death so that different treatment programs can be more accurately compared. Wagner, Knaus, and Draper (1983) and Knaus, et al. (1985) found a highly significant relationship between the APACHE/APACHE II and hospital survival for adult ICU patients. APACHE has been used by Knaus, et al., (1985) to compare treatment course and outcomes in studies of therapeutic efficacy, in determining the relative benefit of an invasive procedure, and for clinical decision-making. Knaus, Draper, Wagner, and Zimmerman (1986) used APACHE II to compare treatment courses and outcomes in 13 hospitals.

The Acute Physiology and Chronic Health Evaluation (APACHE) is a two-part severity of illness

classification. A copy of the APACHE system can be found in Appendix A. The first part, the Acute Physiology Score (APS), consists of a weighted sum of 33 potential physiologic measurements obtained from the patient's clinical record. This score reflects the degree of derangement of all of the body's seven major vital physiologic systems: neurologic, cardiovascular, respiratory, gastrointestinal, renal, metabolic, and hematologic. According to Wagner, et al. (1983) these seven categories are often more relevant descriptors of ICU patients than diagnoses because failure in one of them is frequently the reason for ICU admission.

The second part of the APACHE classification system is the chronic or preadmission health status score. This includes four categories designed to reflect the patient's chronic health status six months prior to ICU admission. Age is also a variable in the APACHE system. APACHE II, simply an updated version of APACHE, uses fewer physiological variables (12) to assess the seven major body systems.

Evaluation

APACHE's physiological variables were developed for adult responses to illness and would not be appropriate for neonates. Physiologic variables have different normal values and ranges in adults, as compared to

neonates. For example, the normal heart rate in an infant is 120 to 160 beats per minute. In an adult, the normal heart rate is 60 to 80 beats per minute. Respiratory and blood pressure parameters also differ greatly. These physiologic variables do not determine care regimens nor differentiate between patient types. They are, particularly not important in predicting resource utilization in the recovery stage of a neonate's NICU stay. Variables such as diagnosis, gestational age, family education, mothering support, and feeding tolerance are the biggest indicators of care requirements at this stage. The NICU needs a classification system which includes all of the patient attributes that determine outcome.

APACHE and APACHE II are also inappropriate for use in the NICU because diagnoses are more relevant than body system failures as patient descriptors. For example, the diagnosis--30 weeks small for gestational age--entails a nursing and medical plan of care to support growth by addressing real and potential problems (but not necessarily body system failures) in this patient type. Respiratory distress syndrome is another common diagnosis in the NICU that implies a growth deficity, not failure.

Wagner, et al. (1983) found that APACHE was applicable to acutely ill, adult hospitalized patients.

Infants are hospitalized in the NICU throughout various stages of illness and recovery. An NICU case-mix measure must conceptually address many levels of severity of illness, not all of which are acutely ill. An NICU case-mix measure must also account for varying levels of illness within individual patients. A classification system designed for acutely ill adults is not appropriate to classify NICU populations for the purpose of resource utilization prediction or for classifying infants into clinically meaningful groupings. For the NICU, a classification system is needed that will capture neonatal variables predictive of resource utilization and care regimens.

A classification system for reimbursement purposes should be based on patient attributes present prior to the initiation of therapy and should be independent of providers' actual therapeutic decisions. The APACHE classifications are not entirely independent of therapy. Most studies have used APACHE throughout the ICU stay or after the first 24 hours of ICU admission. As such, this system will reward treatment inefficiencies already in place. A case-mix system designed primarily to predict resource utilization should focus not on actual care provided, but on the ideal, efficient use of resources resulting from the production of high quality, nursing and medical care of various patient types.

The APACHE system classifies patients for the primary purpose of mortality prediction, i.e., severity of illness. In an adult ICU, mortality and resource utilization are highly correlated. Mortality prediction can be a useful proxy for iso-resource groups. However, Galanes, Harris, Dulski, and Chamberlain (1986) found that the APS cannot be used as an indicator of case mix for financial reimbursement or as a marker for cost outliers in an ICU.

One issue that arises is the ethical problem of the value of heroic measures. This problem is also present in the NICU. A case-mix scheme should, ideally, account for the decision not to provide heroic interventions, i.e., to provide palliative care, rather than seeking the "miracle" in appropriate patient types.

Mortality prediction cannot be used as a proxy for resource utilization within the NICU. Rather, birth weight, instead of survival, is highly correlated with resource utilization. Birth weight is the single variable which most determines neonatal length of stay. A premature infant, for example, may have a very high probability for survival, but require a long hospitalization within the NICU to stabilize and grow. The conceptual framework necessary to accurately predict resource utilization is not identical to that required to

predict mortality within the NICU. Thus, the APACHE system is not useful on this basis.

Physiologic Stability Index (PSI)

Description

The PSI, physiologic stability index, is the severity of illness classification system under investigation in pediatric intensive care units (PICUs). A description of this system can be found in Appendix A. Both the PSI and the APACHE system represent severity of illness by assessment of physiologic variables. There is much similarity between the two systems in the variables and abnormal ranges chosen. The major difference is the presence of age-adjusted variable ranges in the PSI system to make it applicable to infants and children. The respiratory and cardiovascular variables, however, are the only two with parameters divided into infant and children categories. Infants are defined as 12 months of age or less. The PSI does not include a chronic health assessment.

The PSI has been found to be significantly related to hospital mortality and other established severity measures (Yeh, Pollack, Ruttimann, Holbrook, and Fields, 1984; Ruttimann, Albert, Pollack, and Glass, 1986). Yeh, et al. (1984) used the PSI and TISS in combination to compare the different pediatric intensive care services

and the amount of therapy given at differing severity of illness levels. Ruttimann, et al. (1986) used the PSI to identify high risk groups for more aggressive therapy and low risk groups for discharge. Pollack, Ruttimann, Glass, and Yeh (1985) used the PSI and TISS to identify PICU patients that could be cared for in lesser cost hospital areas.

Evaluation

The PSI is not appropriate for use in the NICU. It does not contain appropriate measures or parameters for neonatal evaluation within the seven major body categories. Premature infants, as compared to infants up to one year of age, have different ranges for normal measurement of physiologic variables. These ranges may change as their systems mature. Heart rate, respiratory rate, and blood pressure parameters would need to be adjusted on the PSI for premature infants. Parameters may need to be broken down by gestational, as well as postdelivery, ages.

As discussed before, severity of illness is not an appropriate classification measure for predicting resource utilization in NICU populations. Most neonates stay in the NICU throughout all stages of their recovery. Severity of illness also does not group neonates by variables important in determining care

regimens in all patient tpes. Like APACHE, the PSI does not adequately assess indicators for intermediate and low-risk NICU care, i.e., education, support, care in conjunction with diagnoses and gestational age. Ruttimann, et al. (1986) propose that although the PSI can predict hospital mortality relatively well, it does not consider the dynamics of the disease and recovery processes. Pollack, et al. (1984) found that severity of illness is not always correlated with resource utilization.

The PSI's conceptual framework is more appropriate for use by clinicians in clinical decision-making than for purposes of reimbursement (Ruttimann, et al. 1986). Assisting clinicians in decision making is an appropriate use for a case-mix scheme; this research, however, is comparing case-mix schemes for the primary purpose of resource prediction. Clinical decision making, in this sense, is an input that must be accounted for in determining variables and appropriateness of care. Using diagnoses to determine classifications in the NICU is appropriate because it presents the conceptual structure governing the actions of clinicians.

Ruttimann, et al. (1986) found that mortality prediction was best when based on the most recent PSI measurements, meaning that measurements must be taken at

intervals after therapy has been initiated. In this way, the PSI incorporates treatment processes and is not based primarily on patient attributes prior to treatment initiation. A case-mix scheme developed primarily for resource prediction should focus on the ideal, efficient use of resources required to provide high quality care to various patient types. The NICU needs a classification system that can take into account its unique population and classify patients in a manner predictive of resource utilization and care requirements.

Therapeutic Intervention Scoring System

TISS, Therapeutic Intervention Scoring System, has been used to measure the therapeutic interventions given to a patient. It is often used in conjunction with APACHE or PSI to measure resource utilization as correlated with severity of illness. TISS is not truly a case-mix classification scheme because it does not directly take into account patient attributes or characteristics. It measures treatments, which are inputs into the care process. TISS does not deal with the appropriateness, effectiveness, or efficiency of care provided.

TISS is not appropriate for use in the NICU as a system of patient classification for the purpose of reimbursement. Research utilizing TISS has, however,

documented the need for modified classification systems in areas that provide intensive medical and nursing care. It has also identified the need for modified reimbursement to intensive care areas in order to adequately reimburse for resource consumption and provide incentives for the admission, treatment, and discharge of severely ill patients.

Neonatal Care Groups (NCGs)

Description

Resnick, et al. (1986) developed and validated a classification system using 12 categories of neonatal care groups (NCG) (Figure 2). This system is based on the diagnostic related framework that is used in DRGs. However, the data base came from Florida's ten regional neonatal intensive care centers. The sample included 8,492 neonates who received intensive care. This classification system was developed for use in neonatal intensive care units. It does not account for infants who receive normal newborn care and are never admitted to the NICU. It also does not account for care given to infants tranferred out of NICUs to other care units. The aim was to categorize all infants cared for exclusively in the NICU into groupings that are homogeneous with respect to resource consumption.

Resnick, et al., (1986) found that the newborn DRGs did not classify their NICU population into homogeneous,

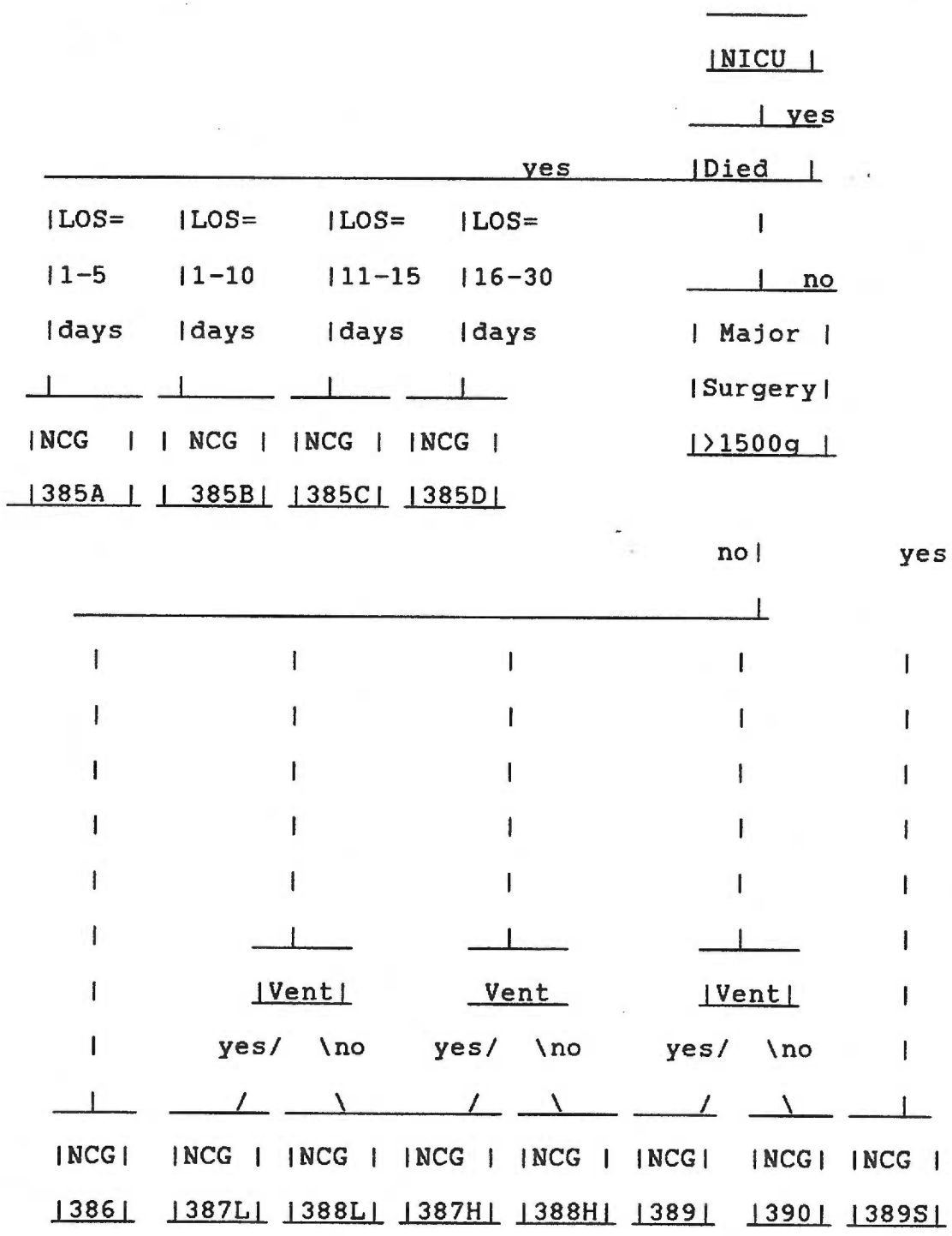

Figure 2. Neonatal Care Groups.

resource utilization groupings. They attributed this failure to the fact that the newborn DRGs were based on data from infants unlike those served by tertiary care NICUs, i.e., community hospitals. However, they felt that certain aspects of the newborn DRG system were valid, even for infants with higher morbidities than found in the DRG data base. For example, they thought it justifiable to cluster infants who die, regardless of birth weight, and to group survivors by birth weight. Therefore, they decided to modify the DRGs instead of starting anew. The NCG system uses the DRG coding, especially 385 through 390, but modifies these groupings based on variables documented as important determinants of neonatal hospital resource consumption.

The NCGs divide the groupings initially by mortality. Mortality is then broken into four categories by length of stay. Major surgery with birth weight greater than 1500 grams is the next divisive variable. Birthweight in 500-1000 gm intervals and ventilation are the other classification variables used in the NCGs. Resnick, et al. (1986) found that this system grouped infants more homogeneously than the seven category DRG system; in other words, the NCGs explained 52% of the variance in NICU charges while the DRGs accounted for only 16% of the variance in the same dataset.

The modifications to the DRGs made by the NCG system are summarized as follows:

1) Infants with respiratory distress syndrome were not grouped with extremely premature infants as in DRG 386. Instead, they were classified by birth weight, ventilation, and major surgery.

2) DRG 387 was divided into two separate weight groups (NCG 387L and NCG 387H).

3) Instead of major problems being defined on the basis of more than 500 diagnoses, as in DRG 387 and 389, ventilation and major surgery were used to define major problems in NCGs 387, 388, and 389.

4) The infants who died (NCG 385) were subdivided into four groups depending on length of life in days. Deaths after 30 days would exceed the outlier cutoff and, therefore, would receive outlier per diem compensation.

Evaluation

Two of the variables used in the NCGs are service entities (ventilation and surgery). Ideally classification variables should be patient characteristics. This is because service entities used as classification variables provide incentives to these entities. Efforts to decrease the manipulability of ventilation, or to eliminate it, call for two possible approaches: 1) a length of time which ventilation must

exceed before reimbursement begins (24 - 72 hours); or 2) blood gas level ranges for 24 hours (Shannon, Crone, Todres, and Krishnamoorthy, 1981). However, these efforts do not rely on patient attributes prior to the initiation of the care process.

Resnick, et al. (1986) originally used ventilation as a yes/no variable. Several years ago, they decided that ventilation should occur for 48 hours before it is recognized as a reimbursement factor. They added this qualification to their reimbursement system and found no significant difference in the way this qualification divided ventilated/non-ventilated neonates.

Resnick, et al. (1986) justify using ventilation because it is the primary cost factor for all of the "major problems" NCG categories for infants weighing more than 1,000 gm. This reflects, in part, the intensive monitoring and care given by nurses to this patient type. They believe duration of ventilation and oxygen concentration are important descriptors of morbidity and, therefore, influence cost. They agree that there is potential danger in "rewarding ventilation", but feel the clinical justification through peer review is easier to ascertain than the diagnoses that determine groupings in the DRG system.

By using death as the first variable to separate infants, Resnick, et al. (1986) preclude the use of

mortality to evaluate care. Also, most studies recommend breaking birthweight by 500 gm. categories, at the greatest. NCGs use one category that spans 1,000 gms. Infants weighing 1500 and those weighing 2450 gms present to NICU clinicians different levels of maturity and requirements for support and monitoring.

NCGs do not deal with infants that are outborn or transferred. How do facilities that transfer to or from this facility get reimbursed? It appears that under NCGs a Level III facility would get the same reimbursement, whether or not an infant fully recovered in that facility. Resnick, et al. (1986) state that transport status is an important variable in their analysis, but they do not report findings or justification for not using it in the NCGs.

Poland, et al. (1985) found that infants classified as surgical had mean lengths of hospital stay that were from 4.5 to 28 days longer than those infants classified as medical. The smaller the infant at birth, the more the stay was lengthened by the surgical condition, i.e., infants weighing 500 - 1,500 gms had the greatest increase. This brings to question the accuracy of the NCG surgery cutoff at 1,500 gms.

In summary, the NCG system proposes to be more predictive of NICU resource consumption by neonates than

the DRG system. The NCG systems incorporates variables that make it more clincially meaningful, and thus, would allow for regional and interhospital comparisons of treatment modalities and case mix. It also creates a data base that would be helpful in quality assurance programs and staffing forecasting. The groupings formed by the NCG system are more clinically meaningful and homogeneous than those formed by the DRGs

Children's Diagnosis Related Groups (CDRGs)

Description

NACHRI sponsored the Children's Hospital Case-Mix Classification Project. The objective of the project was to develop a case-mix classification system that would be applicable to the case mix and length of stay of children in all types of hospitals, including children's hospitals. The basic approach was to supplement, rather than discard, the current DRG definitions, in order to improve their applicability to children.

Children's hospitals treat large numbers of patients who are treated in no other setting. Such cases are rare in general hospital populations, but can represent a substantial portion of pediatric care at children's and other tertiary care hospitals. Therefore, the CDRGs were developed and tested using national data samples that dramatically oversampled children's hospitals and

university hospitals. This allowed the identification of cases that are low in volume in the general population, but that are treated almost exclusively in tertiary care facilities.

A concern arises, however, with this sampling procedure, as to how well this classification system will represent tertiary neonatal centers. NACHRI (1986) states that the majority of neonatal caseloads at children's hospitals will be 2500+ gram infants with various congenital anomalies and malformations. Many of these infants may require surgery. On the other hand, the majority of the caseload at some tertiary NICUs, for example, is not 2500+ gram infants, with or without surgery. Conceptually, children's hospitals and tertiary centers have some similar attributes, but not enough to serve as the foundation for an NICU case-mix index. The oversampling of children's and university hospitals may distort the applicability of this system to tertiary neonatal care centers because of their caseload differences.

The CDRGs are divided into two subsets: neonatal CDRGs, including infants from birth to 28 days of age, and childrens' CDRGS, that include infants over 28 days of age. Twenty-eight days was chosen as the cut off because it is the traditional end of the neonatal

period. Infants transferred or admitted to any facility at 29 days of age or older would be classified in the children's CDRGs.

The conceptual reasoning for using the 29-day cut off for the NICU population is unclear. Infants that are born one to three months prematurely and require transfer to another institution after 29 days of age, would be classified in the children's CDRGs. Yet, they may still not be full term and will not have care regimens similar to other infants born at full term and over 29 days old. These infants will remain in a neonatal care setting, yet be included in a childrens' case-mix scheme.

The other issue that arises here is how do we define age; from the point of birth, which can vary dramatically, or from the point of conception, which would be the same starting point for all? It seems that the point of conception would be more appropriate here as a means of capturing resource utilization needs and care requirements.

The neonatal CDRGs include 32 classifications (Figure 3). The CDRGs follow the basic DRG coding system, but add more variables to divide the DRG groupings. None of the DRGs remains unchanged. Like the DRG system, the CDRGs are designed to encompass all newborn infants in the classification system. Normal

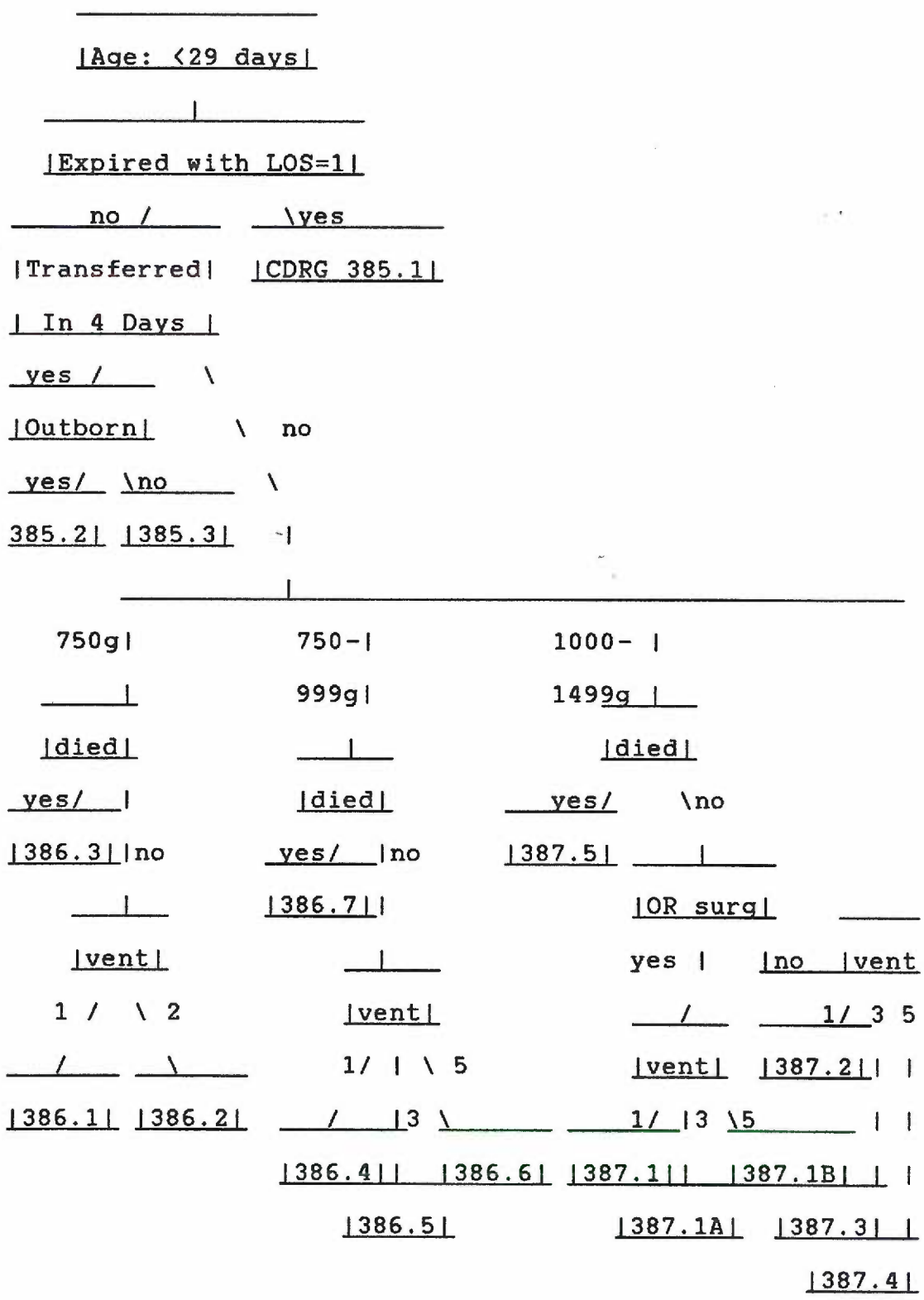

Figure 3. Neonatal groups in Childrens' Diagnosis Related Groups.

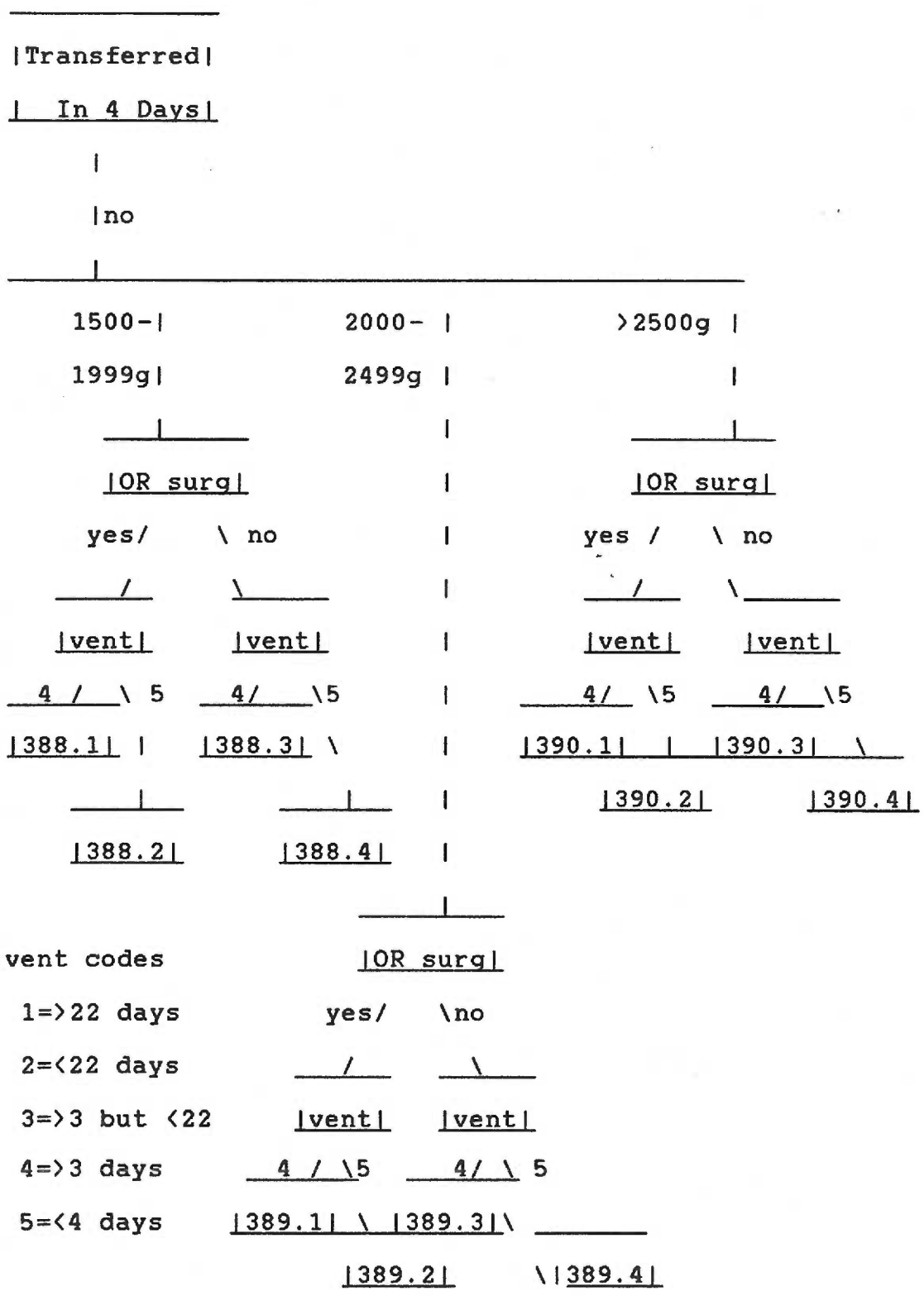

Figure 3. (Continued).

newborn infants would be classified in CDRG 391.2, the highest volume CDRG for the general hospital population.

Classification variables in the CDRG system include the following: mortality, LOS if died within one day or transferred, transfer status, birth weight, OR surgery, duration (in days) of mechanical ventilation, major problem diagnoses, uncomplicated diagnoses, and routine care diagnoses. Transport admissions within four days of birth, and transports back to the hospital of birth for routine care within 28 days of birth, are the only transports included in the CDRG system. It is unclear how infants who are transferred to a facility for specialized care, and then returned to the originating NICU, will be classified. This is a fairly common practice in some tertiary centers. Infants of low birth weight who are transported back to the home facility after 28 days of life are not accounted for in the neonatal CDRG system. Also, it seems possible that some infants could be transferred to intermediate care facilities and not meet the routine care requirements for the transport-back CDRG. It is unclear how these infants are accounted for in the CDRG system.

All infants who do not fall into the died/LOS=1 or transferred categories are divided into six birth weight

categories. Birth weights in the CDRG system are broken into 500 gram intervals, with the exception of birth weights less than 1000 grams, which are broken into 250 gram intervals.

Evaluation

Ventilation in the less-than-1500-gram groupings was divided at three-week intervals. Conceptually, this seems appropriate because newborns who stay on a respirator for extended periods of time are prone to higher morbidity, especially of the respiratory system, than are infants who are ventilated for shorter periods of time. Ventilation in all birth weight categories, except less than 750 grams, was divided at three days. Infants ventilated for three days or less are categorized with infants having no ventilation requirements. This should dramatically decrease provider gaming concerns regarding ventilation as a system variable.

All birth weight categories above 1000 grams include a split based on the presence or absence of OR surgery (any surgery performed in the operating room). A minor surgery split of the birth weight categories above 2000 grams was later added to the CDRG system.

Deaths are divided by birth weight up to the 1500 gram groupings. Infants who died with birth weights of 1500 grams or more are categorized with infants that

lived by birth weight, presence of surgery, and ventilation status. Categorizing infants who died by birth weight should encourage treatment and quality of care comparisons between hospitals and regions. Infants who died should be placed into more clinically meaningful groupings.

However, those infants who died at greater than 1499 grams may be classified inappropriately. They may have LOSs divergent from the rest of the infants in their grouping. They may be nearly full-term infants with severe problems requiring intensive life support for several days. As such, they will require a greater amount of hospital resources and different care regimens than the surviving infants in their birth weight grouping. These infants, however, do have a much lower risk of death from their prematurity than those born weighing under 1500 grams. The developers of the CDRG system felt that the presence of medical problems, the need for surgery, and ventilation became more important factors for resource use than mortality, in infants weighing 1500 grams or more.

Summary

There is consensus in the literature that although the neonatal DRG system needs improvement, the diagnosis related groupings framework is the most appropriate for

classifying infants in neonatal intensive care units for the purpose of reimbursement (NACHRI, 1986; Hornbrook, 1985; Poland, Bollinger, Bedard, and Cohen, 1985; Lagoes, et al. 1986; Resnick, Ariet, Carter, Fletcher, Evans, Furlough, Ausbon and Curran, 1986). The NCG and CDRG systems are both based upon this framework. They both propose to form more homogeneous groupings and to be more predictive of hospital resource utilization than the DRG system. The essential aim of this study is to assess the success of these two schemes in correcting the flaws in the DRGs. It is important, therefore, to test all three of these systems in a neonatal intensive care population, in order to make judgements about their strengths, weaknesses, and validity as predictors of neonatal hospital resource utilization.

CHAPTER IV

AIMS AND METHODS

Aims

The overall aim of this study is to compare the performance of three case-mix schemes (DRGs, NCGs, and CDRGs) in classifying NICU patients for the purpose of reimbursement. In this application, cases in a given case-mix category should require a similar level and mix of resources for treatment at a given level of quality. The validity of each classification scheme as an iso-resource grouping system for NICUs is explored.

The specific aims of this study are:

1) to examine construct/content validity of the three case-mix schemes: i.e., to determine whether each classification system is representative of the entire NICU patient population;

2) to determine the predictive validity of the three case-mix schemes: i.e., to assess the extent to which the classifications are predictive of the overall intensity of inpatient care;

3) to determine the homogeneity of the resource groupings formed by each system from both clinical and resource use perspectives;

4) to investigate the extent to which three fetal characteristics--lethal anomalies, gestational age, and birthweight, predict fatal outcomes; and,

5) to derive implications for reimbursement policy and future research on NICU case mix.

This chapter summarizes the sampling technique and presents the characteristics of the sample. The types of variables that are generally available from an inpatient discharge information system are discussed. Modifications to the CDRG system and DRG assignment are explained. Resource utilization measures available from billing and abstract systems are described. Finally, data collection procedures are highlighted.

Research Setting

The setting for this study is the NICU at Emanuel Hospital, one of three NICUs in the Portland metropolitan area. Emanuel Hospital has a neonatal ground transport team, as well as the capability to transport mothers and infants on a Life Flight helicopter. The NICU has 34 bassinets fully staffed for use.

Sample Selection

The sample was obtained using two sampling procedures: one for infants who died and another for those who were discharged or transferred. All infants

who died in the NICU at Emanuel Hospital between April 1, 1986 and March 31, 1987 (N=29) were included in the sample. Oversampling of this category was done to increase sample size in respective reimbursement groupings. Infants who were either transferred or discharged from Emanuel's NICU between September 1, 1986 and March 30, 1987 made up the rest of the sample. Not all of the infants discharged or transferred during March, 1987 were included in the sample, due to time constraints in data collection. Two infants were excluded from the sample in the CDRG system due to age at admission, i.e., greater than or equal to 29 days of age. Total sample size equaled 254 infants.

Characteristics of the Sample

Tables 1 and 2 contain descriptive statistics for the study cases. Table 1 shows that 59.4% of the total sample was male. Only 8 of the 29 who expired (27.5%) had diagnosed lethal anomalies.

Gestational age in the sample ranged from 22 to 42 weeks. Seventeen percent were under 30 weeks gestation, or extremely premature. Forty-nine percent fell between 32 and 36 weeks, and 25% were born at 37 weeks or greater. The latter could be classified as full-term infants. Birth weight ranged from 370 grams to 4370 grams. Thirty-five infants, or 14%, weighed under 1000

Table 1

Frequencies on Selected Characteristics

Characteristic		Frequency	Percent	
Sex:	male	151	59.4	
	female	103	40.5	
Fetus number:	1	204	80.3	
	2	47	18.5	
	3	3	1.9	
Birth order:	1	229	90.2	
	2	24	9.4	
	3	1	.4	
OR surgery:	yes	22	8.7	
	no	232	91.3	
Admit status:	inborn	199	78.4	
	outborn	53	20.9	
	readmit	1	.4	
	home	1	.4	
Transfers:	total	93	37.0	
	pediatrics	1	1.0	(% of
	Family Birth Center	50	54.0	those
	Good Samaritan Hosp.	24	26.0	trans)
Lethal anomalies:	yes	8	0.4	
	no	246	99.6	

Table 2

Descriptive Statistics on Selected Characteristics

Characteristic	Mean	Median	SD	Min	Max
Gestational age (in weeks)	33.6	34	4.5	22	42
Birthweight (in grams)	2110	2015	920.9	370	4370
LOS	24.4	13.5	31.6	1	193
Ventilation days (for those infants ventilated)	15.0	4.5	27.6	0	191
Days after birth until NICU admission	.7	0.0	5.3	0	76
Total NICU charges	$39,716	$16,687	$67,117	$628	$474,567

grams. Seventy-nine, or 31%, weighed 2500 grams or greater. Most of the infants (N=106 or 41%) weighed between 1500 and 2499 grams at birth.

The LOS ranged from 1 to 193 days. Eighty percent of the sample had a LOS less than or equal to 31 days. Six percent of the sample stayed longer than three months, with a range from 96 to 193 days. Eighteen infants were transferred to pediatrics for continuing NICU care. Therefore, their length of stay in pediatrics and the costs incurred were included as days of NICU hospitalization and NICU charges to maintain consistency with other observations.

One hundred and eighteen infants, or 46%, of the sample received mechanical ventilation. Ventilation days ranged from one to 191. Eighty-nine infants, or 75% of those ventilated, received mechanical ventilation for 14 days or less. Forty-seven infants were ventilated for 48 hours or less. Fourteen infants received ventilation for over 40 days; three of those for over 100 days.

Twenty-two infants received surgery in the OR at Emanuel Hospital. Seven of these were operated on two times during their hospitalization. One infant received four surgeries. Some infants were transferred to other hospitals for surgery. Their surgery expenses and days of recovery are not reflected in this study.

One hundred ninety-nine infants, or 78%, were born at Emanuel. Of the 53 babies not born at Emanuel, the majority (41) were admitted to Emanuel's NICU within one day of birth. The interval of time between birth and admission ranged from one to 76 days. Ninety-three infants were transferred from the NICU to other facilities. Over half of those transferred went to the Family Birth Center, which is a well-infant nursery at Emanuel Hospital. Another local hospital, Good Samaritan Hospital, has a level II nursery with physician and neonatal nurse clinician ties to Emanuel Hospital. Of those infants who were transferred to other hospitals, three were later transferred back to Emanuel's NICU. These infants were not counted as new admits, because they were transferred to another specialized, level III center for a service not available at Emanuel Hospital. They were then returned to Emanuel's NICU for continuing level III care. Their LOS and hospital charges were, therefore, continued from their previous stay.

Total hospital charges for NICU care ranged from $628 to $474,567. Twenty-seven infants, or 10.8%, had charges in excess of $100,000. Eighty-one percent of the infants had charges less than $50,000.

Measurement

This study focuses on comparing case-mix measures for their ability to discriminate among NICU case types.

A global case-mix measure, in comparison, would correctly classify NICU cases separately to distinguish between NICU and non-NICU case types. NICU managers need a case-mix tool to measure unit output. They are only interested in NICU cases because they do not have responsibility for cases elsewhere in the hospital. Classification variables in this study are selected to discriminate NICU case types.

Classification Variables

Six conceptual dimensions should be included in a classification system for NICU reimbursement in order to form clinically meaningful groupings: physiologic developmental status; probability of survival; respiratory developmental stage; performance of surgery; diagnosis; and transport status. In this section, the operational measures of these concepts are derived. The dimensions used in the DRG, NCG, and CDRG systems respectively are listed in Figure 4.

Physiologic Development

Birth weight is a simple proxy measure of the overall maturity of an infant's body systems; i.e., gestational age, the presence of underlying developmental deficits and complications, and the strength an infant possesses to overcome immaturity and disease. Birth weight is predominantly mentioned in the literature as an

	DRG	NCG	CDRG
birthweight	X	X	X
mortality	X	X	X
ventilation		X	X
surgery		X	X
diagnoses	X		X
transfer status	X		X

Figure 4. Variable dimensions used in the DRG, NCG, and CDRG systems.

important variable in neonatal resource consumption (McCarthy, Koops, Honeyfield, and Butterfield, 1979; Kaufman, et al. 1982; Zarfin, Van Aerde, Perlman, Pape, and Chipman, 1986; Phibbs, Williams, and Phibbs, 1981; Resnick, et al., 1986; Poland, et al., 1985).

Infants with birth weights of 600 grams, for example, are usually unable to regulate body temperature. Lungs are so immature that oxygenation, even with mechanical ventilation, is difficult. The skin is so underdeveloped that it is not an effective barrier from outside insults. Digestive and immune systems are too immature to function properly, increasing susceptibility to malnutrition and infections. Support is required for virtually all body system functions. Infants born at 1000 grams, on the other hand, are considerably more mature. They are able to regulate temperature and skin in a more effective barrier to infectious agents. Lungs, though immature, generally function well with assisted ventilation. Digestive systems may be able to tolerate small amounts of slow, continuous feedings. These infants are more mature, less susceptible to complications associated with prematurity, and have more reserves to fight disease.

The literature reveals lack of agreement about where to divide birth weight for reimbursement purposes. Most

authors recommend dividing birthweight by 500 gm. categories. Kaufman, et al. (1982) recommend dividing by 250 gm intervals. Five hundred gram intervals are likely to be sufficiently refined to capture differences in the maturity of body systems but large enough to capture differences in resource consumption reflected by birth weight. In addition, 500 gm intervals provide for a manageable number of classes.

Probability of Survival

Mortality should be grouped by birth weight in order to compare outcomes, evaluate treatments, and perform other quality of care determinations. In this sense, mortality is used as a measure of outcome. Mortality, as a proxy for severity of illness, is not always appropriate in the NICU. Infants, not severely ill, can die because they are born too prematurely or because they have anomalies that are incompatible with life. Prematurity itself is not a disease process. The degree of prematurity, however, is indicative of immaturity in body systems that are critical to survival. Infants can also die after long lengths of stay during which they go through several cycles of illness and recovery.

It is not appropriate to divide deaths by length of survival. The literature does show that nonsurvivors consume substantial amounts of hospital resources prior

to death. However, it is appropriate to predict mortality based on patient attributes. It is hypothesized that birthweight, gestational age, and the presence of lethal anomalies are the most important predictors of mortality in this patient population.

Respiratory Development

Ventilation is a useful proxy for the presence of respiratory immaturity and/or severity of illness. The respiratory system matures very late in a fetus's development. Therefore, immature infants often require respiratory support. The more immature an infant is, the more respiratory support (ventilation) required. In addition, infants born at term requiring neonatal intensive care are often severely ill with mature, but compromised respiratory function requiring ventilatory support. Ventilation is consistently noted in the literature as one of the most important determinants of neonatal resource consumption (Resnick, et al., 1986; Poland, et al., 1985; Phibbs, et al., 1981; Shannon, Crone, Todres, Krishnamoorthy, 1981).

Prolonged mechanical ventilation, itself, can lead to complications that extend an infant's course. NACHRI's research (1987) found that most newborns staying on a respirator for over three weeks developed some extreme tissue damage in the respiratory system,

bronchopulmonary dysplasia (BPD), which considerably prolonged hospital stays. These infants were distinctly sicker and used more resources than all other patients. Very premature infants usually require long durations of ventilation. As birth weight increases, the need for extended ventilation decreases due to immature respiratory functioning. Extended ventilation requirements, then, are indicative of those infants suffering from complications that prolong their recovery, and, thus, hospital stays.

Ventilation as a classification variable is problematic because, as a service entity, it creates incentives for overutilization when higher payments follow. Ventilation should be utilized for over 24 hours, according to Phibbs, et al. (1981), before an infant is eligible for reimbursement in this category. It is the primary responsibility of medical practice to balance the necessity of mechanical ventilation against the potential risk. However, Children's Hospital Case-Mix Classification System Project physicians and physicians from The Committee on The Newborn and The Fetus of the American Academy of Pediatrics (NACHRI, 1987) determined it essential to establish minimum thresholds of duration of mechanical ventilation for use in case-mix grouping. In their opinion, infants with

respiratory problems requiring the assistance of mechanical ventilation for a short period of time must be distinguished from those with more serious repiratory problems requiring prolonged assistance by mechanical ventilation. Their recommendation was a minimum threshold of three days.

In NACHRI's opinion (1987), since prolonged mechanical ventilation increases the risk of chronic lung damage, there should not be much concern about "gaming." In fact, gaming at this level would likely be to the financial disadvantage of the hospital, as the patient would become more costly to treat if lung damage or other complications ensued. Some time qualification is necessary to discourage marginal use of ventilation to qualify infants for a higher payment grouping, and to classify infants into groupings that will be homogeneous clinically and with respect to resource utilization.

Phibbs, et al. (1981) and Shannon, et al. (1981) propose including continuous positive airway pressure (CPAP) in the ventilation category also. This may not be appropriate, however. Infants requiring CPAP do demand intense nursing care, but not to the degree that ventilated infants do. Infants requiring CPAP without ventilation are less severely ill and have less morbidity than those infants requiring ventilation. CPAP may also

provide more opportunity for provider gaming, due to fewer side effects associated with it and utilization parameters that could become open for interpretation. Neither the CDRG nor the NCG system includes CPAP in the ventilation reimbursement categories.

Ventilation in the NCG system was originally operationalized as a dichotomous variable. In the last several years, Resnick, et al. (1986) defined it as ventilation over 48 hours in duration. However, there was no significant difference in the groupings formed by the dichotomous and the 48-hour variables. NACHRI (1987) confirmed the appropriateness of the three-day and 21-day thresholds used in the CDRG system. For the purpose of this study, ventilation in the NCG system employs the following levels: none; duration of less than 24 hours; at least 24 hours but less than 48; and 48 hours or more.

The disparity of ventilation duration times used in the CDRG and NCG systems suggest that further study is required to determine which ventilation groupings are most useful for distinguishing differences in resource consumption and clinical courses in neonates.

Surgery

Surgery is performed primarily to correct anomalies or complications of prematurity/treatment. Surgery also presents the problem of being a service entity. It,

however, is much less manipulable than ventilation. Surgery is confirmed in the literature as an important classification variable (Phibbs, et al., 1981; Resnick, et al., 1986; Poland, et al., 1985; Shannon, et al., 1981; Kaufman, et al., 1982).

Surgery in the NCG and CDRG systems was defined by the developers as surgery performed in the operating room (OR). The place where the surgery was performed, and not the surgical procedure, was the critical variable. Surgical procedures likely to be performed outside the OR within the NICU were: ligation of patent ductus arteriosus, central venous catheter placement, cutdown, and circumcision. These are similar to the surgeries described by Poland, et al. (1985) that should be excluded from a surgical reimbursement grouping. This is appropriate because these "surgeries" are not indicative of general care regimens, overall clinical status, or a level of resource consumption. OR surgery is appropriate because the goal of this division is to divide infants with medical versus surgical care plans and, thus, account for clinical and resource utilization differences. Surgery, narrowly defined by these parameters, would be fairly protected from provider gaming. However, any of these procedures performed in the OR would be classified as major surgery. In this

way, it is not an absolute division from a clinical perspective.

Utilization review and quality control committees should take on new responsibilities when a classification system includes service entities such as surgery and ventilation.

Diagnosis

Disease status of neonates is captured by principal and secondary diagnoses. The list of major versus minor diagnoses used in the CDRG system is yet undefined. Diagnosis is not used to split infants in CDRG groupings in this analysis. It is known that the diagnoses defining major problems in the CDRG system are not identical to those in the DRG system. Diagnoses defining uncomplicated groupings and a "back" transport grouping have been added, but again, are not contained in this analysis. Diagnoses are used to split infants in the CDRG system beginning with the 1500 gm. groupings and continuing through 2,500 gms and greater. Diagnoses in the DRG system are globally defined by major or significant problems, which is then broken down by individual diagnoses.

Transfer Status

The last variable, transfer status, would not necessarily be used to divide neonates into iso-resource

groupings, because the decision to transfer is not based primarily on patient attributes. However, infants transported to a regional NICU for special treatment or returned to the community hospital for continuing care, usually in the growth and recovery stage, must be incorporated into a classification system. Resnick, et al. (1986) mention transfer status as an important variable, but do not use it in the NCG system. Phibbs, et al. (1981) also felt that it was an important variable, but did not find a strong association with total cost in their regression analysis.

Transfers can be of three types: infants transferred to a lower level of care after observation, evaluation, or special procedures (short NICU LOS); infants tranferred to a lower level of care for growth and recovery (longer NICU LOS), and infants transferred to another NICU for surgery, special treatments, and so on. Transfer practices among NICUs are highly variable. Transferred patients averaged from 8% to 50% of neonatal populations within ten hospitals sampled in NACHRI's (1987) case-mix classification project. According to NACHRI, five factors affect transports: birth weight; clinical condition; presence of multiple or severe problems; family's residence; and neonatal/teaching status of hospital receiving transport. Transfer status,

then, is affected by several factors that will vary from institution to institution.

A NICU case-mix system should have incentives for the transport of critically ill infants and the return transport of stable infants. Otherwise, access to care will be hindered for selected populations of neonates. Moreover, community hospitals will not be paid for care of these transported infants, or reimbursers will pay twice for this phase of growth and recovery. Either option is inequitable and contains adverse incentives.

CDRG System Modifications

The neonatal CDRG system used in this analysis is a modification of the one developed by the Children's Hospitals Case-Mix Classification System Project. Diagnoses used to define major problems, uncomplicated care, and routine care were unavailable. The diagnostic categories used for the DRG system were altered for the CDRGs, and thus, could not be used accurately. Therefore, five CDRGs were left out of this comparison due to an inability to separate diagnostic categorizations. They are listed below:

CDRG 385.4: Neonate, referred back from another hospital for routine care.

CDRG 389.5: Neonate, birth weight 2000-2499 grams, without an OR surgery, without a major problem.

CDRG 391.1: Neonate, birth weight 2000-2499 grams, uncomplicated.

CDRG 390.5: Neonate, birth weight at least 2500 grams, without an OR procedure, without a major problem.

CDRG 391.2: Neonate, birth weight at least 2500 grams, uncomplicated.

The remaining CDRGs were used in this comparison and can be found in Appendix D. The CDRG system works as a tree. The first three CDRGs: CDRG 385.1, 385.2, and 385.3, contain infants that could be classified in other CDRG groupings that occur later in the system. Six CDRGs were modified for use in this comparison. They are listed below.

CDRG 388.3: Neonate, birth weight 1500-1999 grams, without OR procedure, with a major problem.

CDRG 388.4: Neonate, birth weight 1500-1999 grams, without OR procedure, without a major problem.

CDRG 389.3: Neonate, birth weight 2000-2499 grams, without an OR procedure, with a major

problem, with mechanical ventilation over 3 days.

CDRG 389.4: Neonate, birth weight 2000-2499 grams, without an OR procedure, with a major problem, with no mechanical ventilation or ventilation under 4 days.

CDRG 390.3: Neonate, birth weight at least 2500 grams, without an OR procedure with a major problem, with mechanical ventilation over 3 days.

CDRG 390.4: Neonate, birth weight at least 2500 grams, without an OR procedure, with a major problem, with no mechanical ventilation or ventilation under 4 days.

CDRGs 389.3, 389.4, 390.3, and 390.4 were modified by simply dropping the major problem variable from the CDRG statement. CDRGs 388.3 and 388.4 were modified by dropping the major problem variable and by adding ventilatory splits to these statements. Subsequent analysis of the CDRG system led to the development of a mechanical ventilation split for these two CDRGs.

CDRGs 385.2 and 385.3 were also modified in theory. These two transfer CDRGs were developed to include only those infants transferred to another hospital within four days of birth. In the tertiary neonatal center in which

this research took place, it is a frequent practice to transfer stable, close to term infants to the level I nursery, within the hospital, for continuing care. The transferred infants no longer need intensive or intermediate level care.

For the purpose of this research, this transfer is considered a transfer to another hospital, because it is a transfer out of intensive care to a very different level of care. A classification system for NICU infants should not overlap groupings for intensive and normal newborn care. Reimbursement for these two very different types of care should be separated to prevent provider gaming and inhospital transfers for the benefit of reimbursement gains. If not, hospitals that have level I nurseries available will be provided with incentives to transfer NICU infants at an earlier stage in their recovery in order to gain a higher reimbursement at a lower cost for care.

DRG Assignment

The DRG data in this study are based on the Emanuel Hospital grouper program. Hospital programmers input patient information into the grouper, which utilizes this information to place neonates into the most appropriate DRG classification. It must be noted that errors in classification for this study could be the result of

inadequacies in the DRG system, in the hospital grouper program, in data entry to the DRG grouper, or in the data made available to the grouper.

Resource Utilization Measures

Resource utilization is defined, for the purposes of this study, to be the overall costliness of all procedures and services provided during an NICU stay. Total hospital charges consist of charges for bed and room, nursing care, and ancillary services. Nursing charges reflect the intensity of care, monitoring, and family education/support required throughout various stages of the care process and recovery. Previous research has used charges as a proxy for hospital costs. Average costs for ten regional NICUs in Florida were found to be 70% of average charges (Resnick, et al., 1986).

A case-mix system used for reimbursement purposes must classify neonates as homogeneous, from both clinical and resource use perspectives. In this study, infants transferred out of the NICU for non-intensive care are considered discharged at the time of transfer. Billed charges are employed as the resource use measure. Pricing strategies introduce systematic variation between cost and charges because a constant mark-up is not used on all services. The specific elements comprising total

hospital NICU charges are as follows: bed charges for NICU or Pediatric stay (if continuing NICU care); respiratory therapy charges, including ventilation, oxygen therapy, and blood gas analysis; NICU charges, including equipment and nursing care (includes Pediatric charges if applicable); laboratory charges; pharmacy charges including IV therapy; radiology; surgery, including anesthesiology and pathology; special procedures, i.e. cardiac catheterization; diagnostic procedures, including nuclear medicine, EEG, EKG, ultrasound, apnea studies; and miscellaneous charges, including blood bank, cardiac transducers, OT/PT, etc.

Transport fees and neonatalogist fees are not included in this analysis. Neonatalogist fees were unavailable for the majority of sample neonates. The purpose of this analysis is to determine the extent to which three case-mix systems place infants into resource groupings that are homogeneous with respect to hospital resource consumption. Neonatologists are not always employed by the hospital and, thus, bill for their own services. In this research setting, neonatologist fees were billed separately and were not part of hospital resource consumption. In addition, neonatalogist fees may not parallel hospital fees. A more accurate picture of hospital resource consumption will be available with

neonatologists fees excluded. Physician fees incurred by radiology, nuclear medicine, or other hospital-based services are included in hospital resource consumption.

Hospital charges are not the same as hospital costs. Costs are the financial resources the hospital required to provide a certain type of care. Charges are bills the hospital sends to families or insurance companies for the provision of this care. Costs and charges differ by the pricing strategies of hospitals. Charges are perfectly correlated with costs only if hospitals use a fixed markup pricing scheme. The study hospital has different markups in each department, but these markups do not vary across patients. Thus, patterns of departmental cross-subsidy may potentially confound our analysis of resource patterns. Nevertheless, it is assumed that the variation in patient days, ventilation, and surgery are sufficient to dominate any confounding variation introduced by pricing strategies.

Predictors of Mortality

Neonatal clinicians and NICU mortality statistics have indicated three neonatal variables as primary predictors of mortality. This research will examine the extent to which these three variables predict mortality in the sample population: presence of a lethal anomaly--anomaly that is not compatible with life; gestational age

of 23 weeks or less, generally considered to be nonviable; and birth weight of 500 grams or less, generally considered to be nonviable.

Data Collection

Sources of Data

Data for variables used to classify neonates were obtained from the NICU computerized data base, from the discharge summary form, and from medical records. These forms are contained in Appendix A. Figure 5 shows the source from which each variable was obtained.

The DRG assignment of each infant was taken from the Disease Indices record obtained from Medical Records. Computer programs were used to classify infants into the NCG and CDRG systems. The programs were based on the variables contained in each system. Each infant was classified into only one resource grouping within each system.

Problems in Data Collection

Sample size in this study is relatively small. Resnick, et al. (1986) used 8,492 neonates in their research and Poland, et al. (1985) used over 3,000 infants. NACHRI used a sample larger than Resnick, et al. (1986) in developing and testing their CDRG system. The sample size in this research may be too small to draw accurate conclusions about the validity of iso-resource groupings within the NCG and CDRG systems. Several of

	NICU Data Base	Discharge Summary	Medical Records	Summary Cost Sheet
Birth weight	X			
Mortality	X			
Ventilation		X	X	
Surgery		X	X	
Transfer status	X		X	
Mortality predictors	X			
Hospital charges				X

Figure 5. Data sources.

the groupings in the CDRG system did not have an adequate sample size for any conclusions to be drawn.

Charge data for many of the infants transferred to the Family Birth Center (FBC) at Emanuel Hospital were approximated based on LOS in the FBC and NICU. Hospital charges were separated by services rendered and not by patient location, and they were not entered on a daily basis. Thus, charges incurred in the NICU and in the Family Birth Center were, at times, hard to distinguish. These undistinguishable charges, however, were a minor portion of the infants' total charges and should not affect the findings substantially.

CHAPTER V

FINDINGS

This chapter will examine the DRG, NCG, and CDRG systems with respect to content/construct validity. Classification variables within each system will be examined for their contribution to validity. External validity will also be examined. Finally, each system's ability to function as a reimbursement system within the NICU will be discussed.

Diagnosis Related Groups (DRG)

The seven DRGs designed to classify both normal newborn and neonatal intensive care infants are primarily medical groupings. They are based on three variables: diagnoses, transfer status, and mortality. (See Figure 1, page 38, for a diagram of this system).

Content/Construct Validity

Table 3 shows how the sample was clustered throughout the DRGs. Nine infants were classified into DRGs that are not newborn DRGs. Only three of these infants had surgery--diaphragmatic hernia repair, ventriculo-peritoneal shunt repair (V-P), and multiple surgeries to repair a tracheal-esophageal fistula. One infant received cardiac catheterization.

Table 3

Number and Percent of Newborns Admitted to the NICU by DRG Classification

	Frequency	Percent
Newborn DRGs		
DRG 387-premature/maj problems	81	32.9
DRG 385-died or transferred	71	28.0
DRG 389-full-term/maj problems	38	15.0
DRG 386-extreme immaturity	34	13.4
DRG 388-premature/no maj problems	9	3.5
DRG 390-other signif. problems	9	3.5
DRG 391-normal newborn	3	1.2
TOTAL-Newborn	245	96.5
Non-Newborn DRGs		
DRG 75-Maj chest procedure	1	.4
DRG 125-Circulatory disorder with cardiac catheterization	1	.4
DRG 156-Stomach, esophageal, & duodenal/age 0-17	1	.4
DRG 422-Viral illness /age 0-17	1	.4
DRG 424-OR proc/dx mental illness	1	.4
DRG 429-Organic disturbance	1	.4
DRG 442-OR procedure for injury > age 69 &/or complications or comorbidities	1	.4
DRG 468-Unrelated OR procedure	2	.8
TOTAL-Non-Newborn	9	3.5
TOTAL-All	254	100.0

Other infants classified into newborn DRGs had these same surgeries or catheterization.

One infant was readmitted at 29 days of age for a V-P shunt repair. This is the only infant that clinically would be more appropriately classified into a non-newborn DRG, primarily due to his age and surgical admission. The other infants not classified in newborn DRGs would be more appropriately categorized, in terms of clinical meaningfulness, with the newborn sample. It is important to keep newborns grouped together, since their birth is the principal reason for admission to the hospital and calls for specialized care.

Three infants in the sample were classified into DRG 391: normal newborns. This categorization is not appropriate for any infant receiving neonatal intensive care. Normal newborn care focuses on the support of normal, physiologic processes within the infant and mother-infant dyad. Neonatal intensive care focuses on abnormal or immature processes and consists of intensive monitoring and aggressive therapy provided to neonates by a multidisicplinary team. Care regimens, and thus resource utilization, differ greatly between normal newborn nurseries and NICUs. As discussed before, this may not reflect a problem with the DRG system itself.

It is a concern, however, that this error may be inherent in, or can be introduced into, the system.

The newborn DRG classes are not exhaustive and are not mutually exclusive for the NICU population. They do not separate NICU care from normal newborn care or from the care of other age groups, as exemplified by three normal-newborn-DRG infants who received neonatal intensive care. They should be placed in a category reflecting a higher level of care. Eight infants were classified in non-newborn DRG groupings but possess no characteristics strong enough to exclude them from the rest of the NICU sample. They also should be classified in one of the newborn DRG groupings.

Clinical Homogeneity

Ideally each grouping within a classification scheme should be relatively homogeneous with respect to the classification criterion, so that cases in a given group are more alike than cases from different groups. The DRGs, however, have not formed groupings that are clinically meaningful with respect to patient variables that influence medical and nursing care. Tables 4 and 5 contain statistics on variables reflective of clinical meaningfulness in the NICU per DRG grouping. LOS statistics are listed as outcome measures for practitioners' clinical decision making that reflects infants' conditions and care requirements.

Table 4

Variables Reflective Of Clinical Homogeneity in DRGs 385-388

	Mean	SD	Min	Max
DRG 385 (N=71)				
(29 expired/42 transferred)				
ventilation days	7.2	20.6	0	191
birth weight	1575	889	370	4170
gestational age	30.9	4.8	22	40
LOS	27.7	40.2	1	190
DRG 386 (N=34)				
ventilatory days	17.1	23.5	0	114
birth weight	1732	744.8	600	2940
gestational age	31.3	4.0	24	37
LOS	51.7	40.2	9	158
DRG 387 (N=81)				
ventilation days	2.8	8.2	0	49
birth weight	1732	744.8	690	3240
gestational age	33.5	2.5	26	39
LOS	23.4	21.4	1	102
DRG 388 (N=9)				
ventilation days	.1	.3	0	1
birth weight	2320	275.2	1800	2690
gestational age	34.1	1.7	31	36
LOS	7.9	5.3	1	15

Table 5

Variables Reflective of Clinical Homogeneity in DRGs 389-391

	Mean	SD	Min	Max
DRG 389 (N=38)				
ventilation days	.8	2.5	0	13
birthweight	3137	672.7	1650	4370
gestational age	38.2	2.8	31	42
LOS	7.9	5.9	1	22
DRG 390 (N=8)				
birth weight	3056	880.8	1510	4260
gestational age	38	2.0	34	40
LOS	4.4	4.2	1	12
DRG 391 (N=3)				
birthweight	3695	624.0	3005	4220
gestational age	40.3	.6	40	41
LOS	3.0	1.7	1	4

DRG 385 (died and transferred).

This class is the most clinically heterogeneous of the DRG groupings. The birth weight (BW) range is 3800 grams, and the gestational age (GA) range is 18 weeks. These are the largest GA and BW ranges in the DRG groupings. DRG 385 contains two categories of clinically divergent infants: those who died and those who were transferred to another facility. However, separating this grouping into two broad categories, died and transferred, does not solve the problem of heterogeneity. To illustrate, infants who died ranged in birth weight from 370 to 4050 grams. Infants who were transferred ranged from 670 to 4170 grams at birth.

Infants who die after a short NICU LOS predominantly have lethal anomalies or are pre-viable. Some may be given only supportive care. If they are severely ill at birth, they may not respond to therapy and expire after a short period of time. These infants may consume a large amount of resources during their relatively short LOSs, if heroic efforts are provided. In contrast, those infants who expire after long LOSs have complicated courses. They may have lethal anomalies that are discovered late or upon autopsy. They often have complications arising from prematurity, therapies, or their diagnoses. They have not always

been severely ill, but have predominantly required intensive, aggressive treatment that consumed high levels of resources.

A small percentage of infants are transferred to another NICU. In this sample, infants were transferred for Extracorpuscular Membrane Oxygenation (ECMO) or for surgery. These infants are severely ill and require immediate treatment that is not available in the originating NICU. They are often returned to the originating NICU for continuing or recovery care. However, these return transfers are usually not reassigned a DRG grouping. For example, two infants in this sample were transferred for observation for ECMO therapy and/or surgery at other hospitals, and returned to the NICU at Emanuel for continuing care. Their return stays were 24 and 59 days. They remained under DRG 385 for their entire stays. However, the mean LOS for DRG 385 reimbursement purposes is 1.8 days. The care regimens and resource utilization of such infants are, therefore, not accounted for in the DRG system.

Infants transferred to a lower level of care after a short LOS are predominantly admitted to the NICU for observation, evaluation of a condition or anomaly, or for a special procedure, such as an exchange transfusion. These patients are close to full term

gestation and require less intensive care than the usual NICU admission.

Infants transferred to a lower level of care after a long LOS are predominantly pre-term infants who have entered their growth and recovery phase. They no longer require intensive care and their conditions are stable. However, they intially required intensive support for their prematurity and monitoring for complications. These infants have consumed a high level of resources within the NICU.

DRG 385 can be divided into five clinically meaningful infant groupings: infants who died after a short or long LOS and infants who survived and were transferred to the same level of care, to a lower level of care after a short or long LOS in the NICU, or to a higher level of care, e.g., ECMO transfers. These groupings cover broad patient types and care regimens. DRG 385 is too diverse to be clinically homogeneous from any perspective.

DRG 386 (extreme immaturity).

This class contains infants with birth weights up to 2940 grams. Extreme immaturity is defined as infants with birth weights less than 1000 grams. Gestational age varies from 24 to 37 weeks (full-term) infants. It is clinically inappropriate that these two GAS are

classified in the same DRG. Even if the 24-week neonate had no complications, his care regimen and clinical course is different from that of a 37-week infant. For example, a 24-week neonate has underdeveloped respiratory, gastrointestinal, and central nervous systems. He needs intensive support of all body systems to maintain equilibrium and enhance recovery. A 37-week infant, on the other hand, is classified as "term" and all body systems should be mature. He is admitted to the NICU for relatively less intensive care, i. e., for observation, evaluation, a special procedure, or more intensive care such as surgery or management of one or more body systems. Because his body systems are mature, his care regimen will be different than that of a less mature infant. In addition, once the problem is resolved/corrected, this infant's need for intensive care will be over. A premature infant, on the other hand, needs continued supportive care and monitoring until he reaches approximately full-term gestation.

DRG 386 also does not account for the differing care regimens of very low birth weight infants (VLBW). These infants can have either uncomplicated or complicated courses. Since all of their body systems are immature, they can easily be damaged by birth, early feeding, inadequate oxygenation, or extended mechanical

ventilation. They are also susceptible to problems associated with prematurity, i.e., feeding intolerance or apnea of prematurity. There is no component within DRG 386 that accounts for the resource consumption or care regimen differences between the VLBW infants who have complications and those who do not.

DRG 387 through 391.

The same overlapping of birth weights can be seen in DRG 387. The grouping, prematurity with major problems, theoretically should contain infants with birth weights between 1000 and 2500 grams. Birth weights in this category varied from 690 to 3240 grams. Infants less than 1000 grams, from a clinical perspective, should be classified in DRG 386. Those with birth weights above 2500 grams are close to full term gestation. As discussed above, full-term infants require different care than do premature, low birth-weight infants. Thus, it is clinically inappropriate, due to widely differing care requirements, to classify infants of this diversity together.

DRG 388 is a relatively more homogeneous grouping. This may be due to the small sample size. Most infants in this birth-weight grouping have some problems associated with prematurity. The birth-weight range is small (890 gms.) in this grouping. Potentially,

according to the definition of prematurity, the range could be up to 1500 grams.

DRG 389 contains one infant that was transferred to another hospital for ECMO therapy and then returned. This infant was misclassified because he was transferred and also because he was one of the most critically ill of NICU infants. To qualify for ECMO therapy, infants must be severely ill with indications of impending death. Aggressive therapy to improve oxygenation is given to these infants with no response. Complications of inadequate oxygenation are present. Before transfer, this infant would have received much more intense nursing and medical care than the other infants in this grouping. The DRGs appear to be unable to account for major differences in care regimens and patient types within the NICU.

DRG 390 is a small, but very heterogeneous grouping. DRG 391 also contains a small group of infants who received intensive care at some level and should not be classified into a normal newborn grouping. If these infants truly belong in DRG 391 then, theoretically, they were inappropriately admitted to the NICU. DRG 391 could also be a subset of DRG 390. None of the infants in either grouping were ventilated; birth weight and gestational age parameters

are overlapping. A case-mix system that is appropriate for the NICU must be able to differentiate between normal newborn and neonatal intensive care.

None of the DRG groupings is homogeneous from a clinical perspective. The groupings contain infants requiring a wide diversity of care regimens. Infants within individual groupings are heterogeneous in terms of clinically pertinent attributes. In general terms, the DRGs classify infants into higher, less acute birth weight groupings more appropriately than they do the acutely ill or low birth weigh infants. For these reasons the DRG system is an inappropriate case-mix system for NICU populations.

Resource Use

Statistical analysis of variance (ANOVA) showed that the DRGs do explain a significant amount of hospital resource utilization. There is a significant difference in the means of the different DRG groupings, based on total neonatal intensive care charges ($F=7.28$, $P=.000$). Table 6 contains the means and standard deviations for NICU resource utilization within the DRG groupings. The means are significantly different between DRG 391 and 385 or 386. DRGs 385 and 386 have means greatly variant from all the other DRG means.

All of the DRGs have distributions that are skewed to the right. Four groupings, DRG 385, 387, 389, and

Table 6

Resource Utilization In DRG Groupings

DRG	N	Mean($)	SD($)	Mean(LOS)
Newborn				
385	71	55,396	90,508	27.7
386	34	91,593	89,554	51.7
387	81	27,834	36,174	23.4
388	9	8,119	5,619	7.9
389	38	10,882	11,736	7.9
390	8	4,625	4,825	4.4
391	3	3,028	1,350	3.0
Non-newborn				
75	1	26,777	---	13.0
125	1	5,635	---	4.0
156	1	114,752	---	68.0
422	1	3,156	---	4.0
424	1	15,861	---	16.0
429	1	13,338	---	12.0
442	1	18,422	---	15.0
468	1	7,787	---	7.0

390, have standard deviations that are greater than their means. DRG 386, the group with the highest mean resource use ($91,593), has a standard deviation only $2,000 below its mean. The standard deviation in DRG 385 is almost twice the size of the mean. The resource utilization heterogeneity in DRG 385 is most likely reflective of the clinical heterogeneity in this grouping. This grouping was the most clinically diverse grouping, with two distinct patient types included within it.

DRGs 387 and 389 (infants with major problems) were also very heterogeneous with respect to resource utilization. This can be explained by examining their clinical attributes. The birth weight and gestational age ranges were large in both of these groupings. LOS in DRG 387 is particularly reflective of differing care regimens.

DRGs 388 and 391 (prematurity without major problems and normal newborns, respectively) are the most homogeneous resource use groupings. However, normal newborns (DRG 391) is a clinically inappropriate grouping for this patient population. This suggests that the DRG system is best at accounting for the variability in less acutely ill infants. However, these groupings have too few infants within them to make

judgements about their homogeneity for the NICU population as a whole.

In DRG 385, assuming a fairly normal curve, 95% of the infants should require between zero and $236,411 in hospital resources. This variation is too large for a reimbursement system. There is a high degree of resource utilization variability which differs from DRG group to group.

Cochran's C was computed to determine if there were significant differences in the variances in hospital charges between DRG groups. It was significant at the .05 level. DRG groupings cannot be said to be homogeneous in terms of resource utilization (Table 7).

Only 16% of the total variation in NICU charges was explained by differences among DRG groupings, the same percentage that Resnick, et al. (1986) reported. Also in this sample, the DRGs accounted for only 18% of the variation in LOS, 10% of the variation in ventilation, and 38% of the variation in gestational ages. The DRG system accounted for none of the variation in birth weight or surgical status. Birth weight was reported by NACHRI (1986) as the most important determinant of neonatal resource utilization. A classification system, for the purpose of NICU reimbursement should account for at least some of the variation in this critical variable.

Outlier cutoffs for each of the DRGs are listed in Table 7. All but two DRG groupings had a disproportionate share of outliers. DRG 385 and 386 had the highest percentage of outliers. They are very heterogeneous with respect to resource utilization, which reflects their clinical heterogeneity. They contain a very wide range of birth weight infants, indicative of a wide range of care regimens and clincial courses. Outliers in DRG 390 substantially contributed to the resource utilization heterogeniety of this grouping. Costs range approximately $4,000 without the outliers, and $12,000 with them. Thus, DRG 390 does not account for the resource utilization variance within this grouping of infants.

Consistency

The DRGs do not meet the requirement for consistency. Each member of one group does not bear the same ordinal relationship to a member of another group. Table 8 contains the DRGs organized in descending resource use order. Ninety-five percent confidence intervals were computed to demonstrate that an infant requiring NICU care (DRG 391 excluded) and incurring hospital charges up to $14,275 could fit into any DRG category. The DRGs are unable to distinguish between differing levels of resource utilization within the NICU population.

Table 7

DRG Number and Percentage of Outliers

DRG	Outlier Cutoff	Outliers	
		N	%
385(died or transferred)	14 days	31	44.0
386(extreme immaturity/RDS)	38 days	16	47.0
387(premature/maj problems)	33 days	13	16.0
388(premature/no maj problems)	29 days	0	
389(full term/maj problems)	16 days	5	13.0
390(other significant problems)	9 days	2	22.0
391(normal newborn)	7 days	0	

Table 8

Ninety-Five Percent Confidence Intervals for DRG Resource Utilization

DRG	95% Confidence Interval
386	0 - $270,701
385	0 - $236,412
387	0 - $100,182
389	0 - $ 34,354
388	0 - $ 19,357
390	0 - $ 14,275
391	$328 - $ 5,728

None of the DRG groupings was clinically homogeneous, which is consistent with their lack of resource use homogeneity. The DRG groupings are not divided by any of the variables that determine clinical meaningfulness or hospital resource utilization in neonates. Birth weights overlap among groupings. Ventilation and surgery can be found to varying degrees in almost all DRG groupings. Infants who expired are inconsistently mixed with infants who were transferred.

Classification Variables' Contribution to Validity

The DRGs primarily use three variables to classify infants: diagnosis, mortality, and transfer status. It

has been proposed that there are also birth weight divisions, i.e., DRG 386 should contain birth weights less than or equal to 1,000 grams and DRG 387 and 388 should contain birth weights between 1,000 and 2,500 grams. This was not true in the DRGs assigned to this sample population. It is unclear why the DRGs in this sample did not follow the birth-weight guidelines. It is possible that there is an error in data entry to the DRG grouper or in the data made available to the grouper.

The three variables, diagnosis, mortality, and transfer status, are reliably measured and easy to audit from hospital records. Transfer status would be less difficult to measure if it was operationalized as any infant transferred out of a NICU, rather than out of the facility as it is now. In other words, all infants transfered to another level of care within or outside of the transferring hospital would be counted as transfers.

Diagnoses, once defined, are reasonably stable over time in patients. However, they influence resource consumption only in conjunction with other variables. For example, two infants with very different birth weights and gestational ages could have the same diagnosis of respiratory distress with sepsis. However,

these infants would require different levels of resource consumption because of their differing birth weight and gestational ages, which indicate the degree of maturity in body systems and the ability to support growth and recovery. None of the DRG diagnoses are gestational-age appropriate. The diagnoses commonly used in this NICU are not listed in the newborn DRG diagnostic category. Infants' diagnoses can change as they mature. Diagnoses, as used in the DRGs, are neither a prospective means of reimbursement nor an accurate reflection of resource utilization in neonates.

Transfer status and mortality do influence hospital resource consumption and are measureable on a retrospective basis. They also must be combined with other variables to reflect an infant's resource utilization. For example, an infant with a birthweight of 880 grams transferred to another facility for continuing care will have consumed more resources and had a longer NICU stay than an 1800 gram infant transferred for continuing care. Infants must be in stable condition and reach certain birth weights before they can be transferred for continuing care. Tranfer status alone, then, does not accurately reflect hospital resource utilization. Mortality can be viewed in the same way.

None of these three variables are direct measures of patterns of care or service. Mortality and diagnoses reflect patient, not provider, attributes. Transfer status can be said to reflect provider, patient, and other facility attributes, as there are multiple influences on whether or not infants are transferred from NICUs. The following factors can influence transfer decisions within institutions: family living situation; census within the NICU; availability of level II nurseries to provide continuing care; NICU staffing; and presence or absence of staff physicians (e.g., residents) within the NICU or receiving nursery. The ability to transfer infants for continuing or recovery care, then, will vary among NICUs. Transfer status, more than the other variables, is at risk for manipulation by providers.

External Validity

The DRGs do not meet the established criteria for iso-resource groupings. Therefore, they are not generalizable for neonatal intensive care units. They were developed from a data base that predominantly consisted of community hospitals and did not include many intensive care units (Pasternak, et al., 1986). The variables are available across NICUs, but have not been identified by practitioners or researchers as those

primarily responsible for predicting hospital resource utilization.

The DRGs form a manageable number of groups, so that administratively they are feasible. However, the distribution across the groups is very uneven. In this sample, 60% of the infants were assigned two DRGs and 12% of the sample was distributed among eleven DRGs. Iso-resource groupings should be designed to minimize negative incentives and provider gaming. The DRG system was not shown to be predictive of NICU resource utilization within this particular NICU. Implementing this reimbursement system within NICUs would, therefore, create adverse incentives to the quality and accessibility of NICU care. The DRGs create incentives to restrict access to NICUs for certain high cost patient types and to keep patients, rather than transfer them, to a lower care facility. There are also incentives to provide lesser quality of care in DRG groupings with a high percentage of outliers. Positive incentives that should be present for the provision of high quality, accessible, and efficient NICU care are not present here because the DRGs so inadequately estimate LOS in the NICU.

Summary

The DRG groupings did not form homogeneous groupings based on clinical attributes or resource

utilization within this sample. They do not account for differences in care regimens or clinical courses. Birth weight, ventilation, surgery, and mortality are the variables that are consistently noted in the literature as predictive of hospital resource utilization in infants. DRGs classify infants together in groupings that have wide, overlapping birth weight ranges. The literature substantiates birth weight divisions of no greater than 500 grams (Resnick, et al., 1986; Poland, et al., 1985; Kaufman, et al., 1982; Pomerance, Ukrainski, Ukra, Henderson, Nash, and Meredith, 1978; Zarfin, Van Aerde, Perlman, Pape, & Chipman, 1986). Surgical status is spread through out the DRGs in an inconsistent manner. Mortality is combined with another variable into one grouping. The DRGs do not take into account ventilation as an indicator of resource utilization.

In addition, the DRGs classify together, in the same groupings, infants who have received intensive care and infants who have received normal newborn care. A case-mix system that can not distinguish between two widely differing levels of care cannot be homogeneous with respect to clinical meaningfulness or resource utilization.

The DRGs are not appropriate for use as a reimbursement system in NICUs. Other authors concur

with this finding, i.e., Poland et al. (1985), Lagoe, et al. (1986), and Resnick et al. (1986). The DRGs do not form a clinically meaningful data base that would be useful for comparisons between hospitals, regions, and modes of treatment. The groupings are not based on patient variables that would be helpful to practitioners in analyzing case mix or quality of care within a unit. The groupings would also not be helpful to administrators in projecting staffing needs and budget requirements. They would be of no assistance in making future policy decisions. This analysis is consistent with the consensus in the literature, that the newborn DRG system is not an appropriate case-mix system for the NICU.

Neonatal Care Groups (NCG)

Content/Construct Validity

The NCGs were designed specifically to classify NICU infants for the purpose of reimbursement. The NCGs start with the basic DRG newborn groupings and subdivide them, using variables that have been documented in the literature as important determinants of hospital resource utilization in neonates: mortality; if expired, days of life; surgery; birthweight; and ventilation, as a dichotomous variable. Please refer to Figure 2 for a diagram of this system.

The modifications resolved some of the problems with the DRG groupings. The NCGs are mutually exclusive and exhaustive. Table 9 shows how this sample was distributed across the NCGs. Each case was unambiguously classified into a particular group and no others. All infants could be classified in either a birth weight or a LOS grouping, based on their survival status. The birth weight groupings were often further divided, but no infant was excluded from a grouping. All cases treated in this NICU setting were accounted for and every case was classifiable within the system.

Clinical Homogeneity

NCG 385A through 385D (all expired infants). The groupings varied in their clinical homogeneity. Table 10 displays the clinical attributes of infants who expired. Those expired infants who had LOSs greater than 30 days are outliers in NCG 385D. For the purpose of this analysis, those outliers are separated from the rest of 385D, to demonstrate that they represent the patient types that have complicated courses and die after long LOSs. NCGs 385A through 385D are clincially heterogeneous groupings. Birth weight is highly variant in each of these groupings. Gestational age is also highly variant, except in NCG 385B (N=2). Ventilation is fairly homogeneous, but this is reflective of the LOS

Table 9

NCG Distribution

	Frequency	Percent
NCG 385A (exprd/LOS 0-5)	15	5.9
NCG 385B (exprd/LOS 6-10)	2	.8
NCG 385C (exprd/LOS 11-15)	4	1.6
NCG 385D (exprd/LOS 16-30)	8	3.2
NCG 386 (BW <1000)	22	8.7
NCG 387L (BW 1000-1499/vent)	18	7.1
NCG 388L (BW 1000-1499/no vent)	9	3.5
NCG 387H (BW 1500-2499/vent)	31	12.2
NCG 388H (BW 1500-2499/no vent)	65	25.6
NCG 389S (ORsurg/BW >1500)	12	4.7
NCG 389 (BW>=2500/vent)	20	7.9
NCG 390 (BW>=2500/no vent)	48	18.9
Total	254	100.0

Table 10

Variables Reflective of Clinical Homogeneity in NCG Classifications of Expired Infants (N=29)

		Mean	SD	Min	Max
NCG 385A:	N=15				
	ventilation(days)	2.1	20.2	0	5
	birth weight	1356.0	1065.6	370	4050
	gestational age	33.6	4.5	22	42
NCG 385B:	N=2				
	ventilation(days)	4.0	0.0	4	4
	birth weight	2644.5	911.5	2000	3289
	gestational age	35.5	2.1	34	37
NCG 385C:	N=4				
	vent.(days)	13.3	1.3	12	15
	birth weight	1682.5	1358.3	770	3670
	gestational age	29.8	6.8	26	40
NCG 385D:	N=1				
	vent.(days)	26.0	0.0	26	26
	birth weight	630.0	0.0	630	630
	gestational age	25.0	0.0	25	25
NCG 385D (outliers):	N=7				
	LOS	119.3	62.8	44	191
	vent.(days)	77.3	68.4	0	191
	birth weight	1471.4	856.1	470	2920
	gestational age	32.4	5.1	26	40

divisions (many infants were ventilated for all their days of life), rather than clinical homogeneity. The widely differing birth weights and gestational ages suggest that though these infants survived for similar LOSs, they required different care regimens and had different clinical courses.

Multiple surgeries indicate complicated courses with, perhaps, multiple body system involvement. Two infants in 385C had surgery. Four infants in 385D had surgery; three required two OR visits. No infant in these groupings was transported out of the NICU at any time during their stay. The outliers in NCG 385D actually form two subgroups. The subgroup with the longer LOS (139 to 193 days) had lower birth weights and a lower mean gestational age. This subgroup represents the nonsurvivors in the larger classification grouping of very low birth weight infants with complications. It is clinically more homogeneous than the other NCG 385 groupings.

As with infants who survive, clinically meaningful groupings are formed using birth weight and gestational age parameters, not LOS. LOS is not a patient attribute, rather it is an input into the care process. LOS is inappropriate for use as a variable in a case-mix system. Infants expire in all birth weight groupings,

require different care regimens, and consume vastly differing amounts of resources. Classifying these infants by LOS results in heterogeneous groupings, from a clinically meaningful perspective. Infants would be more appropriately classified if they were first grouped by birth weight, and then divided by survivors and nonsurvivors.

Fifty-two percent (N=15) of the infants who died, lived for five days or less. Fourteen percent (N=4) lived for over four months. Sixty-three percent (N=5) of the infants with lethal anomalies died within six days, the rest lived for up to six months. This indicates that some lethal anomalies are not detected at birth and/or do not cause imminent death in newborns. Infants who expire are, inherently, a heterogeneous group.

Clinical parameters for the rest of the NCG groupings are found in Table 11 and 12. The NCG groupings for survivors, divided primarily by birth weight, are much more homogeneous groupings for gestatiional age and birth weight than their DRG counterparts.

NCG 386 (BW < 1,000 grams). Birth weight in NCG 386 has a 2000 gram decrease in range from DRG 386. This grouping, however, contains very low birth-weight

Table 11

Variables Reflective of Clinical Homogeneity in NCG Classifications for Surviving Low Birth Weight Infants

	Range	Mean	SD
NCG 386 (N=22)			
ventilation days	63	28.4	19.0
birth weight	330	811.1	100.8
gestational age	8	26.8	2.4
LOS	100	71.3	33.8
NCG 387L (N=18)			
vent.(days)	113	14.7	28.3
birth weight	480	1260.6	145.0
gestational age	5	29.7	1.8
LOS	146	48.2	36.0
NCG 388L (N=9)			
vent.(days)	0	0.0	0.0
birth weight	390	1290.0	128.2
gestational age	7	31.1	2.4
LOS	35	32.1	12.6

Table 12

Variables Reflective of Clinical Homogeneity in NCG Classifications for Surviving Infants with Birth Weights Greater than 1500 Grams

	Range	Mean	SD
NCG 387H (N=31)			
vent.(days)	11	3.5	2.8
birth weight	910	1913.7	285.4
gestational age	6	32.7	1.5
LOS	68	24.2	14.5
NCG 388H (N=65)			
vent.(days)	0	0.0	0.0
birth weight	985	2025.8	267.0
gestational age	11	34.2	1.9
LOS	31	12.8	7.9
NCG 389 (N=20)			
ventilation days	13	4.8	4.1
birth weight	1650	3002.0	441.0
gestational age	8	37.3	2.3
LOS	22	15.7	6.4
NCG 390 (N=48)			
vent.(days)	0	0.0	0.0
birth weight	1840	3278.0	531.0
gestational age	10	38.2	2.6
LOS	15	4.7	3.6

(table continues)

Table 12 (continued)

Variables Reflective of Clinical Homogeneity in NCG Classifications for Surviving Infants with Birth Weights Greater than 1500 Grams

	Range	Mean	SD
NCG 389S (N=12)			
ventilation days*	21	2.7	6.2
birth weight	2300	2674.0	699.0
gestational age	6	36.6	1.9
LOS	125	30.7	36.5

*ventilation required for surgery is not included here

relatively small standard deviation, indicating that this grouping broadens DRG 388 without relinguishing its homogeneity.

Ventilation is more variant than is desirable. It is particularly variant in NCG 387L and 389S. The latter is the surgery category with a very large birth weight range, i.e., greater than 1500 grams. The differing birth weights seem to account for the differing ventilation requirements. In 387L, for example, three low birth-weight infants required extended amounts ventilation for treatment of apnea, a complication of prematurity. A division in ventilation duration would improve the clinical homogeneity of NCG 389S and 387L.

Surgical cases are primarily found in NCG 389S. In this sample, NCG 386 and 387L contain three and one surgical infants, respectively. These infants primarily had surgery for complications of prematurity. Their post-surgical care regimens remained primarily medical with the focus on their prematurity status. They cannot be separated from the rest of their groupings based on clinical attributes.

NCG 389S is not a homogeneous grouping. It has a large birth weight range. This heterogeneity, however, is also reflective of the differing care requirements

that most surgical infants present. One of these infants required four surgeries to correct a congenital anomaly. Another infant required one surgery and numerous diagnostic procedures for tracheal insufficiency. In addition, some surgical infants have two care plans: one to treat their surgical problem and one to treat their prematurity. A surgical grouping with a large birth weight range will not distinguish between those infants requiring primarily surgical care regimens and those infants requiring both surgical and medical care regimens. A grouping that includes most of the surgical cases within a NICU will, inherently, be a heterogeneous grouping.

Transports are spread throughout the NCG groupings, but are predominantly present in the higher birth weight NCGs. For instance, 58% of the infants in NCG 390 and 40% of the infants in NCG 388H were transported to another level of care. With the exception of 387L and 388L (39% and 22% transfers, respectively), higher percentages of infants were transported from nonventilated NCGs than from ventilated NCGs. This may be reflective of practitioner and family preferences.

In summary, the NCGs form groupings that are appreciably more clinically homogeneous than the DRGs. This is primarily due to their use of birth weight,

ventilation, and surgical status variables. Two NCG groupings, 385A-D and 389S, could be more clinically homogeneous by utilizing birth weight or ventilation to refine the groupings.

Resource Use

The NCGs also improve the explained variation in NICU hospital charges. Table 13 shows the means and stadard deviations for total NICU hospital charges for each of the NCG groupings. The NCGs categorize infants into groups that use significantly different amounts of hospital resources.

The NCGs significantly improve on the DRGs' ability to account for the variation in hospital charges in this NICU population. The NCGs accounted for 60% of the variation in NICU charges. This is slightly higher than the 52% reported by Resnick, et al. (1986). The NCGs also substantially improve on the DRGs' ability to account for variation in LOS (63%), gestational age (63%), ventilation (51%), and birth weight (4%). The NCGs account for a substantial proportion of the variation in variables that determine resource utilization and clinical meaningfulness. The NCGs, therefore, recognize differences in resource utilization and care regimens within the NICU.

Cochran's C was significant at the .95 level, indicating that the variances are not homogeneous across

Table 13

NICU Charges for the NCG Groupings

	N	Mean	SD
NCG 385A	15	$ 9,156	$ 7,094
NCG 385B	2	15,883	2,473
NCG 385C	4	57,488	8,775
NCG 385D	1	89,075	0
NCG 385D outliers	7	262,609	153,514
NCG 386	22	129,572	68,510
NCG 387L	18	75,829	97,104
NCG 388L	9	31,593	14,930
NCG 387H	31	32,943	23,051
NCG 388H	64	12,202	6,906
NCG 389	20	29,518	14,793
NCG 390	48	5,355	4,576
NCG 389S	12	47,682	68,510

the classes. This is very apparent when examining the standard deviations for the NCG categories. The standard deviations vary from $153,514 to $2,473. Four groupings are particularly heterogeneous: low birth-weight infants who were ventilated (386 and 387L), infants who died with LOSs greater than 30 days, and infants above 1,500 grams who had surgery (389S).

NCG 387L has a standard deviation that is greater than its resource utilization mean. This category of low birth weight infants could be more homogeneous if split on ventilation duration parameters (Appendix B, Table A). Three infants in this grouping required extended ventilation that greatly increased their LOS. NCG 386 has a standard deviation that is less than its mean. However, the 95% confidence interval created by this grouping is much too great for a system based on averaging, i.e., 0 to $266,592. This range is reflective of the two patient types contained in this NCG, those with complicated and uncomplicated courses. A further split in this grouping, to reflect extended ventilation requirements, would make this grouping more predictive of hospital resource utilization.

In NCG 389S the resource utilization heterogeneity is also most likely a reflection of its clinical heterogeneity; i.e. large birth weight range and varying

surgical and medical care regimens. Surgical cases may need to be divided further by birth weight, in order to increase clinical and resource utilization homogeneity.

Infants who died and were classified by LOS form homogeneous resource utilization groupings. NACHRI, (1986) has used LOS as a proxy for resource utilization. LOS is a better proxy for resource utilization in infants who die than in infants who survive, because infants who die primarily consume resources at a consistently high level during their days of life. LOS is not as good a proxy in infants who survive, because levels of care decrease as the infant matures and recovers. However, while LOS classifies infants into homogeneous resource groupings, it does not classify infants into groupings that are clinically homogeneous.

Dividing infants who expire by LOS does not eliminate resource utilization heterogeneity. Twenty-four percent of the infants who died were LOS outliers. Four of these would be termed catastrophic by the NCG definition: i.e., LOS over 100 days, or hospital charges over $100,000. These LOS outliers had varying birth weights and LOS before death. The NICU is, by definition, the home of neonatal outliers. Many infants who expire will do so only after extensive efforts to

prevent their death have failed. Therefore, groupings of infants who have expired will inherently contain outliers and, to some degree, be heterogeneous with respect to resource utilization.

NCG 387H is a fairly deviant grouping. Dividing the birth weight parameter into 500 gram intervals, as suggested in the literature and adding a duration of ventilation parameter would improve this grouping's homogeneity (Appendix B, Table A).

A grouping that is surprisingly heterogeneous is NCG 390. Fifty-eight percent of these infants were transferred to a lower level care, decreasing their LOS. This grouping of infants may be more predictive of resource utilization in a NICU that is not able to transport such a high percentage of this patient grouping.

Tables A and B in Appendix B contain resource utilization statistics comparing dichotomous, 24-hour, and 48-hour ventilation splits for NCG 387L, 388L, 387H, 388H, 389 and 390. These statistics indicate that a 48-hour is more effective than a 24-hour split in increasing the resource utilization homogeneity in ventilated NCGs. Resource utilization homogeneity was decreased slightly in 387L and 390 by adding ventilated infants to these groupings. Homogeneity increased with

the addition of ventilated infants to NCG 388H. Regression analysis also proves the 48-hour split to be the better of the three. A 48-hour ventilation split accounted for 44% of total NICU charge variance and 57% of LOS variance. A yes/no ventilation split accounted for only 29% of total NICU charge variance and 45% of LOS variance. These results strongly support the addition of ventilation duration parameters within the NCGs.

Consistency

The NCG system is not entirely consistent. The infants who expired are grouped solely by LOS. They have an ordinal relationship with other groupings based only on mortality. No other grouping is divided by LOS. No other grouping is without some division for birth weight differences and their affect on care. Each infant within the expired NCGs will have different ordinal relationships to a member of another grouping, based on classification variables such as birth weight, ventilation status, and OR procedures. These infants would be more consistently classified if they were grouped by birth weight, and then separated by mortality. The rest of the NCG system is consistently grouped based on clinical attributes.

Table 14 contains the NCG groupings organized in descending resource use order. Ninety-five percent

Table 14

NCG Hospital Charges in 95% Confidence Intervals

NCG	95% Confidence Interval
385D outliers	0 - $569,637
387L	0 - $270,037
386	0 - $266,592
385C	$39,938 - $ 75,038
389S	0 - $184,702
387H	0 - $ 79,045
388L	$ 1,733 - $ 61,453
389	0 - $ 59,104
385B	$10,937 - $ 20,829
388H	0 - $ 26,014
385A	0 - $ 23,344
390	0 - $ 14,507

confidence intervals are much too large in several of the NCGs (385D, 386, 387L, 389S) to be predictive of resource utilization and used in a system based on averaging. Only two of the groupings are distinctly non-overlapping; i. e. 385B and 385C. Only a narrow hospital charge range could be found in any grouping; i.e., $10,937 to $14,507. This is an improvement over the DRG system. However, all but three groupings go to zero. Infants with low hospital charges could fit into numerous groupings. Improvements in the predictive ability of this system obviously need to be made.

Classification Variables' Contribution to Validity

All of the NCG's variables have been widely recognized in the literature as being important determinants of neonatal hospital resource consumption. Mortality, OR surgery (in infants greater than 1500 grams), and birth weight are reliably measured. Ventilation is not as reliably measured because it is not a variable recorded on hospital discharge abstracts. Ventilation required chart reviews, especially when duration of ventilation parameters were used. Systems will need to be developed to accurately record ventilatory status on patient discharge records for easier measurement and auditing.

Mortality, OR surgery, and birth weight are stable and influence resource consumption. Ventilation, on the

other hand, may not be present long enough to influence resource consumption. Ventilation does increase the intensity of nursing, medical, and respiratory care that infants require. however, ventilation for only short periods of time may have little or no impact on patterns of resource consumption and care regimens.

Infants who require long periods of ventilation, for the most part, have very immature respiratory systems or severe respiratory/circulatory disturbances. As such, ventilation can be a proxy for the intensity of care an infant requires and predictive of resource utilization. In addition, extended ventilation is associated with respiratory complications, i.e., BPD, and greater morbidity. The longer an infant is ventilated, therefore, the more the ventilation affects his resource requirements. It is advisable, therefore, to develop ventilation parameters that divide infants by duration of ventilation.

Two variables used in the NCG system are direct measures of patterns of care; i.e., ventilation and surgery. These variables, though important determinants of neonatal resource consumption, offer incentives to providers for utilization of these entities. Proposals to substitute blood gas documentation in place of ventilation have not been widely received (Shannon, et al., 1981).

One reason for the continuance of ventilation as a variable is that the decision to ventilate is a multifaceted one. Physicians consider blood gases, X-rays, birth weight, diagnoses, general clinical status, and more in deciding whether or not to ventilate. All of these parameters are difficult to capture in another, single variable. Record keeping and documentation on these multiple facets would be an enormous task for hospitals. Record keeping would need to continue throughout the critical period of an infant's care in order to predict continuing ventilatory needs.

In addition, it remains in question how accurately other variables could predict the increased resource requirements and morbidities of ventilated infants. Variables designed to predict ventilation would have to be extremely accurate to capture these increased requirements and morbidities.

Adding duration to the ventilation variable would decrease its manipulability. Providers would need to ventilate an infant for a substantial period of time, i.e., 48 to 72 hours, before reimbursement would be given in a ventilatory category. In addition, developing ventilatory parameters may create more homogeneous groupings.

Surgery is less manipulable than ventilation. The addition of the qualifier, OR surgery, decreases its

manipulability to a great extent. Quality control processes should already be active in hospitals to protect against inappropriate OR procedures. Ventilation and surgery are too important in predicting hospital resource utilization to discard them until accurate replacements are found.

External Validity

The NCG system is generalizable to all NICUs. The system consists of a manageable number of groups (12) and would be feasible administratively. In this sampling, the infants are not evenly spread throughout the NCG groupings. Sixty-nine percent of the sample are distributed throughout the five NCGs that contain 1,500 gram or greater birth weight infants. This is more reflective of case-mix within NICUs, than insufficencies within the NCG system. NACHRI (1986) found that the majority of neonatal caseload at childrens' hospitals consists of 2500 gram or greater infants. A NICU case-mix scheme will not be able to equally divide infants into groupings, while still accounting for resource consumption variance and maintaing a reasonable number of groupings.

The system is designed to provide incentives to hospitals for the provision of high quality, accessible, and efficient NICU care. The NCG system accounts for

more of the resource utilization variance in NICU populations than does the DRG system. This helps to minimize negative incentives for NICUs to restrict access to certain high-cost patient types or to manipulate the system for higher reimbursement.

Summary

The NCGs were developed to capture the care requirements and resource consumption of neonates within the NICU. This is reflected in their appreciably improved ability to predict resource utilization in the NICU. This increased predictive ability is primarily due to the NCG's utilization of variables documented as important determinants of neonatal resource utilization.

Utilization of these variables, especially birth weight, is responsible for the improved clinical homogeneity found in the NCG groupings. There is one primary exception--infants who have expired and are classified by LOS. LOS has proven fairly accurate at classifying infants into homogeneous resource utilization groupings. However, LOS is a poor indicator of differing care requirements and clinically meaningful patient attributes.

Expired infants could be classified into clinically meaningful groupings by birth weight. Ventilation and/or surgical status might be added to make these

groupings more clinically homogeneous and predictive of hospital resource utilization. Outliers are inherent in any grouping of expired infants within the NICU and cannot be eliminated altogether. Grouping expired infants by LOS prevents the comparison of modes of treatments and quality of care across hospitals and hinders the formation of a data base that is helpful to practitioners and administrators.

Homogeneity could be improved by creating duration of ventilation parameters within the NCG system. This analysis has demonstrated that a 48-hour split is superior to 24-hour or yes/no splits. The addition of a ventilation duration parameter is also important in decreasing the opportunities for provider gaming and manipulation.

The NCG system creates a data base that can be useful to practitioners and administrators. The majority of infants are grouped by clinically meaningful attributes that can be used in the comparison of quality of care, modes of treatments, and case-mix differences across regions and hospitals. This data base will be helpful to practitioners in analyzing case-mix, modes of treatment, and quality of care. The only exception to this is infants who expire. Infants in NCG 385A-D have only LOS and their expired status in common.

Comparisons based on deaths per birth weight, deaths per diagnosis, or deaths per treatment entity will require further documentation.

Administrators can also utilize this information for staffing and budget projections. In addition, policy makers will be able to use this data base in making informed decisions regarding accessibility, quality of care, and allocation of resources within NICUs.

In summary, the NCG system is able to account for a substantial amount of resource utilization within the NICU. With the exception of infants who died or were ventilated, the NCG system accurately captures the NICU case mix. It can fulfill all of the purposes desirable in a case-mix system.

Children's Diagnosis Related Groups (CDRG)

The CDRGs were developed to capture pediatric case-mix and resource utilization within all hospital settings, particularly childrens' and university hospitals. They were developed to replace the DRGs for all pediatric and neonatal care. The authors kept the DRG framework because they felt, after evaluating other reimbursement systems, that it was the most appropriate means by which to classify pediatric and neonatal patients.

As discussed in the Methods section, the neonatal CDRG system used in this analysis is a modification of the system developed by researchers at NACHRI. For clarification, the CDRGs that were modified have a (M) after their CDRG number in Table 15, which shows how this sample was clustered throughout the modified CDRGs.

Content/Construct Validity

The neonatal CDRG system is not exhaustive for the NICU population. The system will only classify infants less than 29 days old on admission, because that is the traditional end of the neonatal period. Two infants were excluded from the neonatal CDRG system in this sample because they were 29 days or older at admission; one was a readmit and one was a transfer from another NICU. These infants would be classified in the children's DRG subset of the CDRGs.

CDRG 385.4 (back transports for routine care), which usually denotes a return to hospital of birth, was excluded from this analysis due to unavailability of routine care diagnoses. This neonatal CDRG is applicable only to infants who are transferred at 28 days or less. In this sample population, ten infants who were transferred for continuing care to level I or II nurseries were 29 days or older. These infants were

Table 15

CDRG Frequencies

	Frequency	Percent
CDRG 385.1 (exprd/LOS=1)	3	1.2
CDRG 385.2 (transfered)(M)	6	2.4
CDRG 385.3 (transfered)(M)	32	12.7
CDRG 386.1 (BW <750/vent >21)	6	2.4
CDRG 386.2 (BW <750/vent <22)	1	.4
CDRG 386.3 (BW <750/exprd)	6	2.4
CDRG 386.4 (BW 750-999/vent >21)	9	3.6
CDRG 386.5 (BW 750-999/vent 4-21)	1	.4
CDRG 386.6 (BW 750-999/vent <4)	2	.8
CDRG 386.7 (BW 750-999/exprd)	5	2.0
CDRG 387.1 (BW 1000-1499/surg/vent>21)	1	.4
CDRG 387.1A(BW 10-1499/surg/vent 4-21)	0	0.0
CDRG 387.1B(BW 10-1499/surg/vent <4)	0	0.0
CDRG 387.2 (BW 1000-1499/vent >21)	2	.8
CDRG 387.3 (BW 1000-1499/vent 4-21)	6	2.4
CDRG 387.4 (BW 1000-1499/vent <4)	18	7.1
CDRG 387.5 (BW 1000-1499/exprd)	7	2.8
CDRG 388.1 (BW 1500-1999/surg/vent>3)	0	0.0
CDRG 388.2 (BW 15-1999/surg/vent <4)	1	.4
CDRG 388.3 (BW 15-1999/vent >3)(M)	8	3.2

(table continues)

Table 15 (continued)

CDRG Frequencies

	Frequency	Percent
CDRG 388.4 (BW 15-1999/vent <4)(M)	41	16.3
CDRG 389.1 (BW 2000-2499/surg/vent>3)	1	.4
CDRG 389.2 (BW 20-2499/surg/vent <4)	4	1.6
CDRG 389.3 (BW 20-2499/vent >3)(M)	5	2.0
CDRG 389.4 (BW 20-2499/vent <4)(M)	36	14.3
CDRG 390.1 (BW >2499/surg/vent >3)	4	1.6
CDRG 390.2 (BW >2499/surg/vent <4)	4	1.6
CDRG 390.2A (BW >2499/minor surgery/ vent <4)	0	0.0
CDRG 390.3 (BW >2499/vent >3)(M)	11	4.4
CDRG 390.4 (BW >2499/vent <4)(M)	32	12.7
Total	252	100.0

primarily in the less-than-1500-gram birth-weight categories. They required longer lengths of stay before being stablized for back transport or transport to a less acute facility.

In theory, since they are not yet full-term infants, their 28-day neonatal period has not yet begun. The CDRG system does not, in this sence, account for premature infants. It is unknown whether these infants would meet the criteria for "routine care" within this CDRG. However, there is no indication that the children's CDRG system has a grouping developed for back transported infants. In addition, these infants have very different care regimens than infants born at full term and are now over 28 days of age. They would be inappropriately classified in the childrens' CDRG system. An exhaustive system should include a grouping for those infants transported back after 28 days of age, or it should account for premature infants who have extended neonatal periods.

The neonatal CDRG system is mutually exclusive. Please refer to Figure 3 for a diagram of this system. Due to the number of groupings in this system, Tables C through G, which contain patient attributes in the CDRG system, can be found in Appendix C.

Clinical Homogeneity

The CDRG system, for the most part, forms clinicially homogeneous groupings. Birth weight in the CDRG system is divided by 250 to 500 gram intervals, which accounts for much of the homogeneity. CDRG 388 and 389 divide the NCG categories spanning 1000 grams, 387H and 388H, into two birth-weight categories. The greater homogeneity achieved by CDRG 388 and 389 support consensus from the literature that birth weight groupings should be divided by no more than 500 grams. There is, in addition, a significant difference in the birth weights and LOS of infants in CDRG 388 versus 389. Gestational age and ventilation also differ, but not as significantly. The clinical homogeneity of CDRG 388 and 389 has been decreased, somewhat, by the inclusion of expired infants in these groupings with survivors.

Mortality. Mortality is grouped in several different ways in the CDRG system. CDRG 385.1 contains infants who lived for one day and expired. This is not a very homogeneous grouping from a clinical standpoint. The three infants in this grouping form two clinical types. One infant (birth weight 1870) had an encephalocele, a lethal anomaly, and received minimal nursing and medical care before his demise. The other

two infants (birth weights 320 and 620) received increasing amounts, respectively, of nursing and medical care before their demise. Infants who die within one day of life will either receive intense care for a short period of time or receive minimal care. Lethal anomalies did not clearly differentiate these two care requirements.

CDRG 385.1 is more homogeneous than if classified with infants of similar birth weights and mortality; i.e., their care regimens are very different from infants who were not recognized initially as having little chance for survival and/or lived for greater than 24 hours. This grouping is useful to clinicians in examining infants with conditions that are incompatible with life.

The birth weight groupings that contain only expired infants are more heterogeneous than similar birth weight groupings with survivors. This is reflective of the differing conditions and clinical attributes that can contribute to infant demise. In lower birth weight categories, some infants will expire after long lengths of stay and numerous efforts to prevent their deaths and/or diagnose their problems. Others have conditions more incompatible with life and die after very short LOSs. Although these infants

require different care regimens, grouping them by birth weight produced many care similarities that will make this grouping useful to care providers.

Classifying expired infants with survivors is not clinically meaningful. Infants who expired in CDRG 390, for example, appear to have had different care regimens from the infants who survived. Three of the expired infants in CDRG 390 had lethal anomalies. Infants who expire in these birth-weight groupings primarily have a disease process or disruption that significantly increases their severity of illness and affects their care. Infants who survive, on the average, are less severely ill and require care more focused on growth, development, and the support of normal body systems. These infants would be more appropriately classified, in terms of clinical meaningfulness, if separated by BW from survivors.

Infants with lethal anomalies lived from one to six days. They had multiple diagnoses and required very different levels of care. It appears that lethal anomalies are not good predictors of hospital resource utilization or care requirements.

Ventilation. As an indicator of severity of illness or degree of immaturity, ventilation helps to further divide the birth-weight groupings into

clinically meaningful groups. Ventilation splits at 21 days and/or 3 days appropriately divided birth weight groupings into differing care regimens. In all the groupings, the range of ventilatory requirements was great enough to justify the number of ventilatory divisions.

Surgery. Surgery is not a variable in the very low birth-weight groupings. This appears appropriate in this sample. Surgery did not divide infants into different clinical classes based on care requirements or clinically pertinent patient attributes. The care of VLBW infants remains primarily medical in focus, with or without the presence of surgical procedures. It seems appropriate that at greater maturity levels, less care would be focused on medical needs and more would be determined by surgical needs, if necessary.

The surgical CDRGs in this sample that are large enough to be evaluated, i.e., 389 and 390, differ from their medical counterparts only by LOS. LOS, as one crude indicator of care requirements, is significantly longer in those groupings of infants requiring surgery. Further study on larger samples needs to be done, however, to validate NACHRI's division from a clinically meaningful perspective.

Transfers. The CDRG system accounts for transfers made to another facility within four days of birth. The

underlying assumption is that infants transferred after very short LOS no longer require level III care and are being transferred to lower level facilities. In this sample, however, three infants were classified in CDRG 385.2 or 385.3 who were tranferred to other level III facilities for surgery or ECMO therapy. Their care requirements had not decreased, and thus, they were clincially different from the rest of the infants in 385.2 and 385.3. These infants returned to this NICU for recuperation and total LOSs up to 61 days. They were not classified into a second CDRG because it is unclear how these infants would be accounted for in the CDRG system. Only one of these infants was assigned a second DRG in the DRG system. The rest remained under DRG 385.

These infants were more appropriately classified under the NCG system in their respective birth-weight categories, although the NCG system does not account for transfers. Transfers are such a common practice in tertiary centers that a classification system must support the appropriate transfer of infants to ensure access to intensive care beds and promote quality of neonatal care for infants and their families.

CDRG 385.2 and 385.3 primarily group infants into clinically meaningful categories. These groupings

should be useful to providers. The CDRG system does not account for transfers within a facility to a lower level of care nor for return transports after 28 days of life. These tranfers should be accounted for within the system, in order to encourage appropriate transfers while discouraging the "dumping" of NICU infants on lower level facilities.

Resource Use

Statistical analysis using ANOVA showed that the CDRGs improve upon the DRG's ability to explain the variation in NICU hospital charges. The CDRGs accounted for 54% of the total NICU charges. The CDRGs accounted for less of the variance in ventilation and LOS. However, the CDRGs accounted for more of the variance in birth weight and gestational age, 8% and 71%, respectively. This is due to the CDRGs use of 250 to 500 gram birth weight divisions.

Cochran's C for the NCG and CDRG systems were almost identical. It was significant at the .05 level, indicating that the variances are not homogeneous across the classes. This is very apparent when examining the standard deviations in the CDRG categories. Table 16 shows the means and standard deviations for total NICU hospital charges for each of the CDRG groupings. The standard deviations vary from $972 to $197,014. Two

Table 16

Resource Utilization in CDRGs

	N	Mean	SD
CDRG 385.1	3	$ 2,395	$ 972
CDRG 385.2	6	14,506	13,490
CDRG 385.3	31	5,336	15,454
CDRG 386.1	6	179,688	11,996
CDRG 386.3	6	128,386	154,689
CDRG 386.4	9	137,046	43,876
CDRG 386.6	2	45,812	15,299
CDRG 386.7	5	32,483	22,963
CDRG 387.2	2	152,311	63,587
CDRG 387.3	6	66,906	24,268
CDRG 387.4	18	29,100	13,656
CDRG 387.5	7	150,165	197,014
CDRG 388.3	8	57,532	30,339
CDRG 388.4	41	18,598	8,490
CDRG 389.2	4	33,492	29,420
CDRG 389.3	5	32,827	17,193
CDRG 389.4	36	11,537	4,930
CDRG 390.1	4	84,468	57,124
CDRG 390.2	4	17,998	4,813
CDRG 390.3	11	35,158	15,028
CDRG 390.4	32	11,287	8,709

groupings have standard deviations that are greater than their means; i.e. 386.3 and 387.5. Another expired grouping, CDRG 386.7, has a high degree of variability. These groupings contain only infants who have expired. The resource utilization variance is reflective of their differing care requirements and days of life. Many of these infants have had surgical procedures and may be ventilated for their entire stays. Others have more fatal conditions, i.e., hydrops or congenital heart defects, that greatly shorten their LOSs. By the nature of the case-mix within NICUs, these categories will be inherently heterogeneous from clinical and resource utilization perspectives.

CDRGs 385.2 and 385.3 are also highly variant with respect to resource utilization. They would be much more predictive of NICU charges, however, if the infants who were transported and then returned were removed from the groupings. Resource utilization ranges would be decreased to $7,721 and $4,745, respectively. These infants need to be accounted for in another, or additional, grouping within the CDRG system.

CDRGs 388 and 389 are fairly homogeneous groupings, giving support to the birth weight split at 500 gram intervals. NACHRI (1987) found that birth weight was the single most predictive piece of information for

newborn resource utilization. The groupings within 388 and 389 that are less homogeneous have been affected by the addition of surgical infants. Both systems support the greater heterogenity of surgical infants versus medical infants, in terms of resource utilization. The surgical CDRG groupings are more heterogeneous and have significantly higher resource utilization means than their non-surgical counterparts. Surgery does appear to be an important indicator of resource utilization in the higher birth weight, neonatal population. Duration of ventilation also significantly divides the groupings when comparing means for total NICU charges.

Consistency

The CDRG system is very consistent from a clincial perspective. The infants are grouped primarily by patient characteristics that make them clinically homogeneous and distinct to other groupings. Infants who are transported and then returned, and infants who have expired but are grouped with survivors could be more consistently classified within this system.

Table 17 contains the 95% confidence intervals created by each of the CDRGs. These CDRGs are listed in ascending order of resource utilization means. Ten groupings are significantly skewed to the right, with low-charge range parameters of zero. This also allows

Table 17

95% Confidence Intervals per CDRG

	Range
CDRG 386.1	$155,696 - 203,680
CDRG 387.2	25,137 - 279,518
CDRG 387.5	0 - 544,193
CDRG 386.4	49,294 - 224,798
CDRG 386.3	0 - 437,764
CDRG 390.1	0 - 198,716
CDRG 387.3	18,370 - 115,442
CDRG 388.3	0 - 118,210
CDRG 386.6	15,214 - 76,410
CDRG 390.3	5,102 - 65,214
CDRG 389.2	0 - 92,332
CDRG 389.3	0 - 67,213
CDRG 386.7	0 - 78,409
CDRG 387.4	1,788 - 56,412
CDRG 388.4	1,618 - 35,578
CDRG 390.2	8,372 - 27,624
CDRG 385.2	0 - 41,486
CDRG 389.4	1,677 - 21,397
CDRG 390.4	0 - 28,705
CDRG 385.3	0 - 36,244
CDRG 385.1	451 - 4,339

for considerable overlapping in resource utilization among these groupings. Three in particular have extremely wide ranges, i.e., 386.3, 387.5, and 390.1. These groupings have cost ranges that are too wide to be predictive of resource utilization. They contain infants who have expired or had surgery. The NCG system also found a great deal of variation in these patient types. Perhaps there is inherently greater variation in resource utilization for infants with surgical procedures and for infants who die. Prospective pricing systems may be unable to account for the variation in these two patient types.

Several of the CDRG groupings are clearly non-overlapping, i.e., CDRG 385.1, 390.3, 389.4, 387.2, 386.4, 385.3, 390.4, 385.2, 390.2, and 386.4. This is a significant improvement over the NCG and DRG system, indicating that the CDRGs are distinguishing between different levels of resource utilization within the NICU. There still remains, however, a great deal of overlap between CDRG groupings. This table shows that the medical CDRGs, i.e., 389.4 and 390.3, are low-cost subsets of their surgical comparables, i.e., 389.2 and 390.1. This relationship is not supported between 390.2 and 390.4. However, it does appear that surgery is an important determinant of hospital resource utilization in neonates.

Classification Variables' Contribution to Validity

The CDRG system uses primarily the same variables as the NCG system. Transfer status is added and ventilation is divided at different durations. Transfer status is reliably measured and stable. Ventilation, divided into duration lengths, is much more stable than as a dichotomous variable. However, it may not initially be reliably measured. NICUs will need to develop systems by which this variable can be accurately documented and measured per case-mix requirements. LOS is used only for those infants who die within one day

of life. These infants have lethal anomalies or conditions that are not compatable with life. They will primarily be identifiable at birth. LOS, in this context, is not manipulable by providers. Care regimens may vary considerably, but they will all consume a minimal amount of resources. This variable is reliably measured and is very stable.

Ventilation and surgery, as discussed in the NCG system, are service entities. The duration parameters added to ventilation in the CDRG system makes it much less manipulable. Gaming in the CDRGs, by increasing days of ventilation, would likely be to the financial disadvantage of the hospital. Prolonged ventilation can make a patient more costly to treat if lung damage or other complications arise.

Transfer status is not a direct measure of patterns of care or service. Transfer practices are highly variant and depend on patient condition, family's residence, and status of the hospitals receiving and initiating the transport. Tranfer status built upon LOS and targeting certain patient types, as in the CDRG system, is the most reasonable means by which to incorporate this variable into a case-mix system.

However, transferred infants within non-transferred classification groupings will reduce the amount of

variance explanation that can be achieved using variables other than discharge status. In other words, patients with the same diagnosis can have longer or shorter LOSs, depending on their discharge status. This may create adverse incentives for tertiary/level III centers to transfer infants for routine care to lower level centers. These lower level centers may or may not be equipped to handle the infants appropriately. In addition, how will transfers within facilities to lower levels of care be reimbursed to avoid adverse incentives?

There is no indication that any neonatal classification system has developed means by which to reimburse hospitals for these "back transports" after the infants are 29 days of age or older. How the tertiary care facilities and primary care facilities should be reimbursed is an important issue in assuring that referrals between community hospitals and regional referral centers are used to the maximum benefit of the neonatal patient.

External Validity

The CDRG system is generalizable to all NICUs. The groupings are based on variables that are available across NICUs and are identifiable by practitioners. The number of groupings are manageable and would be feasible

administratively. Despite the larger number of groupings, the sample was still concentrated in a few classes. Fifty-five percent of the infants fell into four groupings: infants who were transferred and born in the transferring hospital and infants weighing 1500 grams or more requiring minimal, or no, ventilation and no surgery. Infants were distributed throughout the NCG system in a similar manner. This may be more reflective of the case-mix in NICUs, than insufficiencies within the systems.

In addition, five groupings within the CDRG system contained only one infant from this sample. They were spread throughout all birth weight categories, except over 2500 grams, three were surgical. Four CDRGs contained no infants from the sample. All of these groupings were surgical groupings. This hospital may treat fewer surgical neonatal cases than childrens' or university hospitals, or the CDRGs may contain an inappropriate number of surgical groupings. Further research may indicate that some of these groupings can be combined, or it may support lower birth weight infants requiring smaller, divided groupings to form iso-resource groupings.

Incentives within the CDRG system are primarily for the provision of high quality, accessible, and efficient

neonatal intensive care. As with all systems, infants who are transferred for continuing care to lower level facilities must be accounted for at the tertiary center and at the community hospital. Otherwise, incentives will be present in tertiary facilities to transport infants to lower levels of care in greater numbers and earlier in their clinical course. In this way, tertiary centers can optimize their reimbursement by decreasing LOS, while still receiving the same reimbursement. Community hospitals and level I facilities are then threatened by inadequate reimbursement for increasing numbers of premature infants. "Dumping" of these infants can threaten quality of care and extend clinical courses. Incentives need to be present for the appropriate transfer of non-intensive care infants to other facilities, in order to assure accessibility within NICUs and provide for high quality of care to all eligible neonates and their families.

Summary

The results of this analysis are reflective of the purpose for which the CDRGs were developed, i.e., to represent all neonatal and pediatric populations in all types of hospitals. The CDRGs present difficulty in appropriately classifying infants who are transferred to other level III care and then returned. They also

present difficulties in establishing a 29-day cut-off for admissions and transports in a substantially premature population. The oversampling of childrens' and university hospitals in the formation of the CDRGs is apparent from its number of surgical categories, four of which were without infants from this sample. This research has suggested that the 250-gram split in <1000 gram infants may be important in distiguishing clinical and resource utilization differences in VLBW infants. However, further research with a larger sample is needed to justify this division.

The CDRGs primarily formed homogeneous groupings from a clinical perspective. They classify infants who expired by birth weight. Further improvements could be made in this system by initially separating infants in all birth weight categories by mortality, and thus, separating infants who expire from infants who survive. Ventilation duration parameters in the CDRG system have also contributed to increased clinical meaningfulness from providers' and practitioners' perspectives. Dividing birth-weight groupings by 500-gram intervals and dividing surgical infants by birth weight were additional improvements. The incorporation of transfers into the CDRG system is also an improvement from a clinical perspective. However, it is unclear whether or

not all of the divisions created by the CDRG system are necessary to create clinical and resource utilization homogeneity.

The CDRGs account for a significant amount of the variation in resource utilization in the neonatal population. However, because they were developed to reflect resource utilization in a variety of newborn units, improvements could be made in this area. The CDRGs have helped to demonstrate that predicting resource utilization, in some neonatal patient types, will be inherently difficult with a system based on averaging.

The CDRGs form a data base that can be of limited use to practitioners and providers. It is not useful for the comparison of treatments and quality of care across all patient types within the NICU. A major flaw is created in the CDRG data base by the exclusion of patients admitted to the NICU after 29 days of age. Premature infants appropriately admitted to a NICU are excluded from this data base. Administrators can not use this information for budgeting and staffing projections, because all of the case mix in a unit will not be included. Policy makers would also not be able to use this data base to make accurate decisions regarding NICU patient types. The data base formed by

the CDRG system may be harmful if used without recognition of this weakness.

Variables Important in Predicting Mortality

Three variables were chosen, based on data from Emanuel Hospital's NICU, as possible predictors of mortality: birth weight, gestational age, and lethal anomalies. Table 18 below shows the impact of lethal anomalies on mortality.

Lethal anomalies are good predictors of mortality; i.e., every infant that has one dies. However, for the total population of expired infants (N=29), only 28% of the infants who expired had lethal anomalies. Hence, other variables would be required to improve mortality predictions. There are other difficulties in using lethal anomalies to predict mortality. Twenty-five percent (N=2) of the infants with lethal anomalies died within 24 hours. One infant died within 48 hours. Two more died within 6 days of birth. The rest of the infants with lethal anomalies (38%) lived for up to six months. Some lethal anomalies are not detected at birth and may not be confirmed until autopsy. Others do not cause imminent death in infants and may go undiagnosed until later in the care process.

Birth weight may be a very good predictor in low birth-weight infants, but not in the total population of

Table 18

Impact of Lethal Anomalies on Mortality

Lethal Anomaly	Died	Lived
yes	8	0
	100%	0%
no	21	225
	9%	91%

infants who expire. Three (10%) of the infants who expired had birth weights of less than 600 grams. No infant under 600 grams survived, although one survivor weighed 600 grams at birth. Gestational age is even less predictive for the population as a whole. One infant expired at 22 weeks gestation. Five infants were born at 24 weeks gestation. Only three of those infants (60%) expired. For the total population of expired infants, gestational age only accounted for 14%.

Although no variables can be suggested from this analysis for use as predictors of mortality within a case-mix system for NICU infants, these variables may be important from a policy perspective. A data base that collects information on these variables may show that infants, below certain birth weights and/or gestational ages and infants with certain conditions/anomalies, have

very low survival rates and require very high cost care with poor outcomes. This information will be useful to policy makers and practitioners in issues regarding access, resource allocation, and care regimens to selected patient types within the NICU.

Cross-Mapping of the DRG, NCG, and CDRG Systems

Cross-mapping of the three classification systems for NICU infants is shown in Tables 19 and 20. Cross-mapping provides a picture of the extent of congruence among classifications. Maximum congruence would occur when the classes are the same (except for different labels). Maximum divergence would occur when no two cases were in the same classes together across schemes. Cross-mapping reveals differences in the underlying classification criteria. It can be used to demonstrate the heterogeneity of patient types within a system, based on patient-type groupings formed by other systems. The classification criteria that are most valid are the variables that establish clinical meaningfulness: birth weight, mortality, ventilatory status, and presence of OR surgery. However, the way the systems define and divide these variables can dramatically affect the classification groupings that are formed.

The DRG system, for example, contains fifteen or sixteen CDRGs within three of its groupings, i.e., DRGs

TABLE 19

Cross-Mapping of DRGs with NCGs and CDRGs

	NCG	CDRG
DRG 385	1,2,3,5,8,13, 14,2,12,11,9,10,	1,2,3,6,7,8,9,10, 16,17,21,24,26,28, 30,31
DRG 386	7,8,9,10,11,12, 13,14	3,5,7,9,11,14,15, 16,20,21,23,25,26, 30,31
DRG 387	7,8,9,10,11,12, 13,14	2,3,7,14,15,16, 19,20,21,24,25,26, 29,30,31
DRG 388	11,12,14	3,26,29,31
DRG 389	7,12,13,14	2,3,24,26,29,30,31
DRG 390	7,12,14	3,26,29,31
DRG 391	14	3,31

Table 20

Cross-Mapping of NCG and CDRG Systems

	N	CDRG
NCG 385A	15	1,6,10,17,21,31
NCG 385B	2	25,30
NCG 385C	4	10,17,28
NCG 385D	8	6,17,24,28
NCG 386	22	2,3,5,7,8,9
NCG 387L	18	11,14,15,16
NCG 388L	9	16
NCG 387H	31	20,21,25,26
NCG 388H	65	3,21,26
NCG 389	20	2,3,30,31
NCG 390	48	2,3,31
NCG 389S	12	19,23,24,28,29
Total	254	

385, 386, and 387 (Table 20). This is reflective of the clinical heterogeneity within these DRG groupings. Previously, DRG 385 was found to be clinically heterogeneous and not predictive of resource utilization. This is supported by the cross-mapping. DRG 385 contains the most NCG groupings of all the DRGs. Also, from the cross-mapping on Table 19, it appears that the DRGs are more clinically heterogeneous in the low-birth-weight groupings.

Table 20 displays the cross-mapping between the NCG and CDRG systems. The groupings in the NCG system that contain expired infants are clearly heterogeneous clinical categories. NCG 385A contains infants that fall into five birth-weight groupings in the CDRG system. NCG 385D contains infants spread into four birth-weight groupings. LOS is not a clinically homogeneous means by which to classify expired infants.

NCG 389S also contains a large amount of CDRG groupings for the number of infants contained in that grouping. This is also reflective of need to further divide this grouping from a clinical perspective. The CDRGs found in NCG 386 are reflective of further birth-weight and ventilation divisions found in the CDRG system. NCG 387L and 387H are further divided in the CDRG system based on duration of ventilation.

This cross-mapping displays how the addition of variables within the NCG and CDRG systems have further divided the DRG system. These divisions are reflected in the NCG's and CDRG's improved abilities to predict resource utilization and form clinically meaningful groupings. The cross-mapping also displays how the CDRG system has further divided NCG groupings. Some of these divisions resulted in more clinically meaningful groupings and increased homogeneity with respect to resource utilization.

CHAPTER VII

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary of the Case-Mix Systems

Tables 21 and 22 compare the case-mix systems on their development and validity, or appropriateness for use, with the NICU population.

Database

The NCG system was developed from a data base exclusively consisting of tertiary centers in Florida. The CDRGs were developed from a data base that oversampled childrens' and university hospitals, all of which contained NICUs. The newborn DRGs were not developed with a data base representative of neonatal tertiary (NICU) centers.

Purpose

The NCGs were designed to classify only NICU infants. The groupings formed by this system and its ability to predict resource utilization, are reflective of its goal. The CDRGs, on the other hand, were designed to classify normal newborn, NICU, and pediatric patients. The neonatal CDRGs classify normal newborn and NICU infants up to 28 days of age, although not within the same groupings. The neonatal CDRGs do not

Table 21

Summary of Case-Mix Systems

	Newborn DRGs	NCGs	Neonatal CDRGs
Development of Data Base	community hospitals	NICUs	childrens/ university
Designed for NICU	No	Yes	No
Classification Variables	mortality/ diagnoses/ transfer	mortality, LOS/ BW/ ventilation/ surgery	mortality, transfer/ vent./ BW/ surgery
Number of Classes	6	12	37/30(M)
Distribution	No	No	No
% cases in largest grp	32%	25%	16%
% cases in largest 3 groups	75%	57%	43%
Resource Use Measure	LOS	hosp charges	LOS/ hosp charges
Classification Strategy	statistical	theoretical/ statistical	theoretical statistical
R2: $	.16	.60	.54
LOS	.18	.63	.53

Table 22

Comparison of Case-Mix Systems by Validity Criteria

	Newborn DRGs	NCGs	Neonatal CDRGs
Content/Construct Validity			
Exhaustive	No	Yes	No
Mutually Exclusive	No	Yes	Yes
Homogeneity: Clinical	No	Yes/No	Yes/No
Resource Use	No	Yes/No	Yes/No
Consistency	No	Yes/No	Yes/No
Validity - Variables			
Reliable	Yes	Yes	Yes
Stable	Yes	Yes/No	Yes
Service Oriented	Yes/No	Yes/No	Yes/No
External Validity			
Generalizable	No	Yes	Yes
Number of Groups	Yes	Yes	Yes?
Minimization of Negative Impact	No	Yes	Yes

(table continued)

Table 22 (Continued)

Comparison of Case-Mix Systems by Validity Criteria

	Newborn DRGs	NCGs	Neonatal CDRGs
Purposes			
Reimbursement	No	Yes	Yes
Policy Making	No	Yes	No
Quality of Care	No	Yes	Yes
Staffing/Budgeting	No	Yes	No
Strengths	framework	predictive exhaustive	> clinical homogen: exprd by BW vent splits util transf
Weaknesses	heter resource groupgs clinically divergent grps intensive/ normal tog.	exprd-LOS no vent splt no BW splt in surg	28dy limit no level III transfers
Total - Met & Partially Met Criteria	4	15	12

capture all of the case mix within the NICU. Infants transferred or admitted at 29 days of age, or greater, are classified within the pediatric CDRG system. This is not ideal for a NICU population that deals primarily with premature infants. These infants require many weeks of hospitalization to reach term and begin their "neonatal period".

The DRGs were designed to classify normal newborn infants; infants requiring intensive care must be subsumed within the same groupings. Groupings that contain normal newborn and intensive care infants, together, cannot be homogeneous from any perspective. Normal newborn and intensive care infants require vastly different care regimens and consume different levels of resources.

Classification Variables

The DRGs utilize the variables of diagnoses, mortality, and transfer status. The NCGs are based on the DRG framework, but utilize birth weight, ventilation, mortality status, and surgical procedures, instead of diagnoses, to divide the groupings. The CDRGs also utilize these variables, but make improvements on the NCG system by classifying expired infants by birth weight, placing surgical infants into birth weight categories, dividing birth weight

categories by 500 gram intervals, and adding duration of ventilation parameters. They accounted for more of the variation in birth weight and gestational age than did the NCG system, indicating that the birth weight divisions are important additions.

The CDRG system also incorporates a new variable: transfer status. It accounts for transfers that occur within four days of birth. This is a homogeneous grouping that will be useful to providers. However, infants that are tranferred, and then returned to the originating NICU, must be accounted for within another CDRG grouping.

Number of Classes

The DRGs do not form enough groupings to distinguish between patient types. Three-fourths of the infants in this sample are contained in only three DRGs. The NCGs double the number of groupings, but still do not distinguish adequately between patient types. Half of the infants in this sample are found in three NCGs. The CDRGs greatly increase the number of classes. However, 43% of the sample infants can still be found in three CDRGs. It is questionable whether or not all of the CDRG divisions are necessary to form clinically homogeneous groupings.

Resource Use Measure

The DRGs used length of stay to measure resource use. The NCGs and CDRGs used a combination of theoretical and statistical components to measure resource use.

Variance Explained

The NCG system was the most predictive of resource utilization in this sample of NICU infants. It accounted for 60% of the variation in NICU resource utilization, over three times that captured by the DRGs. LOS was demonstrated to be a good predictor of resource utilization in the majority of infants who expire, albeit not a clinically meaningful way to classify these infants. The surgical grouping in the NCG system was heterogeneous in respect to resource utilization, and thus, not very predictive.

The DRGs only accounted for 16% of the variation in NICU resource utilization. The CDRGs were not as predictive of resource utilization, in this NICU sample, as were the NCGs, primarily because they were developed to reflect resource use in a variety of newborn units. The CDRG changes in the way surgical infants were grouped were reflected in greater resource utilization homogeneity within those groupings. The CDRGs accounted for 54% of the variation in the NICU resource

utilization. This is a very significant improvement over the DRG system.

Comparison of Case-Mix Systems

Content/Construct Validity

The NCG system is the most acceptable system for use in the NICU. It is the only system that is exhaustive for the NICU population. The CDRG data base excludes infants treated in a neonatal intensive care setting who were admitted or transferred at more than 28 days of age. This may exclude important patient types. The DRG system classifies some NICU infants outside the newborn DRG groupings.

The NCG and CDRG systems form clinically meaningful groupings that are reflective of care regimens. The CDRGs made some improvements on the NCG system and, from a practitioner's perspective, were the most clinically meaningful. The way the NCG system classifies infants who expire and infants who have surgical procedures could be modified in order to create more clinically meaningful groupings. From a clincial perspective, the CDRG system could be improved by separating infants who die from survivors at all birth weight levels. In addition, further research in other NICUs is needed to determine if the CDRGs create more groupings; i.e. surgical and VLBW, than are necessary to distinguish

between clinical and resource utilization differences within the NICU population.

The DRG framework is appropriate for classifying NICU infants into groupings that are predictive of resource utilization. The NCG system was the most predictive of resource use, but the NCG and CDRG systems both made substantial improvements over the predictability of the DRG system.

Validity-Variables

All three systems incorporate variables that are reliable and stable. The NCGs utilize ventilation with a dichotomous or 48 hour duration parameter. This may not be long enough to reflect care regimens of ventilated infants, and thus, may not be stable. Further research is needed to determine the most appropriate ventilation duration parameter. All three systems incorporate service oriented variables. The CDRG's use of ventilation duration parameters provides the best safeguard against manipulability.

External Validity

The NCG system most completely meets the criteria for external validity. The CDRGs may contain more groupings than are necessary to form homogeneous resource use and clinically meaningful groupings within the NICU population.

Purposes

The NCGs are the only system that can fulfill all of the purposes of a case-mix system within the NICU. The NCG system forms a data base that will be most useful to practitioners and administrators. Infants are classified in a way that will promote quality of care comparisons and analysis. Treatment modalities can be compared across regions and hospitals. Administrators can use this data base in analyzing case-mix, projecting staffing needs, and analyzing budgetary needs. Policy makers will find this data base useful in issues regarding access, quality of care, and resource utilization within the NICU.

The CDRG system forms a data base that will be useful for practitioners and administrators. However, the data base will exclude infants treated in a neonatal intensive care setting who were admitted or transferred at more than 28 days of age. This may exclude important patient types. Otherwise, the CDRGs have made important improvements on the NCG data base, i.e. birth weight groupings span only 250 to 500 grams, surgical infants are divided by birth weight, infants who expire are primarily separated by birth weight, transfer status is incorporated for some infants. These groupings will be useful to practitioners in quality of care analysis and

in the comparison of treatments. However, it must be recognized that this data base excludes certain patient types that are appropriately treated within the NICU. Thus, administrators and policy makers may find this data base misleading and incomplete in analyzing case-mix, outcomes, and resource allocation within the NICU.

The data base formed by the DRGs cannot be used for quality of care purposes or for the comparison of treatments across facilities or regions. It is not useful for administrators in analyzing case-mix and projecting staffing and bugetary needs. It will also not be useful in policy making regarding quality of care, access, resource allocation, and the impact of new technology within the NICU.

Recommendations for Improvement

The NCG system, however, can be improved. Mortality was the most important variable, in this sample, for predicting resource utilization. This supports the NCG system's use of mortality as the first dividing variable. However, infants who die should then be split by birth weight divisions, rather than LOS divisions. Birth weight should span only 500 gram intervals, as it does in the CDRG system. Further research is needed to determine the need, clinically or with respect to resource utilization, for infants

weighing less than 1000 grams to be split into 250 gram groupings.

Infants with OR surgical procedures should continue to be separated from infants requiring primarily medical care. This analysis, however, did not contain enough surgical infants to determine if the 1500 gram birth weight split, used in the NCG system, is an appropriate point at which to begin this division. The authors of the CDRG system believe that surgical status makes a difference in resource utilization in all infants with birth weights greater than 1000 gram infants. Surgical status was the second most important variable in predicting NICU resource utilization in this sample. These two findings suggest that further research is needed on NICU surgical infants, to determine the most appropriate birth weight to begin separating them from medical care infants.

In addition, surgical infants in NCG 389S should be further divided by birth weight and ventilation requirements. These groupings within the CDRG system improved on the clinical and resource utilization homogeneity of NCG 389S. Ventilation divisions may not be required in all birth weight groupings. Again, further research will be needed to determine the most appropriate splits.

Ventilation duration parameters should be added to the NCG system. This will improve the clinical homogeneity of the NCG groupings. They should improve the groupings' ability to predict resource utilization. In addition, they will decrease the potential for gaming by providers in overutilization of ventilation. The ventilation duration parameters that seem most appropriate for use in a NICU case-mix system are those used in the CDRGs, i.e., three days and 21 days. More research is needed to confirm the appropriateness of these divisions from a clinical and reimbursement perspective. It is unclear whether or not using both of these splits, within a single birth weight grouping, is necessary to achieve clinical meaningfulness and resource utilization prediction. This sample has demonstrated the appropriateness of the 21-day split in low birth weight infants and the 3-day split in higher birth weight infants.

Ideally, a case-mix system within the NICU should account for transfers. The system should encourage appropriate transfers between different levels of care, in order to ensure access to NICU beds and provide for quality of care to infants and their families. However, NICUs transfer at highly varying rates (NACHRI, 1986). The decision to transfer is only partly reliant on

patient conditions and characteristics. Transfers out of a NICU within four days of birth are a fairly clinically homogeneous grouping. This grouping, however, does not account for infants transferred to another NICU for more specialized care, some of which are subsequently returned to the originating NICU.

A fairly common practice in NICUs is to transfer infants to lower levels of care for their growth and recovery stage. These infants no longer require level III care and are very stable. They may be transferred to another facility or to a lower level of care within the same facility. These infants are frequently very premature and, thus, are transferred at several months of age. A case-mix system should account for these infants who have their LOS shortened by transfer. Otherwise, incentives are present to transfer increasing numbers of infants out to lower levels of care, increasing reimbursement gains within the NICU.

In addition, developers of NICU case-mix systems should be concerned that facilities providing this lower level of care are receiving adequate reimbursement. The DRG/NCG system may need to be modified to account for the care given to these transferred infants. The facilities need to be appropriately staffed and equipped to handle these patient types. A case-mix system that

appropriately groups these infants for reimbursement and quality of care/administrative purposes, will ensure that this transfer process meets the needs of patients, families, and providers.

Policy Implications

This study generated information on the ability of two classification schemes, NCGs and CDRGs, to appropriately classify neonates for the purpose of reimbursement. HCFA is presently examining the CDRG system for use in the Medicaid program and the NCG system is being used in Florida. Information resulting from this study on appropriateness for classification, incentives created, and impact on health care delivery will be useful to providers and payers. Identifying adverse incentives for patients early in the implementation process should assist providers in creating peer review, quality assurance, or other programs to combat adverse incentives. Nurse managers can use the results of this study to estimate the impact of this reimbursement system on their patient population. Nursing can then anticipate reimbursement and patient care concerns.

The strengths and weaknesses identified in the NCG and CDRG systems have implications for the development and refinement of other patient classification systems.

Support of the DRG framework for classifying neonatal intensive care populations should encourage other researchers to include this framework in classification systems studied for pediatric, cardiac, burn, or other intensive care units. Support of the DRG framework, however, should not discourage researchers from studying other classification frameworks within the NICU, or other, patient populations.

Recommendations for Future Research

This study has suggested that the NCG system is better than the CDRG and DRG systems for classifying NICU patient populations. However, areas for improvement in the NCG system have been recognized. These improvements need to be implemented into the NCG system. Some areas suggested for improvement need further study, i.e., when to separate surgical and medical patients, what ventilation parameters are appropriate for surgical and medical patients, the importance of a 250 gram split for infants <1000 grams. This system will then need further study in various NICU settings, i.e., childrens' and university hospitals, to see if it remains as predictive of NICU resource utilization.

Further research can also be done on how this system affects the transfer of infants within and

between facilities. Does it encourage appropriate transfers? Are premature infants being "dumped" on community hospitals? Do tertiary centers benefit highly from the transfer of infants for growth and recovery? Are community hospitals being reimbursed appropriately within the present DRG system in caring for these transferred infants?

Research can also be done on how well the NCG system forms a data base that is useful to practitioners and providers. How are nurse administrators utilizing this data base for staffing projections? Is it accurate? How can this data base be used to determine nursing care costs per patient types and reimbursement groupings? Nurses need to be able to determine their contribution, both from a cost and outcome perspective, to patient care within the NICU. Research on how this case-mix system reflects nursing care within the NICU needs to be performed.

Research needs to be performed in quality of care concerns and the comparison of treatment modalities across institutions. Quality of care studies need to be done examining the service entities; i.e. ventilation and surgery, within the NCG system. How is their utilization affected by implementation of this system? What quality control programs are helpful in

discouraging overutilization of these entities? The case-mix in NICUs needs to be analyzed itself for a changing blend of patient types. ECMO therapy is being offered in more NICU settings. How are these infants reimbursed and classified? It may not be long before new patient types need to be accurately incorporated into the NCG system.

Research can also be done on areas likely to be future policy issues. For instance, what is cost of care versus outcomes in selected-birth-weight infants? What patient types have the lowest quality life projections within the NICU population? Have selected technologies improved quality of life or just LOSs? These issues may be important in future decisions about resource allocation and the effectiveness of NICUs.

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AN ABSTRACT OF THE THESIS OF

FLORENCE L. SPYROW

The primary aims of this study were to examine construct/content validity, determine predictive validity, and determine homogeneity in resource groupings formed by three patient classification systems in the neonatal intensive care unit (NICU)--Diagnosis Related Groupings, Childrens' Diagnosis Related Groupings, and Neonatal Care Groups. These schemes are either being used or proposed as the basis for reimbursement to hospitals for use of NICU services.

The sample for this study included 254 infants admitted to a NICU in a medium-sized short-term general hospital over the period April 1, 1986 through March 31, 1987.

Four criteria for content/construct validity were defined: exhaustiveness, mutual exclusivity, homogeneity (conceptually and statistically), and consistency. The variables included in each classification scheme were evaluated for reliability, stability, and service orientation. Finally each classification scheme was examined for its ability to meet the following established criteria for iso-resource groupings: generalizability, number of groups, minimization of negative impact.

The results show that the Diagnosis Related Groups (DRGs) are not predictive of resource utilization within the NICU and do not place infants into clinically meaningful groupings. The Childrens' Diagnosis Related Groupings improved on the resource predictability of the DRGs. They place neonates into clincially meaningful groupings, based on established criteria. However, they were not developed for the NICU and do not capture all of the patient population within this highly defined unit. The Neonatal Care Groups were the most predictive of resource utilization within the NICU. This system was defined specifically for the NICU, captures all of the case mix, and places infants into clinically meaningful groupings.

APPENDIX A

NSCU INTAKE DATA FORM Computer #_____

1)_____/_____Name
Last First

2)_____Med. Record #

_____Mother's Med.Rec.#

3) Address:_____
House # / street

_____
City /State /Zip

4)____/____/___Birthdate
mo./day /year

5)_____Time of birth
24 hour clock

6)___/___/_____Admit date
mo day year

7)_____Time of admit
24 hour clock

8)_____Admitting MD

9)_____Referring OB/FP

10)_____Referring Peds/FP

11)_____Maternal transport
0) no 1) yes

12)_____Neonatal transport
0) no 1) yes

13)_____Hospital of origin
(Mother or baby)

14)_____Birth Weight(grams)

15)_____Length (cm)

16)_____OFC (cm)

17)_____Multiple gestation
0) no 1) yes

18)_____Number of fetuses

19)_____Birth order (this infant)

20)_____Assigned Gestational Age

21)_____1)AgA 2)SgA 3)LgA

22_____Sex 1)male 2)female
3) unknown

23)_____Gravida
24)_____Parity
25)_____F = Full Term
26)_____P = Premature
27)_____A = Abortions
28)_____L = Living

29)_____Maternal Age

30)_____Marital Status
0) unknown 1) single 2) married

31)___/___Maternal blood type(ABO/Rh)

32)_____Maternal Race
0)unknown 1)black 2)cauc. 3)other

33)_____Smoking (>1/2ppd)
0) no 1) yes

34)_____ETOH (> 2 drinks/week)
0) no 1) yes

35)_____Illicit Drugs
0)no 1)Nar 2)Coc 3)Meth 4)Amp 5)Mar
6) other

36)_____Diabetes
0)no 1)pregnancy induced
2)insuline dependent

37)_____Preeclampsia/eclampsia
0)no 1) yes

38)_____Hypertension
0) no 2) pregnancy induced
1) yes

39)_____Premature Labor
0) no 1) yes

40)_____Bleeding
0) no 1) 1st tri 2) 2nd tri
3) 3rd tri 4) abruption 5) previa

41)_____Amnionitis
0) no 1) yes

42)_____/1 L/S
0) not done

43)_____Pg
0) not done 2) negative
1) positive

44)_____/_____Biophysical Profile
score total possible (most recent)

45)_____Labor
0) none 2) induced

46)_____/_____/_____Duration ROM
weeks days hours

47)_____Amniotic Fluid
0) normal 3) meconium
1) oligohydramnios 4) blood
2) polyhydramnios 5) unknown

48)_____Prenatal Steroids
0) none 2) 2 doses
1) 1 dose 3)> 2 doses

49)_____Tocolytic Drugs
0) none 2) MgSO4
1) Betasympathomimetics 3) other

50)_____Anesthesia
0) none 3) spinal
1) local 4) general
2) epidural 5) narcotics

51)_____C/section
0) no-vaginal 3)fetal distress
1) elective/repeat 4)CPD
2) maternal indications 5)fetal lie

52)_____Fetal Monitor
0) none 1) normal 2) abnormal

53)_____Presentation
0) vertex 1) breech 2) other

54)_____Forceps
0) no 1) yes

55)_____1" Apgar (11)not done

56)_____5" Apgar (11)not done

57)_____10" Apgar (11)not done

58)_____Resuscitation/Airway
0) none 2)bag/mask
1) oxygen 3)ETT

59)_____Resuscitation/Meds.
0) none 4) NaHCO3
1) volume 5) Glucose
2) blood 6) Epi
3) Narcan 7) Other

60)_____Resuscitation/Lines
0) none 3) UVC
1) PIV 4) other
2) UAC

61)_____Scalp pH
0) not done

CORD ARTERIAL BLOOD GAS (62-66)

62)_____ 0) no 1) yes

63)_____pH

64)_____pCO2

65)_____pO2

66)_____base deficit

CORD VENOUS BLOOD GAS (67-71)

67)_____ 0) no 1) yes

68)_____pH

69)_____pCO2

70)_____pO2

71)_____base deficit

FIRST BLOOD GAS (72-79)

72)_____ 0) no 1) yes

73)_____Site Obtained
0) Arterial 2) Venous
1) Capillary 3) Other

74)_____/_____Time after birth
hours mins.

75)_____pH

76)_____pCO2

77)_____pO2

78)_____base deficit

79)_____
0) spontaneous respiration
1) CPAP
2) IPPV

80)_____Admitting Service
0) unknown
1) Neonatology
2) Cardiology
3) Surgery
4) Private Pediatrics

NSCU SUMMARY DATA FORM Computer #_____

_____/_____Name
Last First

81)_____Primary MD

82)_____Discharge MD

83)_____/____/___Discharge Date
mo. day yr.

84)_____Discharge Disposition
0) home 5)other Level III
1) GSH 6)Peds Ward (EH)
2) St. Vincent's 7)FBC
3) other Level I 8)Other
4) other Level II

85)_____Hospital
(if discharged to another hospital)

86)_____Outcome: 0)lived 1)died

87)_____Discharge Hematocrit

88)_____Discharge Weight (gm)

89)_____Discharge Length(cm)

90)_____Discharge OFC (cm)

* * * * * * * * * * * * * * * * * * * *
* * * * * * * * * * * * * * * * * * * *

DISCHARGE TREATMENT:
0) no 1) yes

91)_____Oxygen

92)_____Diuretics

93)_____Theophylline

94)_____Steroids

95)_____Monitor

96)_____Phenobarb

97)_____Other:_____

* * * * * * * * * * * * * * * * * * * *
* * * * * * * * * * * * * * * * * * * *

98)_____Days of hospitalization

99)_____Lowest Weight

100)_____Days to regain birth weight

101)_____Days of C-R Monitor

102)_____Days of Open Warmer

103)_____Days of Isolette

104)_____Days of PIV Fluids

105)____/____Days of UAC (H/L)

106)_____Days of UVC

107)_____Days of perc-line

108)_____Days/other central line

109)_____Days of Drip gastric feeds

110)_____Days of transpyloric feeds

111)_____Days of hyperal

112)_____Days of lipids

113)_____Days of phototherapy

114)_____Days of chest tube

115)_____Days of mechanical vent.

116)_____Max PIP

117)_____Max IMV rate

118)_____Max MAP

119)_____Days FiO2 $\geq$ .80

120)_____Days FiO2 $\geq$ .40 $<$ 80

121)_____Days FiO2 $>$ .21 $<$ .40

122)_____Days NCPAP

123)_____Days of ECMO

124)____/____/____/____/____# trans.
R P C F O

125)_____Days of sedation

126)_____Days of paralysis

127)_____Days of Dopamine

128)_____Days of Dobutamine

129)_____Days of Priscoline

130)_____Days of Antibiotics

131)_____Days of Diuretics

132)_____Days of Methylxanthines

133)_____Days of Hydrocortisone

134)_____Days of Decadron

DAILY DATA COLLECTION

NAME _____ COMPUTER # _____

DAY #0000-2400	1	2	3	4	5	6	7	8	9	10
Date (mo.-day)										
Weight (grams)										
C-R Monitor										
Warmer										
Isolette										
PIV (not hep lock)										
UAC (H=hi;L=Low)										
UVC										
Perc.Line										
other Line										
Drip Feeds (Gastric)										
Drip Feeds (Transpyloric)										
Hyperal										
Lipids										
Photothpy.										
Chest Tubes # R=Right L=Left										
PIP/PEEP (highest)										
IMV # (highest)										
IT (longest)										
MAP (highest)										
FiO2 -> .80										
FiO2 -> .40 <.80										
FiO2 -> .21 <.40										
NCPAP										
ECMO										
Transfusion(RBC)										
Trans.Platelets										
Trans.Cryo										
Trans.FFP										
Trans.Other										
Sedation										
Paralysis										
Dopamine										
Dobutamine										
Priscoline										
Antibiotics										
Diuretics										
Xanthines										
Steroids Hydro										
Steroids Decadron										

HEALTHLINK

MEDICAL RECORD REPORT

EMANUEL HOSPITAL

PATIENT NAME	NUMBER

SUMMARY

ATTENDING PHYSICIAN	DATE
WILLIAM BROWN, M.D.	ADM: 8-28-85 DIS: 9-17-85

cc: Kristin Quentan, R.N.
cc: Dr. Sarah Fryberger
cc: Dr. Daniel Cristofani

HISTORY: is the 40 week gestation infant of a 38 year old gravida V, para IV, white married woman. The pregnancy was uncomplicated. There was artificial rupture of membranes 28 hours prior to delivery. Labor was induced with Pitocin. There were mild late decellerations ~~of~~ Pitocin augmentation which improved with a decrease in the Pitocin. Maternal fever was noted several hours prior to delivery. Delivery was vaginally vertex presentation with epidural anesthesia.

RESUSCITATION: Apgars were 5/3/5. Immediately after birth she had minimal tone, a heart rate greater than 100 and cried weakly once, then deteriorated. She was intubated, then given Albumin for perfusion with a marked improvement ~~and~~ perfusion noted after the Albumin. Initial venous blood gases pH 6.98, PCO2 58, PO2 52 and 100% oxygen. She was transferred to the NSCU.

ADMISSION PHYSICAL: Weight 3850 grams, heart rate 190, blood pressure 66/40, temperature 36.8. Skin normal. HEENT within normal limits. Examination of eyes, ears and mouth deferred. Chest clear bilaterally with good air movement. CV - S1 and S2 normal without murmur or gallops. Abdomen soft without mass or organomegaly. Genitalia normal. Extremities normal. Back normal. Neurologic - Initial limp without spontaneous movement.

PROBLEMS:
Respiratory - Initial ventilator settings were 30/2, IMV 40, 100% oxygen. Her peak settings were 36/4, IMV 80, 80% oxygen at one day of age. She was on Pavulon from 8/29 to 9/2. Her course was consistent with pneumonia. began weaning slowly on 8/30 and by 9/1 was on 28/4, IMV 35, 95% oxygen. She continued to wean and was extubated on 9/5 and placed in an oxygen hood with 35% oxygen. She weaned to room air on 9/6 and had no further requirements for oxygen or respiratory assistance during the remainder of her hospitalization.

(Continued
(5/9/87-bh)

HEALTHLINK

MEDICAL RECORD REPORT — EMANUEL HOSPITAL

PATIENT NAME	NUMBER
ATTENDING PHYSICIAN	DATE
WILLIAM BROWN, M.D.	ADM: 8-28-85 DIS: 9-17-85

SUMMARY

PAGE TWO:

Cardiovascular - Echocardiogram done 8/28 showed normal intracardiac anatomy, a patent ductus arteriosis with a left to right shunt and a patent foramen ovali with evidence of a left to right shunt. Dopamine was started on 8/29 and discontinued on 8/30.

Infection - Ampicillin and Gentamycin were started at birth. Final blood culture report was no growth. Urine specimen was negative for Group B strep by latex agglutination. Gastric aspirate grew heavy group D strep, coagulace negative staphylococcus and moderate neisseria flavescens. Because of her clinical course and CBC consistent with infection, she received a 14 day course of the antibiotics. LP was done on 9/1, and the results were within normal limits.

On 9/3 was noted to have purulent appearing umbilical drainage. There was no evidence of induration or erythema. Culture of the drainage grew coagulace negative staph. The UAC was discontinued and she was maintained on her current course of antibiotics.

Micostatin suspension was started on 9/4 for thrush. It was discontinued on 9/10. On 9/16 Nystatin ointment was started to her diaper rash and it was discontinued on 9/17.

Hematology - is O-positive direct Coombs negative. Her mother is O-positive antibody screen negative. Peak bilirubin was 10.6 at three days of age. She received a five day course of phototherapy. Hematocrit at the time of discharge was 53.1.

Neurologic - Phenobarbital was started on 8/28 for sedation and discontinued on 9/9. Head ultrasound done 8/29 was normal. EEG was done on 9/12 and was normal for age. Neurodevelopmental evaluation was done 9/11 and showed her reflexes to be age appropriate except for the righting responses of her head. Her range of motion was within normal limits and her muscle tone was at the low end of normal. Her movements were nicely symmetrical.

(Continued)
(5/9/87-bh)

H E A L T H L I N K

MEDICAL RECORD REPORT

EMANUEL HOSPITAL

PATIENT NAME	NUMBER

SUMMARY

ATTENDING PHYSICIAN	DATE
WILLIAM BROWN, M.D.	ADM: 8-28-85 DIS: 9-17-85

PAGE THREE:

DISCHARGE EXAM: Weight 3740 grams, length 55 cm., head circumference 35.25 cm. HEENT within normal limits. Lungs clear. CV - No heart murmur. Hips normal.

DISCHARGE MEDICATIONS: Ab-dec 0.3 cc. p.o. q. day.

DISCHARGE FEEDINGS: Mother's milk or Similac-20 calorie with Iron 2.5 to 3 oz. p.o. q. 3 hr.

FINAL DIAGNOSIS:
1. 40 weeks gestation.
2. Perinatal asphyxia.
3. Probable sepsis.
4. Pneumonia.

FOLLOW-UP APPOINTMENTS: Dr. Fryberger within one week of discharge for continuing pediatric care.

(KRISTIN QUENTIN, R.N.)

WILLIAM BROWN, M.D.

D: 5/7/87
T: 5/9/87 (bh)

THE APACHE II SEVERITY OF DISEASE CLASSIFICATION SYSTEM

PHYSIOLOGIC VARIABLE	HIGH ABNORMAL RANGE					LOW ABNORMAL RANGE			
	+4	+3	+2	+1	0	+1	+2	+3	+4
TEMPERATURE — rectal (°C)	≥41°	39°-40.9°		38.5°-38.9°	36°-38.4°	34°-35.9°	32°-33.9°	30°-31.9°	≤29.9°
MEAN ARTERIAL PRESSURE — mm Hg	≥160	130-159	110-129		70-109		50-69		≤49
HEART RATE (ventricular response)	≥180	140-179	110-139		70-109		55-69	40-54	≤39
RESPIRATORY RATE — (non-ventilated or ventilated)	≥50	35-49		25-34	12-24	10-11	6-9		≤5
OXYGENATION A-aDO$_2$ or PaO$_2$ (mm Hg) a FiO$_2$ ≥ 0.5 record A-aDO$_2$ b FiO$_2$ < 0.5 record only PaO$_2$	≥500	350-499	200-349		≤200 PO$_2$ > 70	PO$_2$ 61-70		PO$_2$ 55-60	PO$_2$ < 55
ARTERIAL pH	≥7.7	7.6-7.69		7.5-7.59	7.33-7.49		7.25-7.32	7.15-7.24	< 7.15
SERUM SODIUM (mMol/L)	≥180	160-179	155-159	150-154	130-149		120-129	111-119	≤110
SERUM POTASSIUM (mMol/L)	≥7	6-6.9		5.5-5.9	3.5-5.4	3-3.4	2.5-2.9		< 2.5
SERUM CREATININE (mg/100 ml) (Double point score for acute renal failure)	≥3.5	2-3.4	1.5-1.9		0.6-1.4		< 0.6		
HEMATOCRIT (%)	≥60		50-59.9	46-49.9	30-45.9		20-29.9		< 20
WHITE BLOOD COUNT (total/mm3) (in 1,000s)	≥40		20-39.9	15-19.9	3-14.9		1-2.9		≤1
GLASGOW COMA SCORE (GCS): Score = 15 minus actual GCS									
A Total ACUTE PHYSIOLOGY SCORE (APS) Sum of the 12 individual variable points									
Serum HCO$_3$ (venous-mMol/L) (Not preferred, use if no ABGs)	≥52	41-51.9		32-40.9	22-31.9		18-21.9	15-17.9	< 15

E AGE POINTS: Assign points to age as follows:

AGE (yrs)	Points
≤44	0
45-54	2
55-64	3
65-74	5
≥75	6

C CHRONIC HEALTH POINTS

If the patient has a history of severe organ system insufficiency or is immuno-compromised assign points as follows

a. for nonoperative or emergency postoperative patients — 5 points
or
b. for elective postoperative patients — 2 points

DEFINITIONS

Organ insufficiency or immuno-compromised state must have been evident prior to this hospital admission and conform to the following criteria:

LIVER: Biopsy proven cirrhosis and documented portal hypertension, episodes of past upper GI bleeding attributed to portal hypertension, or prior episodes of hepatic failure/encephalopathy/coma.

CARDIOVASCULAR: New York Heart Association Class IV.

RESPIRATORY: Chronic restrictive, obstructive, or vascular disease resulting in severe exercise restriction, i.e., unable to climb stairs or perform household duties; or documented chronic hypoxia, hypercapnia, secondary polycythemia, severe pulmonary hypertension (>40mmHg), or respirator dependency.

RENAL: Receiving chronic dialysis.

IMMUNO-COMPROMISED: The patient has received therapy that suppresses resistance to infection, e.g., immuno-suppression, chemotherapy, radiation, long term or recent high dose steroids, or has a disease that is sufficiently advanced to suppress resistance to infection, e.g., leukemia, lymphoma, AIDS.

APACHE II SCORE

Sum of A + B + C =

A APS points _____

B Age points _____

C Chronic Health points _____

Total APACHE II _____

FIG. 1. The APACHE II severity of disease classification system.

system is hospital mortality. Hospital mortality can be accurately measured, and although not sensitive to the important question of quality of survival, mortality is an objective and reasonable starting point for evaluation. We therefore evaluated the validity of APACHE II by testing its association with hospital mortality in a large number of unselected but carefully described ICU admissions from 13 hospitals.

The 13 hospitals and the characteristics of the units surveyed for this evaluation are listed in alphabetical order in Table 1. With the exception of the George Washington University Medical Center (GWUMC), where data were collected for all ICU admissions during 1979 through 1981, the remaining 12 hospitals collected data on a minimum of 200 unselected consecutive ICU admissions during 1982. The hospitals were chosen because of their willingness to participate and, in most cases, to support supervised data collection independently. The number of patients per hospital reflects the amount of labor available for data collection—not the overall ICU utilization rate.

One of us (E.A.D.) visited each of the hospitals to initiate and train the data collectors. In most hospitals, these were experienced ICU nurses, but also included medical records personnel, medical corpsmen, and physicians. All data were checked for transcription errors, completeness, and internal consistency. Interobserver reliability testing by others (DL Jackson, personal communication) revealed 96% agreement for all physiologic data. Agreement on preadmission data was somewhat less, but disagreements were minor.

For each patient, the data collected included age, diagnosis, indication for ICU admission, surgical status, preadmission history, APACHE classifications on each ICU day, and outcome at ICU and hospital discharge. Copies of most patients' discharge face sheets (H-ICDA) were also obtained.

At ICU admission, the patients were assigned to specific diagnostic categories according to the *one* principal reason for their admission. Some of the most frequent and important of these diagnostic categories appear in Tables 2 and 3, and a full listing is available in the Appendix and Table 6. Patients without one of these principal diagnoses were designated as admitted

Table 1. *Physiologic Stability Index (PSI)*

System	Points 1+	3+	5+
Cardiovascular			
Infants			
Blood pressure, systolic (torr)	55–65	40–54	< 40
	130–160	> 160	
Heart rate (beat/min)	75–90	50–74	> 220
	160–180	181–220	< 50
Children			
Blood pressure, systolic (torr)	65–75	50–64	< 50
	150–200	> 200	
Heart rate (beat/min)	60–80	40–59	> 200
	150–170	171–200	< 40
All ages			
Blood pressure, diastolic (torr)	90–110	> 110	
Cardiac index [1/(min·m^2)]	2.0–3.0	1.0–1.9	<1.0
$avDO_2$ (vol %)	< 3.0	> 6.5	
	5.5–6.5		
CVP (torr)	< 0, > 15		
PCWP/LA (torr)	< 5, 15–25	> 25	
Respiratory			
Infants			
Respiratory rate (breath/min)	50–60	61–90	> 90
Children			
Respiratory rate (breath/min)	30–50	51–70	> 70
All ages			
Pao_2 (torr)	50–60	40–49	< 40
Pao_2/Fio_2	200–300	< 200	
$Paco_2$ (torr)	< 30, 45–50	51–65	< 65
Neurologic			
All ages			
Glascow coma score	8–11	5–7	< 5
Intracranial pressure (torr)	15–20	21–40	> 40
Seizures	focal	grand mal/status	
Pupils	equal-sluggish	unequal-dilated sluggish	fixed/dilated
Hematologic			
All ages			
Hemoglobin (g/dl)	18.0–22.0	3.0–5.0	< 3.0
	5.0–7.0	22.1–25.0	> 25.0
WBC (cell/mm^3)	3–5,000	< 3,000	
	20–40,000	> 40,000	
Platelets (cell/mm^3)	20–50,000	< 20,000	
	>1 million		
PT/PTT	> 1.5 × control		
FSP (μg/ml)	> 40		
Renal			
All ages			
BUN (mg/dl)	40–100	> 100	
Creatinine (mg/dl)	2.0–10.0	> 10.0	
Urine output (cc·kg·h^{-1})	0.5–1.0	< 0.5	
Gastrointestinal			
All ages			
AST/ALT (IU/l)	> 100		
Amylase (U/l)	> 500		
Total bilirubin (mg/dl)	> 3.5		
Albumin (g/dl)	1.2–2.0	<1.2	
Metabolic			
All ages			
Sodium (meq/l)	115–125, 150–160	< 115, > 160	
Potassium (meq/l)	3.0–3.5	2.5–2.9	< 2.5
	6.5–7.5	7.6–8.0	> 8.0
Calcium (mg/dl)	7.0–8.0	5.0–6.9	< 5.0
	12.0–15.0	>15.0	
Glucose (mg/dl)	40–60	20–39	< 20
	250–400	> 400	
Osmolality (mosm/l)	320–350	>350	
pH (U)	7.20–7.30	7.10–7.19	< 7.10
	7.55–7.65	< 7.65	
HCO_3	< 16, > 32		

TABLE 1. Categories of the Therapeutic Intervention Scoring System (TISS)

Category	TISS Score
Pediatric intensive care unit (PICU) therapies	
Cardiac resuscitation and/or countershock within past 48 h	4
Controlled ventilation with or without positive end-expiratory pressure	4
Controlled ventilation with intermittent or continuous muscle paralysis	4
Balloon tamponade of varices	4
Continuous arterial infusions	4
Atrial and/or ventricular pacing	4
Hemodialysis in unstable patient	4
Peritoneal dialysis	4
Induced hypothermia	4
Pressure-activated blood transfusion	4
G-suit	4
Emergency operative procedure (within 24 h)	4
Lavage of acute gastrointestinal (GI) bleeding	4
Emergency endoscopy or bronchoscopy	4
Intraaortic balloon assist	4
Membrane oxygenation	4
Intermittent mandatory ventilation or assisted ventilation	3
Continuous positive airway pressure	3
Concentrated K^+ infusion	3
Nasotracheal or orotracheal intubation	3
Blind intratracheal suctioning	3
Frequent infusions of blood products (≥20 mL/kg)	3
Vasoactive drug infusion	3
Continuous antiarrhythmia infusions	3
Cardioversion for arrhythmias	3
Active diuresis for fluid overload or cerebral edema	3
Emergency thora-, para-, and pericardiocentesis	3
Treatment of seizures or metabolic encephalopathy (within 48 h of onset)	3
Monitoring: personnel intensive	
Accurate input and output	3
Multiple arterial blood gas, bleeding, and/or stat studies (≥3/shift)	3
Hourly neurologic signs	2
Hourly vital signs	1
Monitoring: technology intensive	
Pulmonary artery catheter	4
Measurement of cardiac output	4
Intracranial pressure monitoring	4
Pacemaker on standby	3
Arterial catheter	3
Non-PICU care	
Platelet transfusion	4
Central intravenous (IV) hyperalimentation	3
Chest tube	3
Bolus IV medications	3
Hypothermia blanket	3
Acute digitalization (within 48 h)	3
Acute treatment for metabolic acidosis/alkalosis	3
Phlebotomy for volume overload	3
Active anticoagulation	3
Coverage with >2 IV antibiotics	3
Central venous pressure	2
>2 peripheral IV catheters	2
Hemodialysis—stable patient	2
Fresh tracheostomy (<48 h)	2
Spontaneous ventilation via tracheostomy tube	2
Replacement of excess fluid loss	2
Parenteral chemotherapy	2
Tracheostomy care	2
Continuous ECG monitoring	1
1 peripheral IV catheter	1
Chronic anticoagulation	1
Standard intake and output	1
Frequently stat blood tests (>1/shift)	1
Intermittent scheduled IV medications	1
Dressing changes	1
Orthopedic traction	1
Decubitus care	1
Urinary catheter	1
Supplemental oxygen	1
Antibiotics (≤2)	1
Chest physiotherapy	1
GI decompression	1

RESULTS

The numbers of admissions to the PICU in the two study periods were 423 in period 1 and 399 in period 2. There were a total of 3,969 days of PICU care and 100,109 TISS points. Because the demographic data in the two study periods were similar, they were combined into a common data base.

There were 226 patients (27.5%) who did not receive any PICU therapy during their PICU stay, and all of these patients survived. The mean age of these patients was 71.3 ± 4.2 months. PICU resource use by these patients was estimated by their total days of PICU care, percentage of total days of care, total TISS points, and percentage of total TISS points (Fig 1). The monitored patients used 297 days of care (7.5%) and 93.8% of them stayed only one or two days. The distribution of duration of stay is illustrated in Fig 2. The total TISS points used by the monitored patients was 3,575 (3.6%).

The primary diagnoses of all monitored patients are shown in Table 2. The number of patients with any single diagnosis was usually small. Therefore, when the number of patients in a single diagnosis was less than five, the disorders were combined into dysfunctions of an anatomic region. Patients with surgical disorders made up 42.9% of the monitored patients, patients with medical disorders were 35.4%, and patients with accidental injuries were 21.7%. The most common single diagnosis was head trauma (11%), and all traumas made up 18.1% of the total. Of the patients with medical disorders, 41 (51.3%) had disorders of the respiratory system. Patients with thoracic, neurologic, and abdominal

NEWBORNS AND OTHER NEONATES WITH CONDITIONS ORIGINATING IN THE PERINATAL PERIOD

MEDICAL M

DRG 385 — Neonate, Died or Transferred. (Mean LOS 1.8) (R.W.=.6811)

Discharge status — transferred to an acute care facility or expired

Assign a newborn transferred to other than an acute care facility to DRGs 386-391, as appropriate.

DRG 386 — Extreme Immaturity or Respiratory Distress Syndrome, Neonate. (Mean LOS 17.9) (R.W.=3.6480)

Immaturity — extreme (765.0)
Syndrome (distress) — respiratory (769)

DRG 387 — Prematurity with Major Problems. (Mean LOS 13.3) (R.W.=1.8267)

Principal/Secondary diagnosis of preterm infant with any additional diagnosis of:
Abscess — anal and rectal regions (566)
Abscess — intracranial and intraspinal (*324)
Abscess — liver (572.0)
Abscess — lung and mediastinum (*513)
Abscess — parapharyngeal (478.22)
Abscess — renal and perinephric (590.2)
Abscess — retropharyngeal (478.24)
Abscess — subperiosteal of mastoid (383.01)
Abscess — thymus (254.1)
Abscess — urethral (597.0)
Acidosis (late) — metabolic of newborn (775.7)
Allescheriosis — Petriellidosis (117.6)
Anemia (acute) — posthemorrhagic (285.1)
Anemia (acquired hemolytic) — unspecified (283.9)
Anemia of prematurity (776.6)
Anemias — non — autoimmune hemolytic (283.1)
Anencephalus and similar anomalies (*740)
Aneurysm of heart wall (414.10)
Anomalies (other congenital) of nervous system (*742)
Anuria — traumatic (958.5)
Arrest — cardiac (427.5)
Arthropathy — meningococcal (036.82)

*See ICD-9-CM coding book for specific code

DRG 387 — *continued*
Aspergillosis (117.3)
Asphyxia — severe birth (768.5)
Asthma — intrinsic (*493.1)
Asthma — unspecified (*493.9)
Asthma — extrinsic (*493.0)
Atelectasis — primary (770.4)
Atony of bladder (596.4)
Bacteremia — unspecified (790.7)
Blastomycosis (116.0)
Block (bilateral, other) — bundle branch (426.53)
Block (complete) — atrioventricular (426.0)
Block — trifascicular (426.54)
Blood loss — fetal (772.0)
Bronchopneumonia (485)
Candidiasis — disseminated (112.5)
Candidiasis of lung (112.4)
Cardiomyopathy in other diseases classified elsewhere (425.8)
Carditis — meningococcal (*036.4)
Cellulitis and abscess — other (*682)
Cerebral depression, coma, and other abnormal cerebral signs (779.2)
Chickenpox (*052)
Cholangitis (576.1)
Chorioretinitis due to toxoplasmosis (130.2)
Chyluria (791.1)
Coccidioidomycosis — other forms of progressive (114.3)
Collapse — pulmonary (518.0)
Coma and stupor (780.0)
Coma — hepatic (572.2)
Coma — hypoglycemic (251.0)
Complication of air embolism — not elsewhere classified (999.1)
Complications affecting other specified body systems — not elsewhere classified (997.9)
Complications — cardiac (997.1)
Complications — central nervous system (997.0)
Complications — gastrointestinal (997.4)
Complications of nervous system from surgically implanted device (349.1)
Complications (other) — infection (999.3)
Complications (other) of procedures — not elsewhere classified (*998)
Complications (other) — vascular (999.2)
Complications — peripheral vascular (997.2)
Complications — respiratory (997.3)
Complications — urinary (997.5)
Conjunctivitis due to toxoplasmosis (130.1)
Convulsions of newborn (779.0)
Cryptococcosis (117.5)
Cyst and pseudocyst of pancreas (577.2)
Cystic fibrosis with meconium ileus (277.01)
Cystitis — acute (595.0)
Cystitis cystica (595.81)
Cystitis in diseases classified elsewhere (595.4)

*See ICD-9-CM coding book for specific code

DRG 387 — *continued*

Cystitis (other specified) — types (595.89)
Cystitis — unspecified (595.9)
Damage — anoxic brain (348.1)
Defect (ventricular) — septal (745.4)
Dermatitis due to drugs and medicine (693.0)
Diabetes insipidus (253.5)
Diabetes mellitus — neonatal (775.1)
Dilatation (acute) of stomach (536.1)
Disease (acute) — pulmonary heart (*415)
Disease (acute, ill-defined) — cerebrovascular (436)
Disease (chronic) — respiratory arising in the perinatal period (770.7)
Disease — hemolytic of fetus or newborn, due to isoimmunization (*773)
Disease — hemorrhagic of newborn (776.0)
Disease — hyperkinetic heart (429.82)
Disorder — other specified conduction (426.89)
Disorders of fluid, electrolyte, and acid — base balance (*276)
Disorders (other) of coagulation — transient neonatal (776.3)
Disorders (other) of papillary muscle (429.81)
Disseminated intravascular coagulation in newborn (776.2)
Disturbances (functional) following cardiac surgery (429.4)
Disturbances (other) — transitory neonatal electrolyte (775.5)
Eczema herpeticum (054.0)
Edema of lung (acute) — unspecified (518.4)
Effect (unspecified) — adverse of drug, medicinal and biological substances (995.2)
Effusion (unspecified) — pleural (511.9)
Embolism — air (958.0)
Embolism — fat (958.1)
Embolism and thrombosis — arterial (*444)
Embolism and thrombosis — vena cava (453.2)
Emphysema — interstitial (518.1)
Emphysema — interstitial and related conditions (770.2)
Emphysema — traumatic subcutaneous (958.7)
Empyema (*510)
Encephalitis — postmeasles (055.0)
Encephalopathy — toxic (349.82)
Endocarditis — acute and subacute (*421)
Endocarditis — candidal (112.81)
Endocarditis — valve unspecified (*424.9)
Enterocolitis (necrotizing) in fetus or newborn (777.5)
Erythema — toxic (695.0)
Excitation — anomalous atrioventricular (426.7)
Failure (acute) — renal (*584)
Failure (congestive) — heart (428.0)
Failure — left heart (428.1)
Failure — respiratory (799.1)
Fetus or newborn affected by Cesarean delivery (763.4)
Fibrillation and flutter — atrial (*427.3)
Fibrillation and flutter — ventricular (*427.4)
Fistula (female) — digestive genital tract (619.1)

*See ICD-9-CM coding book for specific code

DRG 387 — *continued*

Fistula — intestinovesical (596.1)
Fistula — postauricular (383.81)
Fistula — vesical, not elsewhere classified (596.2)
Fistulas (other specified) involving female genital tract (619.8)
Fracture of femur (closed) — shaft or unspecified part (*821.0)
Fracture of femur (open) — shaft or unspecified part (*821.1)
Fracture of neck of femur (*820)
Fracture — pathological (733.1)
Gangrene (785.4)
Gangrene — gas (040.0)
Gastroenteritis and colitis — toxic (558.2)
Gingivostomatitis — herpetic (054.2)
Glomerulonephritis — acute (*580)
Hematoma of broad ligament (620.7)
Hematuria (599.7)
Hemoglobinuria due to hemolysis from external causes (283.2)
Hemopericardium (423.0)
Hemoperitoneum (nontraumatic) (568.81)
Hemorrhage — adrenal (772.5)
Hemorrhage (fetal and neonatal) — subarachnoid (772.2)
Hemorrhage (fetal and neonatal) — gastrointestinal (772.4)
Hemorrhage — gastrointestinal (*578)
Hemorrhage into bladder wall (596.7)
Hemorrhage — intracerebral (431)
Hemorrhage — intraventricular (772.1)
Hemorrhage of rectum and anus (569.3)
Hemorrhage (other and unspecified) — intracranial (*432)
Hemorrhage — pulmonary (770.3)
Hemorrhage — (secondary and recurrent) — early complications of trauma (958.2)
Hemorrhage — subarachnoid (430)
Hemorrhage — subdural and cerebral (767.0)
Hemorrhage — unspecified (459.0)
Hepatitis B (viral) with hepatic coma (070.2)
Hepatitis B (viral) without mention of hepatic coma (070.3)
Hepatitis due to toxoplasmosis (130.5)
Hepatitis — unspecified (573.3)
Hepatitis (viral) with hepatic coma — other specified (070.4)
Hepatitis (viral) without mention of hepatic coma — other specified (070.5)
Hepatitis (viral) with hepatic coma — unspecified (070.6)
Hepatitis (viral) without hepatic coma — unspecified (070.9)
Hernia (diaphragmatic) with gangrene (551.3)
Hernia (diaphragmatic) with obstruction (552.3)
Hernia (femoral, bilateral) with obstruction — not specified as recurrent (552.02)
Hernia (femoral, bilateral) with gangrene — not specified as recurrent (551.02)
Hernia (femoral, unilateral or unspecified) with obstruction — not specified as recurrent (552.00)

*See ICD-9-CM coding book for specific code

DRG 387 — *continued*

Hernia (femoral, unilateral) with gangrene — unspecified or not specified as recurrent (551.00)
Hernia (incisional) with gangrene (551.21)
Hernia (inguinal, bilateral) with gangrene — not specified as recurrent (550.02)
Hernia (inguinal, bilateral) with obstruction, without mention of gangrene — not specified as recurrent (550.12)
Hernia (inguinal, unilateral or unspecified) with gangrene — not specified as recurrent (550.00)
Hernia (inguinal, unilateral or unspecified) with obstruction, without mention of gangrene — not specified as recurrent (550.10)
Hernia (other ventral) with gangrene (551.29)
Hernia of other specified sites, with gangrene (551.8)
Hernia of other specified sites, with obstruction (552.8)
Hernia of unspecified site, with gangrene (551.9)
Hernia of unspecified site, with obstruction (552.9)
Hernia (umbilical) with gangrene (551.1)
Hernia (umbilical) with obstruction (552.1)
Hernia (ventral, unspecified) with gangrene (551.20)
Hernia (ventral) with obstruction (*552.2)
Herpes simplex with ophthalmic complications (*054.4)
Herpes simplex with other specified complications (*054.7)
Herpes simplex with unspecified complications (054.8)
Herpes zoster (*053)
Histoplasmosis — meningitis, retinitis, pericarditis, endocarditis, pneumonia (*115)
Hydronephrosis (591)
Hydrops fetalis — not due to isoimmunization (778.0)
Hydroureter (593.5)
Hypocalcemia and hypomagnesemia of newborn (775.4)
Hypoglycemia — neonatal (775.6)
Hypoparathyroidism (252.1)
Ileus — paralytic (560.1)
Impaction (other) of intestine (560.39)
Impaction (unspecified) of intestine (560.30)
Infarction — hepatic (573.4)
Infarction (unspecified) — myocardial (410.9)
Infection — congenital cytomegalovirus (771.1)
Infection of kidney — unspecified (590.9)
Infection — other congenital (771.2)
Infection (other) specific to the perinatal period (771.8)
Infection — post — traumatic wound — not elsewhere classified (958.3)
Infection (urinary tract) — site not specified (599.0)
Injuries — other cranial and peripheral nerve (767.7)
Injury to abdominal aorta (902.0)
Injury to brachial plexus (953.4)
Injury to carotid artery (*900.0)
Injury to external jugular vein (900.81)
Injury to inferior vena cava — unspecified (902.10)
Injury to innominate and subclavian arteries (901.1)
Injury to innominate and subclavian veins (901.3)
Injury to internal jugular vein (900.1)
Injury to pulmonary artery (901.41)

*See ICD-9-CM coding book for specific code

DRG 387 — *continued*

Injury to pulmonary vein (901.42)
Injury to spine and spinal cord (767.4)
Injury to spleen (*865)
Injury to superior vena cava (901.2)
Injury to thoracic aorta (901.0)
Insufficiency (acute) — vascular of intestine (557.0)
Insufficiency (pulmonary) following trauma and surgery (518.5)
Intussusception (560.0)
Irritability (other and unspecified) — cerebral in newborn (779.1)
Jaundice — neonatal associated with preterm delivery (774.2)
Jaundice — neonatal due to delayed conjugation from other cause (*774.3)
Jaundice — perinatal due to hepatocellular damage (774.4)
Jaundice — perinatal from hereditary hemolytic anemias (774.0)
Jaundice — perinatal from other causes (774.5)
Jaundice — perinatal from other excessive hemolysis (774.1)
Kernicterus not due to isoimmunization (774.7)
"Light — for — dates" without mention of fetal malnutrition (764.0)
Lymphadenitis — acute (683)
Lymphangitis (457.2)
Malnutrition of mild degree (263.1)
Malnutrition of moderate degree (263.0)
Malnutrition (other severe) — protein calorie (262)
Malnutrition (other) — protein calorie (263.8)
Malnutrition (unspecified) — protein calorie (263.9)
Manifestations (acute pulmonary) due to radiation (508.0)
Marasmus — nutritional (261)
Mastitis — neonatal infective (771.5)
Measles with other specified complications (*055.7)
Measles with unspecified complications (055.8)
Mediastinitis (519.2)
Meningitis — bacterial (*320)
Meningitis — candidal (112.83)
Meningitis — coccidioidal (114.2)
Meningitis — due to other organisms (*321)
Meningitis — eosinophilic (322.1)
Meningitis — nonpyogenic (322.0)
Meningitis — unspecified (322.9)
Meningoencephalitis due to toxoplasmosis (130.0)
Meningoencephalitis — herpetic (054.3)
Mumps — encephalitis (072.2)
Mumps — meningitis (072.1)
Mumps — orchitis (072.0)
Mumps — pancreatitis (072.3)
Mumps with other specified complications (*072.7)
Mumps with unspecified complications (072.8)
Myasthenia gravis — neonatal (775.2)
Mycetomas — mycotic (117.4)
Mycoses — opportunistic (118)

*See ICD-9-CM coding book for specific code

DRG 387 — *continued*

Myocarditis (acute) in diseases classified elsewhere (422.0)
Myocarditis due to toxoplasmosis (130.3)
Myocarditis — septic (422.92)
Necrosis (acute and subacute) of liver (570)
Neuritis — meningococcal optic (036.81)
Nonabsorption (other and unspecified) — postsurgical (579.3)
Obstruction — bladder neck (596.0)
Obstruction (intestinal) due to inspissated milk (777.2)
Obstruction — meconium (777.1)
Obstruction (other specified) — intestinal (560.89)
Obstruction (unspecified) — intestinal (560.9)
Obstruction (unspecified) — urinary (599.6)
Occlusion of cerebral arteries (*434)
Omphalitis of the newborn (771.4)
Otitis media — candidal (112.82)
Otitis media — postmeasles (055.2)
Pancreatitis — acute (577.0)
Panencephalitis (subacute) — sclerosing (046.2)
Papilledema associated with decreased ocular pressure (377.02)
Papilledema associated with increased intracranial pressure (377.01)
Papilledema — unspecified (377.00)
Paracoccidioidomycosis (116.1)
Paralysis of vocal cords or larynx (*478.3)
Perforation of esophagus (530.4)
Perforation of intestine (569.83)
Perforation — perinatal intestinal (777.6)
Pericarditis (acute) in diseases classified elsewhere (420.0)
Peritonitis (*567)
Phlebitis and thrombophlebitis — iliac vein (451.81)
Phlebitis and thrombophlebitis of deep vessels of lower extremities (*451.1)
Phlebitis and thrombophlebitis of lower extremities — unspecified (451.2)
Pleurisy — other specified forms of effusion, except tuberculosis (511.8)
Pleurisy with effusion with mention of a bacterial cause other than tuberculosis (511.1)
Pneumocytosis (136.3)
Pneumonia — congenital (770.0)
Pneumonia due to other specified organisms (483)
Pneumonia — organism unspecified (486)
Pneumonia (other) — bacterial (*482)
Pneumonia — pneumococcal (481)
Pneumonia — postmeasles (055.1)
Pneumonitis due to inhalation of food or vomitus (507.0)
Pneumonitis due to other solids and liquids (507.8)
Pneumonitis due to toxoplasmosis (130.4)
Pneumothorax and hemothorax — traumatic (*860)
Problems (other respiratory) after birth (770.8)
Pyelonephritis — acute (*590.1)
Pyelonephritis or pyelonephrosis — not specified as acute or chronic (*590.8)

**See ICD-9-CM coding book for specific code*

DRG 387 — *continued*

Pyeloureteritis cystica (590.3)
Pyemia — portal (572.1)
Reaction — ABO incompatibility (999.6)
Reaction (other) serum (999.5)
Reaction — RH incompatibility (999.7)
Reaction to spinal or lumbar puncture (349.0)
Reaction (other) — transfusion (999.8)
Reactions and intoxications (drugs) — specific to newborn (779.4)
Retention of urine (788.2)
Rhinorrhea — cerebrospinal fluid (349.81)
Rubella — congenital (771.0)
Rubella with neurological complications (*056.0)
Rubella with other specified complications (*056.7)
Rubella with unspecified complications (056.8)
Rupture of bladder — nontraumatic (596.6)
Septicemia (*038)
Septicemia — herpetic (054.5)
Shock (anaphylactic) due to serum (999.4)
Shock due to anesthesia (995.4)
Shock — traumatic (958.4)
Shock — unspecified (785.50)
Spina bifida with hydrocephalus (*741.0)
Spina bifida without mention of hydrocephalus (*741.9)
Spasm — laryngeal (478.75)
Syndrome — defibrination (286.6)
Syndrome — drug withdrawal (292.0)
Syndrome — drug withdrawal in newborn (779.5)
Syndrome — hepatorenal (572.4)
Syndrome — massive aspiration (770.1)
Syndrome — Waterhouse — Friderichsen — meningococcal (036.3)
Tachycardia — paroxysmal ventricular (427.1)
Tachycardia — unspecified (785.0)
Tetanus (037)
Tetany (781.7)
Thalassemias (282.4)
Thrombocytopenia — secondary (287.4)
Thrombocytopenia transient neonatal (776.1)
Thyrotoxicosis — neonatal (775.3)
Toxoplasmosis — multisystemic disseminated (130.8)
Toxoplasmosis of other specified sites (130.7)
Twins — conjoined (759.4)
Urticaria — allergic (708.0)
Volvulus (560.2)
Zygomycosis (phycomycosis or mucormycosis) (117.7)

DRG 388 — Prematurity without Major Problems. (Mean LOS 8.6) (R.W.=1.1571)

Preterm infant without diagnosis listed under DRG 387

DRG 389 — Full Term Neonate with Major Problems. (Mean LOS 4.7) (R.W.=.5425)

Select principal/secondary diagnosis listed under DRG 387

**See ICD-9-CM coding book for specific code*

DRG 390 — Neonates with other Significant Problems. (Mean LOS 3.4) (R.W.=.3486)

All remaining cases not assigned to DRGS 385 — 389

DRG 391 — Normal Newborn. (Mean LOS 3.1) (R.W.=.2218)

Baby — exceptionally large (766.0)
Birth asphyxia — mild or moderate (768.6)
Complications of labor and delivery affecting fetus or newborn — breech delivery or extraction (763.0)
Complications of labor and delivery affecting fetus or newborn — delivery by vacuum extraction (763.3)
Complications of labor and delivery affecting fetus or newborn — delivery — forceps (763.2)
Complications of labor and delivery affecting fetus or newborn — delivery — precipitate (763.6)
Complications of labor and delivery affecting fetus or newborn — unspecified (763.9)
Compressions (other) — umbilical cord (762.5)
Conditions (other specified) involving the integument of fetus and newborn (778.8)
Conditions (other unspecified) of umbilical cord (762.6)
Infants (other) — "heavy for dates" (766.1)
Infants (post-term) not "heavy for dates" (766.2)
Injuries to scalp (767.1)
Jaundice (unspecified) — fetal and neonatal (774.6)
Malpresentation, malposition and disproportion (other) during labor & delivery (763.1)
Multiple (other) — mates all liveborn and born before admission to hospital (V34.1)
Multiple (other) — mates all liveborn and born in hospital (V34.0)
Multiple (other) — mates all stillborn and born before admission to hospital (V35.1)
Multiple (other) — mates all stillborn and born in hospital (V35.0)
Multiple (other) — mates live and stillborn and born before admission to hospital (V36.1)
Multiple (other) — mates live and stillborn and born in hospital (V36.0)
Multiple (other and unspecified) born before admission to hospital (V37.1)
Multiple (other and unspecified) born in hospital (V37.0)
Prolapsed cord (762.4)
Single liveborn — born before admission to hospital (V30.1)
Single liveborn — born in hospital (V30.0)
Twin — mate liveborn and born before admission to hospital (V31.1)
Twin — mate liveborn and born in hospital (V31.0)
Twin — mate stillborn and born before admission to hospital (V32.1)
Twin — mate stillborn and born in hospital (V32.0)
Twin (unspecified) born before admission to hospital (V33.1)
Twin (unspecified) born in hospital (V33.0)
Unspecified — born before admission to hospital (V39.1)
Unspecified — born in hospital (V39.0)

DRG 391 — *continued*

And

No secondary diagnosis

Or

Only secondary diagnoses
Baby — exceptionally large (766.0)
Birth asphyxia — mild or moderate (768.6)
Circumcision — routine or ritual (V50.2)
Complications of labor and delivery affecting fetus or newborn — breech delivery or extraction (763.0)
Complications of labor and delivery affecting fetus or newborn — delivery by vacuum extraction (763.3)
Complications of labor and delivery affecting fetus or newborn — delivery — forceps (763.2)
Complications of labor and delivery affecting fetus or newborn — delivery — precipitate (763.6)
Complications of labor and delivery affecting fetus or newborn — unspecified (763.9)
Compressions (other) — umbilical cord (762.5)
Conditions (other specified) involving the integument of fetus and newborn (778.8)
Conditions (other unspecified) of umbilical cord (762.6)
Infants (other) — "heavy for dates" (766.1)
Infants (post-term) not "heavy for dates" (766.2)
Infection (unspecified local) of skin and subcutaneous tissue (686.9)
Injuries to scalp (767.1)
Jaundice (unspecified) — fetal and neonatal (774.6)
Malpresentation, malposition and disproportion (other) during labor and delivery (763.1)
Multiple (other) — mates all liveborn and born before admission to hospital (V34.1)
Multiple (other) — mates all liveborn and born in hospital (V34.0)
Multiple (other) — mates all stillborn and born before admisison to hospital (V35.1)
Multiple (other) — mates all stillborn and born in hospital (V35.0)
Multiple (other) — mates live and stillborn and born before admission to hospital (V36.1)
Multiple (other) — mates live and stillborn and born in hospital (V36.0)
Multiple (other and unspecified) born before admission to hospital (V37.1)
Multiple (other and unspecified) born in hospital (V37.0)
Phenylketonuria (PKU) (V77.3)
Prepuce and phimosis — redundant (605)
Prolapsed cord (762.4)
Rash — diaper or napkin (691.0)
Single liveborn — born before admission to hospital (V30.1)
Single liveborn — born in hospital (V30.0)
Twin — mate liveborn and born before admission to hospital (V31.1)
Twin — mate liveborn and born in hospital (V31.0)

DRG 391 — *continued*
Twin — mate stillborn and born before admission to hospital (V32.1)
Twin — mate stillborn and born in hospital (V32.0)
Twin (unspecified) born before admission to hospital (V33.1)
Twin (unspecified) born in hospital (V33.0)
Unspecified — born before admission to hospital (V39.1)
Unspecified — born in hospital (V39.0)

DISEASES & DISORDERS OF THE BLOOD AND BLOOD FORMING ORGANS AND IMMUNITY

SURGICAL S

DRG 392 — Splenectomy. Age greater than 17. (Mean LOS 13.7) (R.W.=3.2488)
Biopsy (other) of spleen (41.33)
Excision of accessory spleen (41.93)
Excision or destruction of lesion or tissue of spleen (*41.4)
Operations (other) on spleen (41.99)
Repair and plastic operations on spleen (41.95)
Splenectomy — total (41.5)
Splenotomy (41.2)
Transplantation of spleen (41.94)

DRG 393 — Splenectomy. Age 0 — 17. (Mean LOS 9.1) (R.W.=1.5206)
Select principal/secondary procedure listed under DRG 392

DRG 394 — Other O.R. Procedures of the Blood and Blood — Forming Organs. (Mean LOS 5.0) (R.W.=1.0889)
Biopsy of lymphatic structures (40.11)
Biopsy of peritoneum (54.23)
Biopsy of soft tissue (83.21)
Biopsy of thymus (07.16)
Biopsy (other) of bone (77.49)
Biopsy (other) of kidney (55.24)
Biopsy (other) of liver (50.12)
Biopsy (other) of mediastinal (34.26)
Diagnostic procedures (other) on abdominal region (54.29)
Diagnostic procedures (other) on kidney (55.29)
Diagnostic procedures (other) on liver (50.19)
Diagnostic procedures (other) on lymphatic structures (40.19)
Excision (radical) of cervical lymph nodes (*40.4)
Excision (radical) of other lymph nodes (*40.5)
Excision — regional lymph node (40.3)
Excision (simple) of lymphatic structure (*40.2)
Incision of lymphatic structures (40.0)
Incision (other) of skin and subcutaneous tissue (86.09)
Laparoscopy (54.21)
Laparotomy — exploratory (54.11)
Laparotomy — other (54.19)
Mediastinoscopy (34.22)

See ICD-9-CM coding book for specific code

APPENDIX B

Table A

Comparison of Ventilation Splits in NCG 387 and 388

	LOS		Hospital Charges	
	Mean	SD	Mean	SD
yes-no vent split				
NCG 387L	48.2	36.0	$75,829	$97,104
NCG 388L	32.1	12.6	31,598	14,930
24 hour vent split				
NCG 387L	61.7	38.7	$107,460	$114,376
NCG 388L	29.8	14.5	29,201	14,326
48 hour vent split				
NCG 387L	66.1	37.8	$116,048	$116,763
NCG 388L	29.1	14.3	28,752	13,994
yes/no vent split				
NCG 387H	24.2	14.5	$32,943	$23,051
NCG 388H	12.8	8.0	12,202	6,906
24 hour vent split				
NCG 387H	27.3	16.1	$39,177	$24,717
NCG 388H	13.3	7.7	12,881	6,881
48 hour vent split				
NCG 387H	31.5	17.4	$47,465	$26,638
NCG 388H	14.0	8.2	14,046	8,196

Table B

Comparison of Ventilation Splits in NCG 389 & 390

	LOS		Hospital Charges	
	Mean	SD	Mean	SD
yes/no vent split				
NCG 389	15.7	6.4	$29,518	
$14,793				
NCG 390	4.7	3.6	5,355	
4,576				
24 hour vent split				
NCG 389	16.8	6.3	$32,055	
$14,185				
NCG 390	5.3	4.2	6,433	
6,765				
48 hour vent split				
NCG 389	16.2	5.0	$34,470	
$14,604				
NCG 390	6.2	5.8	7,746	
8,507				

APPENDIX C

Table C

CDRG Patient Attributes

	Range	Mean	SD
CDRG 385.1: N=3			
ventilation days	1	.7	.8
birth weight	1500	953	804
gestational age	10	26	5.3
CDRG 385.2: N=6			
LOS	24*	10.2	11.2
ventilation days	1	.8	1.0
birth weight	3300	3097	1190
gestational age	14	36.2	5.5
CDRG 385.3: N=32			
LOS	60*	4.4	10.5
ventilation days	1	.03	.2
birth weight	3545	3007	828
gestational age	11	37.4	2.7

*LOS includes four infants who returned to this NICU after transfer for continuing care

Table D

Very Low Birth Weight CDRG Patient Attributes

	Range	Mean	SD
CDRG 386.1 (vent >21) N=6			
ventilation days	22	48	8.4
birth weight	140	686.7	52.8
gestational age	2	25.2	1.0
LOS	42	92	14
CDRG 386.2 (vent <22) N=1			
ventilation days		13	
birth weight		740	
gestational age		25	
LOS		99	
CDRG 386.3 (expired) N=6			
ventilation days	88	48	8.4
birth weight	250	687	53
gestational age	9	25.2	1.0
LOS	191	61	84

(table continues)

Table D

Very Low Birth Weight CDRG Patient Attributes

(Continued)

	Range	Mean	SD
CDRG 386.4 (vent >21) N=9			
ventilation days	20	33.5	7.4
birth weight	180	851	70.8
gestational age	7	27	2.5
LOS	71	75.3	27
CDRG 386.5 (vent <3,<22) N=1			
ventilation days		21	
birth weight		930	
gestational age		28	
LOS		70	
CDRG 386.6 (vent <4) N=2			
ventilation days	0	0	0
birth weight	20	930	14.2
gestational age	3	31	2.1
LOS	14	37	10
CDRG 386.7 (expired) N=5)			
ventilation days	12	7.8	5.8
birth weight	200	846	75.4
gestational age	14	29.6	5.9
LOS	12	7.8	5.8

Table E

CDRG Patient Attributes

	Range	Mean	SD
CDRG 387.1 (OR surg/vent >21): N=1			
ventilation days		114	
birth weight		1010	
gestational age		28	
LOS		158	
CDRG 387.2 (vent >21): N=2			
ventilation days	28	41	19.8
birth weight	230	1215	163
gestational age	1	27.5	.8
LOS	37	82.5	26.2
CDRG 387.3 (vent >3,<22): N=6			
ventilation days	14	9.3	5.6
birth weight	330	1293	131
gestational age	4	30	1.7
LOS	27	51	11.7
CDRG 387.4 (vent <4): N=18			
ventilation days	3	.7	.8
birth weight	400	1283	133
gestational age	7	30.6	2.1
LOS	49	29.3	14

(table continues)

Table E

CDRG Patient Attributes (Continued)

	Range	Mean	SD
CDRG 387.5 (expired): N=7			
ventilation days	189	54.4	78.7
birth weight	390	1297	156
gestational age	8	28	2.7
LOS	189	56.9	77.9
CDRG 388.3(M) (vent >3): N=8			
ventilation days	8	7	2.3
birth weight	260	1798	110.4
gestational age	2	32	.9
LOS	54	37.3	20.1
CDRG 388.4(M) (vent <4): N=41			
ventilation days	3	.6	.9
birth weight	490	1768	154.6
gestational age	8	33	1.7
LOS	37	18.3	8.1

Table F

CDRG Patient Attributes

	Range	Mean	SD
CDRG 389.1 (surg/vent >3): N=1			
ventilation days		21	
birth weight		2310	
gestational age		33	
LOS		135	
CDRG 389.2 (surg/vent <4): N=4(expired=1)			
ventilation days	0	0	0
birth weight	220	2155	98.5
gestational age	4	36	1.6
LOS	48	26.8	22
CDRG 389.3 (vent >3): N=5(expired=1)			
ventilation days	3	5.4	1.0
birth weight	450	2218	197
gestational age	2	34	.7
LOS	37	21.4	13.9
CDRG 389.4 (vent <4): N=36			
ventilation days	2	.2	.5
birth weight	495	2216	156
gestational age	10	34.4	2
LOS	25	11.5	5.4

Table G

CDRG Patient Attributes

	Range	Mean	SD
CDRG 390.1 (surg/vent >3)	N=4(expired=2)		
ventilation days	52	20	24.2
birth weight	850	3170	341
gestational age	2	39	1.0
LOS	55	40	31.2
CDRG 390.2 (surg/vent <4)	N=4		
ventilation days	0	0	0
birth weight	1690	3281	778
gestational age	4	37.8	1.7
LOS	11	15	4.8
CDRG 390.3 (vent>3)	N=11(expired=1)		
ventilation days	10	7.5	3.8
birth weight	1360	2929	443
gestational age	7	36.8	2
LOS	17	16	5.5
CDRG 390.4 (vent<4)	N=32(expired=2)		
ventilation days	3	.6	1
birth weight	1840	3123	472
gestational age	10	38	3
LOS	19	8.3	5

APPENDIX D

Table J

Neonatal CDRGs (modified)

CDRG 385.1: newborn, died within one day of birth.

CDRG 385.2: newborn, transferred to another hospital within four days of birth, not born in transferring hsopital

CDRG 385.3 newborn, tranferred to another hospital within four days of birth, born in transferring hospital.

CDRG 386.1: neonate, BW under 750 grams, discharged alive, mechanical ventilation over 21 days.

CDRG 386.2: neonate, BW under 750 grams, discharged alive, no mechanical ventilation or under 22 days.

CDRG 386.3: neonate, BW under 750 grams, died.

CDRG 386.4: neonate, BW 750-999 grams, discharged alive, ventilation over 21 days.

CDRG 386.5: neonate, BW 750-999 grams, discharged alive, ventilation over 3 days but less than 22 days.

CDRG 386.6: neonate, BW 750-999 grams, discharged alive, no ventilation or ventilation under 4 days.

CDRG 386.7: neonate, BW 750-999 grams, died.

(table continues)

Table J

Neonatal CDRGs (modified) (continued)

CDRG 387.1: neonate, BW 1000-1499 grams, discharged alive, with an OR procedure, with mechanical ventilation over 21 days.

CDRG 387.1A: neonate, BW 1000-1499 grams, discharged alive, with an OR procedure, with ventilation over 3 days but less than 22 days.

CDRG 387.1B: neonate, BW 1000-1499 grams, discharged alive, with an OR procedure, with ventilation under 4 days.

CDRG 387.2: neonate, BW 1000-1499 grams, discharged alive, without an OR procedure, with mechanical ventilation over 21 days.

CDRG 387.3: neonate BW 1000-1499 grams, discharged alive, without an OR procedure, with mechanical ventilation over 3 days but less than 22 days.

CDRG 387.4: neonate, BW 1000-1499 grams, discharged alive, without an OR procedure, with no mechanical ventilation or ventilation under 4 days.

(table continues)

Table J

Neonatal CDRGs (modified) (continued)

CDRG 388.1: neonate, BW 1500-1999 grams, with OR procedure, with ventilation over 3 days.

CDRG 388.2: neonate, BW 1500-199 grams, with OR procedure, with no ventilation or ventilation under 4 days.

CDRG 388.3M: neonate, BW 1500-1999 grams, without OR procedure, with ventilation over 3 days.

CDRG 388.4M: neonate, BW 1500-1999 grams, without OR procedure, with no ventilation or ventilation under 4 days.

CDRG 389.1: neonate, BW 2000-2499 grams, with OR procedure, with mechanical ventilation over 3 days.

CDRG 389.2: neonate, BW 2000-2499 grams, with OR procedure, with no ventilation or ventilation under 4 days.

CDRG 389.3M: neonate, BW 2000-2499 grams, without OR procedure, with ventilation over 3 days.

CDRG 389.4M: neonate, BW 2000-2499 grams, without OR procedure, with no ventilation or ventilation under 4 days.

(table continues)

Table J

Neonatal CDRGs (modifed) (continued)

CDRG 390.1: neonate, birth weight at least 2500 grams, with OR procedure, with mechanical ventilation over 3 days.

CDRG 390.2: neonate, birth weight at least 2500 grams, with OR procedure, with no mechanical ventilation or ventilation under 4 days.

CDRG 390.3M: neonate, birth weight at least 2500 grams, without an OR procedure, with mechanical ventilation over 3 days.

CDRG 390.4M: neonate, birth weight at least 2500 grams, without an OR procedure, with no mechanical ventilation or ventilation under 4 days.