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I am submitting herewith a dissertation written by Linda Carol Mefford entitled "The Relationship of Nursing Care to Health Outcomes of Preterm Infants: Testing a Theory of Health Promotion for Preterm Infants Based on Levine's Conservation Model of Nursing." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment for the degree of Doctor of Philosophy, with a major in Nursing.

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We have read this dissertation
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Accepted for the Council:

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Dean of The Graduate School

The Relationship of Nursing Care to Health Outcomes of Preterm Infants: Testing a Theory of Health Promotion for Preterm Infants Based on Levine's Conservation Model of Nursing

A Dissertation
Presented for the
Doctor of Philosophy
Degree
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Linda Carol Mefford
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DEDICATION

This dissertation is dedicated to my parents

Alex and Oneida Mefford

and to my brother

Mike Mefford.

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ABSTRACT

Infants born prematurely are suddenly and often traumatically thrust from a secure home in the womb into a foreign world for which they are not yet adapted to survive. The role of the neonatal intensive care nurse is to provide nursing care which both protects the infant from this foreign extrauterine environment and which also supports the adaptive efforts of both the infant and the family during this period of crisis. The purpose of this descriptive study was to examine the relationship of nursing care to the health outcomes of preterm infants by testing a Theory of Health Promotion for Preterm Infants derived from Levine's Conservation Model of Nursing. An ex post facto study design was used, with retrospective collection of data from the archival records of a Level 3 Neonatal Intensive Care Unit. The statistical methodology was structural equation modeling, using the LISREL® 8.3 statistical package.

The primary research question for this study was:

How do the intensity of nursing care and the consistency of nursing caregivers relate to the health outcomes of preterm infants at the time of initial hospital discharge?

Two subsidiary research questions were also addressed:

1. How do the intensity of nursing care and the consistency of nursing caregivers relate to the severity of illness of preterm infants at the time of initial hospital discharge?
2. How do the intensity of nursing care and the consistency of nursing caregivers relate to the utilization of health care resources by preterm infants during the initial hospital stay?

Three different path diagrams were drawn to test each of the above stated questions.

The path diagram models as originally proposed were not supported by the sample data, however the models were then respecified based on the results of the unsuccessful structural equation modeling test and on the theory. The respecified model of the primary research question testing the Theory of Health Promotion for Preterm Infants provided a reasonably good fit of the model to the data, with a Satorra-Bentler Scaled Chi-Square value of 5.77 with 32 degrees of freedom (p-value = 1.0000), Goodness of Fit Index (GFI) of 0.905, Adjusted Goodnes of Fit Index (AGFI) of 0.836, and Comparative Goodness of Fit Index (CFI) of 0.928. The dimension of nursing care that was tested most extensively in the respecified models was the consistency of nursing caregivers during the initial hospital stay in the Neonatal Intensive Care Unit and the Intermediate Care Nursery. A statistically significant inverse relationship was demonstrated between the consistency of nursing caregivers and the age at which health was attained by preterm infants (that is, an increased level of consistency of nursing caregivers resulted in a decrease in the age at which health was attained). This model was a complete mediation model, with the effects of integrity at birth on the age at which health was attained by preterm infants completely mediated by the consistency of nursing caregivers.

The structural equation modeling test of the subsidiary question # 2 could not be completed due to the presence of an extremely strong correlation between the latent variables representing the consistency of nursing caregivers and the morbidity of the infant at the time of discharge (which was incompatible with use of the structural equation modeling methodology). The test of subsidiary research question # 2 demonstrated only a fair fit of the model to the sample data, with a Satorra-Bentler Scaled Chi-Square value of

14.15 with 41 degrees of freedom (p-value = 0.99997), Goodness of Fit Index 0.811, Adjusted Goodness of Fit Index (AGFI) 0.696, and Comparative Fit Index (0.837). A statistically significant inverse relationship was demonstrated between the consistency of nursing caregivers and the level of resource utilization by preterm infants during the initial hospital stay (that is, an increase in the consistency of nursing caregivers resulted in a decrease in resource utilization). This model was a partial mediation model, with the effects of integrity at birth on the level of resource utilization partially mediated by the consistency of nursing caregivers. The results of this study provide support for the validity of the Theory of Health Promotion for Preterm Infants based on Levine's Conservation Model of Nursing and indicate that the theory holds promise as a theoretical framework to guide neonatal nursing practice.

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LIST OF ABBREVIAIONS

AGFI Adjusted Goodness of Fit Index.

BPD Bronchopulmonary Dysplasia.

CFI Comparative Fit Index.

CNS Central Nervous System.

CPAP Continuous Positive Airway Pressure.

CRIB Clinical Risk Index for Babies.

ELBW Extremely Low Birth Weight (less than 1000 grams at birth).

FiO_2 Fraction of Inspired Oxygen.

GFI Goodness of Fit Index.

IVH Intraventricular Hemorrhage.

IMCN Intermediate Care Nursery.

LISREL® Trade name of Scientific Software International, Inc. for a specific statistical program for structural equation modeling.

L.P.N. Licensed Practical Nurse.

NICU Neonatal Intensive Care Unit.

NIDCAP Neonatal Individualized Developmental Care and Assessment Program

PCA Post-Conceptional Age.

PIVH Periventricular/Intraventricular Hemorrhage.

PO By mouth.

PRELIS™ Trade name of Scientific Software International, Inc. for a specific statistical program for pre-processing matrices for analysis by the LISREL® program.

PVL	Periventricular Leukomalacia.
R.N.	Registered Nurse.
ROP	Retinopathy of Prematurity.
SMC	Squared Multiple Correlations
VLBW	Very low birth weight (1500 - 2000 grams at birth).

CHAPTER I

INTRODUCTION

Infants born prematurely are suddenly and often traumatically thrust from a secure home in the womb into a foreign world for which they are not yet adapted to survive. Despite the rapid technological advances of the past few decades, 11% of the annual live births in the United States continue to be preterm births, occurring prior to the completion of 37 weeks of gestation (Mercer, 1997). In order to merely survive in the extrauterine environment, preterm infants must quickly complete a myriad of physiological adaptations involving all of the major body systems. Yet "survival" is only the beginning. To thrive in childhood and adult life, the infant must also successfully complete many complex adaptations involving the most intricate body system of all — the central nervous system (CNS). Furthermore, these adaptations must be completed in the harsh, "high-tech" environment of the Neonatal Intensive Care Unit (NICU). The mission of the neonatal intensive care nurse is to provide nursing care which both protects the infant from this harsh, but necessary, NICU environment and also supports the adaptive efforts of both the infant and the family during this period of crisis.

The manipulation of the patient's environment to facilitate healing has been an intrinsic part of nursing dating back to the inception of the discipline by Florence Nightingale in the mid-1800s (Reed & Zurakowski, 1989). Although neonatal intensive care units generally utilize a multidisciplinary caregiving model, nurses are the only persons who are present with the infants continuously, 24 hours a day, during the critical adaptation to extrauterine life. This adaptation is not limited to just the first few hours after birth; it may in fact take many weeks or months for extremely preterm infants to attain levels of physiologic and neurologic maturity comparable to those of a term newborn. In order to enhance the infant's adaptive efforts, neonatal nurses should be continuously assessing the infant's reactions to the environment and modifying the environment to better facilitate the process of adaptation. Unfortunately, however, the fast paced, "high tech" atmosphere of the modern NICU often leads to nursing being practiced in a "task-oriented" manner rather than in a holistic manner. This task-orientation can result in the environment being manipulated to meet the needs of the nurses and other caregivers, rather than to meet the needs of the infants and families.

Primary nursing has often been proposed as the optimal model for nursing care delivery in the NICU (Bethea, 1985; Scharer & Brooks, 1994; Smith, 1987). Primary nursing in the NICU has been associated with enhancing the level of trust between parents and nurses, decreasing parental stress, improving the individualization of the nursing plan of care, improving the timeliness and completeness of discharge planning, and, perhaps most importantly, with improving patient-nurse communication (Bethea, 1985; Scharer & Brooks, 1994; Smith, 1987). In a 1996 survey of 199 NICUs throughout the United States, Terres and Dowd found that 133 of those NICUs (67%) reported the use of primary nursing as their care delivery model. Primary nursing has been described by Marram, Barrett and Bevis (1979) as a model for organizing nursing services "that will foster the delivery of individualized patient care for the maximum benefit of patients and their families and encourage better utilization and development of the professional nurse" (p. vii). In the primary nursing model, a specific professional registered nurse is designated the responsibility and accountability for managing the total nursing care needs of an individual patient throughout the duration of the patient's hospitalization. The primary nurse provides as much of the direct nursing care for her/his primary patients as possible, leading to an in-depth knowledge of the patient. (Marram, Barrett & Bevis, 1979; Zander, 1980). Studies have demonstrated that the implementation of a primary nursing model resulted in improvements both in patient satisfaction and in the job satisfaction of nurses (Blenkarn, D'Amico & Virtue, 1988; Marram, Barrett & Bevis, 1979).

In recent years, the primary nursing model has been abandoned in many acute care settings due to concerns about the cost-effectiveness of the model. Primary nursing requires a higher percentage of professional registered nurse (RN) staff than are required in alternate nursing care delivery models such as functional nursing or team nursing (Mundinger, 1977) and as hospitals try to cut costs, they often return to staffing structures which require fewer RN staff (since RN salaries are considerably higher than the salaries of licenced practical nurses or unlicenced assistive personnel). Karen Zander, one of the early champions of the primary nursing model, has now developed a model of care delivery called "nursing case management," which she describes as "second generation primary nursing" (Zander, 1985, p. 18). Nursing case management has been described as "an approach that focuses on the coordination, integration, and direct delivery of patient services, and places internal controls on the resources used for care" (Cohen & Cesta, 1993, p. 6). The goal of nursing case management models is to balance the need for quality care and positive patient outcomes with the competing need for cost effectiveness (Cohen & Cesta, 1993).

Although the concept of nursing case management is beginning to be introduced into the NICU setting (Arday, Dickson, Pitzen, Thacker, Thompson & Whitiker, 1995; Deming, 1996; Elizondo, 1994; Elizondo, 1995; Forsyth, Maney, Ramirez, Raviotta, Burts & Litzenberger, 1998; Fowler, Rodine & Spivey, 1996; Kimberlin & Bregman, 1996; Thompson & Maringer, 1995; Vecchi, Vasquez, Radin & Johnson, 1996; Malnight & Wahl, 1997), many NICUs continue the attempt to maintain at least a modified form of primary nursing due to the documented benefits of primary nursing for NICU infants and their families. This modified primary nursing structure may be used independently or may be embedded in a nursing case management care delivery system.

Since the baby cannot communicate his/her needs verbally, the ability of the nurse to identify and interpret the nonverbal, behavioral signals of the infant and to act as the infant's advocate to the health care team is imperative. The more direct contact that the nurse has with the infant, the better attuned the nurse should be to the baby's specific behavioral cues. In a 1993 study, Pickler used grounded theory methodology to develop a model describing the interactions observed between premature infants and their nurse caregivers. Her findings indicated that specific nurse characteristics and the degree to which the nurse was attached to the infant both served as mediating factors to influence which infant behaviors were noted and interpreted as having meaning . Nurse characteristics included the personal perspective of the nurse regarding how interactions with premature infants should be structured, the "baby-specific knowledge" (p. 557) of the nurse, and the nurse's reported level of fatigue. Nurses who stated that they were attached to a particular infant were more likely to interpret certain infant-initiated behaviors as having meaning.

Even with the use of the primary nursing model, many NICUs encounter difficulty in maintaining consistent nurse caregiver/patient relationships. In their survey of staffing practices in 199 NICUs in the United States, Terres and Dowd identified a variety of factors which contribute to the problem of maintaining consistency of caregivers. Of the 133 NICUs reporting the use of the primary nursing model, 123 (or 92%) also report the use of twelve hour shift staffing patterns (Terres & Dowd, 1996). The use of twelve hour shifts itself presents inherent problems with maintaining consistency of caregivers. In the twelve hour shift staffing model, individual staff members are scheduled for fewer days of work, thus decreasing the continuity of caregivers across days. Also, many twelve hour shift staffing models assign staff members to four "teams" of workers (two day shift teams and two night shift teams). The teams are then scheduled to work opposite schedules, with communication impaired because the members of one day shift team never work directly with the members of the opposite day shift team and the members of one night shift team never work directly with the members of the opposite night shift team. Despite these problems, twelve hour shifts are frequently used because they require fewer staff members (thus decreasing costs) and because they increase staff satisfaction by allowing full time workers to have a greater number of days off.

The NICUs in the Terres and Dowd study (1996) which reported the use of primary nursing also reported that decisions on whether to assign the designated primary nurse to provide care for her/his primary patients during a particular shift were influenced by the level of care required by the infants (50% of units), by attempts to achieve a balance of infants requiring highly complex care and less complex care within nursing assignments (13% of units), and by the need to utilize particular primary nurses to transport infants born in outlying hospitals into the NICU (6% of units). Of the 199 NICUs surveyed, 175 (86%) of the units reported the routine practice of "floating" nurses from other units of the hospital to care for NICU patients, with 68 units (39%) reporting those nurses from non-pediatric units were also floated into the NICU. Only 67 units (38%) reported that the nurses floated into the NICU received any formal education in NICU nursing. The most frequently reported method of providing support for the "floated" nurses was to co-assign the "floated" nurse with an NICU nurse (89 of 175 NICUs, or 51%).

Health care in the United States has undergone tremendous changes in recent years, and change continues at a rapid pace within the industry. With the shrinking financial base for health care and the advent of managed care, there is increasing competition for health care dollars, particularly in acute care settings such as hospitals. Community settings are rapidly becoming the primary sites for the delivery of health care services, with subacute care often delivered in settings such as nursing homes. As a result, the acuity levels of hospitalized patients are rising. Although hospitals continue to employ two-thirds of all of the registered nurses in the United States, hospitals are facing increasing cost constraints and are being forced to explore ways to restructure, reengineer, and redesign how nursing care is delivered to hospitalized patients (Institute of Medicine, 1996). In order to remain competitive in a changing health care market, hospitals must find ways to deliver high quality services with the least possible outlay of capital. Because nursing salaries comprise a large percentage of the hospital's expenses, many hospitals are exploring health care delivery models such as "patient focused care," a model in which nurses, the traditional providers of direct patient care, are "replaced" by unlicenced assistive personnel who are supervised by registered nurses.

The American Nurses Association has recently completed a study examining the relationship of registered nurse (RN) staffing levels to length of hospital stay and patient outcomes (American Nurses Association, 1997). One of the stated purposes of the study was to determine "whether the amount of nursing provided to patients had any impact on adverse outcome rates" (American Nurses Association, 1997, p. 12). The variable "nursing" was operationalized in two dimensions: (1) total number of nursing hours provided (hours of nursing care provided by all of the following: registered nurses, licensed vocational nurses, licensed practical nurses and nursing assistants), adjusted for the patient acuity level using the Nursing Intensity Weight methodology; and, (2) RN hours as a percentage of all nursing hours. The study results indicated a strong relationship between a shorter length of hospital stay and higher nurse staffing levels (i.e., total number of nursing hours). There was also a statistically significant inverse relationship between the percentage of RN hours and the incidence of the specified preventable adverse patient outcomes of pressure ulcers, pneumonia, postoperative infections, and urinary tract infections (the higher the percentage of RN hours, the lower the incidence of adverse patient outcomes).

The relationship of registered nurse staffing levels to selected post-operative adverse events in adult surgical patients was examined by Kovner and Gergen (1998). Data were collected from 589 acute care hospitals in 10 states representing the major regions of the United States. Significant inverse relationships were demonstrated between the levels of full-time-equivalent registered nurses per adjusted inpatient day and the post-operative incidences of urinary tract infection, pneumonia, thrombosis, and pulmonary compromise.

If nursing is to maintain a strong professional registered nurse presence in acute care settings, it is essential that additional nursing research studies such as these be conducted in a variety of patient care settings to document the relationship of nursing care to patient outcomes. This study was a response to the calls expressed by both the Institute of Medicine and the American Nurses Association for additional research studies to explore and document the relationship of nursing care to patient outcomes.

Purpose

The purpose of this study was to examine the relationship of nursing care to the health outcomes of preterm infants cared for in a neonatal intensive care unit (NICU) by testing a middle range theory of health promotion for preterm infants based on Levine's Conservation Model of Nursing.

Theoretical Framework

Levine's Conservation Model of Nursing

The Conservation Model of Nursing was developed by Myra Estrin Levine and first published in the late 1960's and early 1970's in a combination of articles and books

(Levine, 1966; Levine, 1967; Levine, 1969a; Levine, 1969b; Levine, 1971; Levine, 1973). In Levine's Conservation Model, the goal of nursing care is the conservation or "keeping together" (Levine, 1967, p. 46) of the wholeness, or the integrity, of the person. Levine believed that conservation was not passive and did not imply minimal activity on the part of either the nurse or the patient. Levine stated that "In nursing, to keep together means to maintain a proper balance between active nursing intervention coupled with patient participation on the one hand and the safe limits of the patient's ability on the other" (Levine, 1967, p. 46). The word "health" comes from the Anglo-Saxon word "hal," which meant "whole" (Levine, 1973). Therefore, in Levine's model, the concepts of wholeness and integrity are analogous to the concept of health. In her 1969 article entitled "The Pursuit of Wholeness," Levine stated that "From the moment of birth until the instant of death, every individual cherishes and defends his 'wholeness' " (p. 93).

The nurse is an agent of health promotion in the Conservation Model, with the goal of the nurse to assist the patient in that lifelong pursuit of wholeness. Levine (1971) stated:

> The goal of all nursing care should be to promote wholeness, realizing that for every individual that requires a unique and separate cluster of activities. The individual's integrity — his one-ness, his identity as an individual, his wholeness — is his abiding concern, and it is the nurse's responsibility to assist him to defend and to seek its realization (p 258).

Levine very specifically chose to use the word "patient" to refer to the individual who is the recipient of nursing care, rather than the word "client," to emphasize her perspective that the nurse's goal is to assist the individual to a state of wholeness, or health, in which the nursing interventions would no longer be necessary. In a 1996 retrospective of the

Conservation Model, Levine described the reasoning for this choice:

> Gaylin made a distinction between *patient* and client. The word *patient* comes from the Latin "to suffer" while the word *client* comes from the Latin "to follow." All too often the patient (now called a client) is the blamed victim for failing to follow life-style rules. . . . Any individual who enters into the dependency of health care is a *patient*. The nurse provides whatever service is needed — even if it is only health counseling — but only for as long as the nurse's professional services are required. Then the dependency must be ended. I want the patient to walk away from me. As participants in their care, individuals need to retain whatever portion of their independence they can and they should not be defined as followers. (pp. 39 - 40).

In carrying out nursing interventions, the nurse uses her/his skill and knowledge to create an environment in which the process of adaptation can take place with the greatest degree of success (Levine, 1966; Levine, 1973). The person cannot be viewed in separation from the environment, because there is a continual interface between the individual and the environment; the process of adaptation is used by the individual to respond to the various "environmental challenges" (Levine, 1989, p. 336) with which he or she is confronted. The environment includes both the internal environment (involving physiologic and pathophysiologic processes) and the three components of the external environment, described as the perceptual, operational, and conceptual environment. The perceptual environment refers to the component of the environment to which the individual responds using the senses. The operational environment refers to the environmental components to which the individual responds through mechanisms other than the senses (for example, microorganisms and radiation). The conceptual environment includes the cognitive, emotional, psychological, and spiritual experiences of life (Levine, 1973).

Adaptation occurs across a continuum; each individual has a different degree of adaptive potential available with respect to a specific environmental challenge. Levine (1973) describes the process of adaptation as follows:

> Change is characteristic of life, and adaptation is the method of change. The organism retains its integrity in both the internal and external environment through its adaptive capability. Adaptation is the process of change whereby the individual retains his integrity within the realities of his environments. Adaptation is basic to survival, and it is an expression of the integration of the entire organism. The measure of effective adaptation is compatibility with life. A poor adaptation may threaten life itself, but at the same time the degree of adaptive potential available to the individual may be sufficient to maintain life at a different level of effectiveness. Adaptation is not "all-or-none." It is susceptible to an infinite range within the limits of life compatibility. Within that range, there are numerous possible degrees of adaptation. (pp. 10 - 11).

Levine (1971) stated that "The holistic approach to nursing must take place at the interface posed by the generalizations of organism and environment" (p. 262). In the Conservation Model, nursing interventions are designed in accordance with the four conservation principles of nursing: conservation of energy, conservation of structural integrity, conservation of personal integrity, and conservation of social integrity (Levine, 1967). Nursing interventions can be either therapeutic (with the goal of enhancing adaptation and improving well-being) or supportive (with the goal of maintaining the status quo or preventing a downward course), but whenever possible, the goal of nursing care should be to foster successful adaptation (Levine, 1973).

Levine derived her principle of conservation of energy from the fundamental principle of energy conservation as described in the first law of thermodynamics in the discipline of physics, which states that energy can neither be created nor destroyed, but merely transformed from one state to another (Levine, 1973). As in physics, Levine defined energy as "the capacity to do work" (Levine, 1973, p. 14) and viewed the ability of the human body to perform the work of sustaining life as dependent upon the maintenance of an appropriate energy balance, which she defined as "the supply of energy-producing nutrients measured against the rate of energy-using activities" (Levine, 1973, p. 14). Energy balance is a dynamic process, which only reaches a state of equilibrium in the human organism at the time of death.

Levine's principle of conservation of structural integrity is based upon her view of healing as "the process of restoration of structural integrity" (Levine, 1973, p. 15). The principle of conservation of personal integrity relates to the individual's "sense of identity and self-worth" (Levine, 1973, p. 16), which she believed to be "the most compelling evidence of wholeness" (Levine, 1973, p. 16). Finally, from Levine's belief that "individual life has meaning only in the context of social life" (Levine, 1973, p. 17) comes the principle of conservation of social integrity, to preserve the wholeness of the individual within his/her relationships to significant others.

Application of Levine's Model to Nursing Care of the Preterm Infant

Environment

In describing the adaptive potential of the individual when confronted with an environmental challenge, Levine stated: "The ability of every individual not only to survive but to flourish is a consequence of the competence of the person's interactions with the environments in which he or she functions. . . . the organism must possess the ability to stabilize its internal environment in the face of the uncontrolled factors it may confront in its external environment" (Levine, 1991, pp. 4-5). Levine (1991) described two situations in which her concept of adaptation in the face of environmental challenge was illustrated in newborn infants:

> An equally remarkable ability to survive was seen in the rescue of newborn infants buried in the rubble of a hospital after the devastating earthquake in Mexico City in 1988. Several were recovered alive, all reportedly within the same narrow time period and discovered within 8 days of their birth. An adaptive pattern, long dormant until this unique circumstance brought it to light, seems responsible for the miraculous survival of the infants.
>
> The likelihood that there are other potential adaptive configurations that sustain survival under great duress and are hidden in the genetic code is reinforced by Anderson's work with preterm newborns. She describes the introduction of "skin-to-skin" or "kangaroo" care in poverty-stricken Columbia as a successful strategy to save preterm infants who would otherwise have failed. (pp. 5 - 6).

The preterm infant has been described by Als (1986) as being in a "mismatch situation" (p. 7) with the environment. The preterm infant who is quite competently adapted to function in the intrauterine environment has been suddenly introduced into the extrauterine environment for which the infant's body is poorly matched (Als, 1982). The physiologic systems of the preterm infant, though immature, are developmentally suited for survival in the uterus, where vital processes such as respiration, the provision of nutrients and the excretion of waste products are performed by the mother's body through the placenta. However, when the infant is born prematurely, the infant's immature organ systems must attempt to perform independently all of the essential physiologic processes in a new and foreign environment. This "mismatch" between the infant's immature organs and the demands of the extrauterine environment creates a situation which is viewed through Levine's model as an environmental challenge, a challenge to the wholeness, or integrity, of the infant. The infant must respond to the challenge of this "environmental mismatch" by adapting to stabilize the internal environment (physiologic processes) so that survival in the foreign external environment is possible.

Adaptation

In stating her view of adaptation Levine (1996) described the process as a bridge:

> There must be a bridge that allows ready movement from one environmental reality to another. Adaptation is the bridge.
>
> Adaptation is the process by which individuals "fit" the environments in which they live. The environment is fraught with dangers. . . . The internal environment and the external environment are joined through adaptive patterns, and the individual's wholeness is a function of their harmonious interaction. (p. 38).

The preterm infant confronted with this environmental challenge is attempting to generate an integrated adaptive response in order to "fit" in the extrauterine environment. The central nervous system (CNS) is responsible for integrating the adaptive responses into a unified effort, yet the CNS of the preterm infant is also quite immature, adding to the difficulties which the infant encounters in trying to process the barrage of new stimuli from the extrauterine environment. The provision of appropriate nursing care to support the preterm infant's efforts to adapt to extrauterine life is an essential element for the infant's survival.

Nursing

Levine (1973) described the role of the nurse as follows:

> The nurse participates actively in every patient's environment, and much of what she does supports his adaptation as he struggles in the predicament of illness. Nursing intervention means that the nurse interposes her skill and knowledge into the course of events that affects the patient. Thus, nursing

> intervention must be founded not only on scientific knowledge, but specifically on recognition of the individual's holistic response which indicates the nature of the adaptation taking place. The nurse must learn to read the message. Such assessments provide the only rational basis for judicious decision-making by the nurse in the patient's behalf. Furthermore, nursing intervention must be designed so that it fosters successful adaptation whenever possible. (p. 13).

The nurse caring for the preterm infant should therefore have an appropriate level of scientific knowledge and skill with respect to the practice of nursing, should know how to recognize the infant's own adaptive efforts in order to design nursing interventions which compliment the infant's adaptive response, and should have good decision-making ability. Also according to Levine (1973):

> Nursing is a human interaction. It is a discipline rooted in the organic dependency of the individual human being on his relationships with other human beings. An "interaction" by its very nature presupposes a system of exchange between individuals: it can occur only if communication can occur. Language represents only one mode of communication, and indeed, the ability to respond to the behavior of other individuals often requires no exchange of words at all. (p. 1)

Because the infant cannot communicate verbally, the behavior of the infant is the primary route by which the infant communicates with caregivers (Als, 1982), so it is important that nurse caregivers be able to identify and respond appropriately to the various behavioral cues of preterm infants.

Two of the most important dimensions of nursing care with respect to the care of the preterm infant should be the consistency with which the same nurse caregiver provides care for an individual infant and the level of intensity of nursing care which is provided. The more consistently that a particular nurse caregiver provides care for a specific patient, the better the opportunity for the nurse to become closely attuned to the individual infant's behavioral cues and adaptive responses, and the better able the nurse should be to design nursing interventions which are supportive of the infant's unique adaptive efforts. For the purposes of this study, the "intensity" of nursing care provided referred to (1) the knowledge level of the nurse caregiver providing direct care to the infant (with the registered nurse level defined as having a higher knowledge level than the non-registered nurse level), and (2) the number of other infants for whom the nurse caregiver is simultaneously providing care. The responsibility and accountability for the nursing care of the patient always reside with the registered nurse, although direct care provision may be delegated to non-registered nurse caregivers under the supervision of a registered nurse (for example, licenced practical nurses, nursing technicians, or nursing assistants). Registered nurses are generally assigned to provide care for the patients who are assessed to require the highest level of nursing expertise (that is, patients who require a greater "intensity" of nursing care). The intensity of nursing care which a nurse caregiver provides to a particular patient is also assumed to be influenced by the number of patients for whom that nurse must provide care during a shift, because the nurse must divide her/his attention between the assigned patients.

Levine viewed the purpose of nursing care as supporting the adaptative efforts of the patient, with the goal of conserving, or "keeping together," the wholeness, or integrity, of the person (Levine, 1967). Nursing care of the preterm infant should be directed towards conserving the integrity of the infant during the crucial adaptation to extrauterine life. Nursing interventions should be both therapeutic and supportive in nature, and should have as their goal the conservation of the infant's energy, structural integrity, personal integrity and social integrity.

Conservation of Energy

In her 1967 description of "The Four Conservation Principles of Nursing," Levine stated that "Energy conservation during acute illness demands nursing intervention which cautiously balances the individual's resources with the expenditure he can safely afford" (p. 48). One of the major environmental challenges confronting the preterm infant at the time of birth is the task of establishing effective respirations to assure a sufficient supply of oxygen. Since oxygen is an essential element necessary for the cellular release of energy (Guyton, 1987), the energy balance of the preterm infant during the adaptation to extrauterine life is linked to the degree of lung immaturity and respiratory distress present at birth. During fetal development, the lungs are one of the last organ systems to reach maturity, with the process of respiration performed "in utero" through the placenta. One of the major acute illnesses of preterm infants is Respiratory Distress Syndrome, a condition characterized by the structural immaturity of the lungs and by the deficiency of surfactant, a protein substance which normally lines the inner surfaces of the alveoli and prevents them from collapsing (Moore, 1988).

Nursing interventions designed to enhance respiratory functioning should contribute to the conservation of energy in the infant. Levine (1973) stated that "From the nurse's viewpoint, the balancing of energy input with energy output is a very essential aspect of all nursing interventions" (p. 14). Nursing interventions such as monitoring vital signs, assessing both the general condition of the patient and the tolerance of nursing interventions, providing a balance of rest and activity, and assuring adequate oxygenation, thermoregulation, and nutrition are all interventions with the goal of conservation of energy (Levine, 1967; Levine, 1973).

Conservation of Structural Integrity

Levine (1967) described the threat to structural integrity as follows:

> Tissue response to any kind of insult is aimed at the restoration of continuity. When the healing process can take place with minimal structural change, as occurs in resolution, the defense effectively prevents functional aberration arising from structural change. However, when the sequelae of restoration results in the re-establishment of continuity at the expense of structural organization, some functional disturbance is inevitable. (p. 51).

The preterm infant is at high risk for the development of structural injury to various organ systems, due to the potential for adverse effects on the developing organ systems from both the extrauterine environment and from necessary caregiving interventions. The more premature the infant is at the time of birth, the greater the risk of structural injury. The lungs are at risk for the development of Bronchopulmonary Dysplasia (a chronic lung disease of infants), the brain is at risk for hemorrhage into the periventricular and/or intraventricular areas, and the eyes are at risk for a retinal disorder known as Retinopathy of Prematurity. Due to the immaturity of the skin and the immune system, preterm infants are at a higher risk for serious infections. Levine stated that "Structural integrity is seriously threatened unless daily nursing care is frankly rehabilitative in its intent" (Levine, 1967, p. 52). Therefore, nursing interventions designed to minimize the likelihood of these problems or to promote rehabilitation if these disorders occur should contribute to the conservation of structural integrity of the infant.

Conservation of Personal Integrity

In 1973, Levine described the principle of conservation of personal integrity as relating to the individual's "sense of identity and self-worth" (p. 16), which she believed to be "the most compelling evidence of wholeness" (p. 16). Although the preterm infant does not yet have higher cognitive abilities, the groundwork which will determine the infant's capacity to develop those abilities is being established during the infant's stay in the NICU as the immature central nervous system and sensory systems continue the developmental process. Levine (1969) viewed the integration of the sensory systems as an essential component of the wholeness of the individual, stating that:

> Every sensory stimulus is an energy transmission arising from the physical factors in the environment and capable of instigating an energy transmission in the organism, beginning — but only beginning — with the precise sensory-responsive cells in the sense organ itself. Following reception of the stimulus, there are a train of energy events within the organism that constitute a feedback; these events cause change in specific tissues, and result ultimately in an energy expense, manifested by a physiologic and/or behavioral activity of the whole organism.
>
> Thus, the ecosystem is a completed circuit, consisting of an energy input, an energy-mediated feedback, and an energy output. The individual can therefore never be passive. He is an active participant in his environment, not only altering it by his presence but also actively and constantly seeking information from it.
>
> But such information does not come in discrete packages. Rather it is a simultaneous input of many sorts of information from the environment that never ceases during consciousness and even continues during sleep. The background of environmental information is incessant, and every kind of stimulus impinges upon the individual at once. Sight, sound, odor, temperature, posture in relation to gravity and body position — all the information that is necessary in order to orient the individual — he unceasingly receives. (p. 96).

The infant in the NICU is confronted with this incessant barrage of sensory stimuli, yet does not have the mature sensory systems and fully organized nervous system needed to competently process this new and different stimuli. Therefore, an essential role of the neonatal nurse is to modify the infant's environment to protect the infant from harmful stimuli, yet at the same time to provide the infant with the positive types of sensory stimulation that are necessary to promote continued maturation of the sensory and nervous system.

The infant in the NICU is also learning the basic skills necessary to successfully interact with parents and caregivers, such as attaining an alert state and then purposefully attending to social stimuli from others. Infants must also learn how to effectively interact with the extrauterine environment to obtain the nutrients necessary for metabolic needs and growth. The term infant is born with the innate reflexes necessary to successfully bottle-feed or breast-feed already well coordinated, so oral feeding skills are generally learned quite easily by term infants. However, learning the skills necessary for oral feeding is one of the greatest challenges facing the preterm infant. Nursing interventions designed to enhance neurodevelopmental competence (as reflected by social interaction and feeding skills) should contribute to the conservation of personal integrity in the infant.

Conservation of Social Integrity

Levine's principle of conservation of social integrity has as its goal the preservation of the wholeness of the individual within his/her relationships to significant others. In describing this Levine (1967) stated that:

> In some cultures, the members of the patient's family accompany him to the hospital and remain with him, participating in his care. The traditional social isolation of the American hospital, with its visiting restrictions and the limitations placed on family participation in the care of the patient, creates problems of patient management far more troublesome than dealing with visitors. Some part of every person is left behind with those whom he can trust without testing and from whom he can expect love without justifying it. The nurse has tended to make the patient her own, unwilling to recognize that there are others who care intensely about his welfare. (Levine, 1967, p. 57)

In no area of the American hospital has this social isolation been more prevalent than in intensive care units, including neonatal intensive care. The shift towards "family centered care" in neonatal ICUs is a promising development towards promoting social integrity for the preterm infant and his/her family. Levine (1989) stated that: "Individuals define themselves by their relationships. An identity places one in a family, a community, a cultural heritage, a religious belief, a socioeconomic slot, an educational background, a vocational choice" (p. 335). For the infant, the social identity is defined by the family's social identity.

The birth of a child is a time of developmental crisis for the family unit because the parents must transition into the role of parent and integrate the child into the family. The birth of a preterm or critically ill infant complicates this developmental process because the parents are now simultaneously dealing with two crisis situations: the birth of a child and the illness of a family member (Berns, Geiser & Levi, 1993). A primary goal of nursing care should be to assist the family through this period of crisis by fostering parent-infant attachment and the maintenance of an intact family system, with the infant successfully integrated into the family. A primary long term nursing goal is to transition the complete care of the infant back to the parents when the infant is physiologically stable enough to be discharged from the NICU. Nursing interventions designed to support the family and to facilitate the transition of care from the NICU staff back to the parents should contribute to the conservation of social integrity of the infant.

Wholeness

In Levine's Conservation Model, the concept of wholeness is analogous to the concepts of health and integrity. For the preterm infant, one way in which wholeness is assessed is by comparing the level of developmental competence of the infant with the developmental competencies expected for a healthy infant born at that same post-conceptional age. (For example, an infant who was born at 25 weeks post-conceptional age and who has reached a chronologic age of 7 weeks should have attained the development competencies equivalent to those of a healthy infant born at 32 weeks post-conceptional age.) A major marker of wholeness, or health, is for the infant to achieve a level of independent functioning in the extrauterine environment that enables the infant to be discharged to the care of the parents on or before the date the baby had been expected to be born if the pregnancy had gone to term gestation. Therefore, since term gestation is generally considered to be 38 to 40 weeks, the goal is for preterm infants to achieve a level of health that allows them to be discharged from the hospital by a post-conceptional age of approximately 38 to 40 weeks.

Rationale for Selection of Levine's Conservation Model

As this study proposed to explore the relationship of nursing care to the health outcomes of preterm infants, a nursing theoretical framework was selected as the proper perspective within which to examine this phenomenon. Levine's Conservation Model of

Nursing was selected from among the existing nursing theoretical frames because of its focus on the process of adaptation and because the basic terminology used in the Conservation Model should be easily interpretable by members of other disciplines involved in the care of preterm infants.

The Theory of Health Promotion for Preterm Infants
Based on Levine's Conservation Model of Nursing

The process of theory synthesis described by Walker and Avant (1995) was used to derive a middle range theory based on Levine's Conservation Model of Nursing, the Theory of Health Promotion for Preterm Infants. A diagram of the theory is included for reference on the following page as Figure 1. The concepts included in the theory represent concepts from Levine's Conservation Model of Nursing; Levine's concepts are depicted in a corresponding diagram above the diagram of the theoretical concepts. In deriving this middle-range theory, the author has drawn not only from the works of Levine (1966, 1967, 1969a, 1969b, 1971, 1973, 1989, 1990, 1991, 1996), but also from the works of Als, (1982, 1986), Barb & Lemons (1989), Blackman (1991), and White-Traut, Nelson, Burns, & Cunningham (1994), and from her own clinical knowledge. The verbal description of the theory is as follows:

If preterm birth disrupts the usual intrauterine path of fetal growth and development, resulting in the birth of a preterm infant who is fully competent for survival in the intrauterine environment but not yet fully competent for extrauterine life;

And if an environmental challenge is created by the entry of the preterm infant with intrauterine competencies into the extrauterine environment of the NICU;

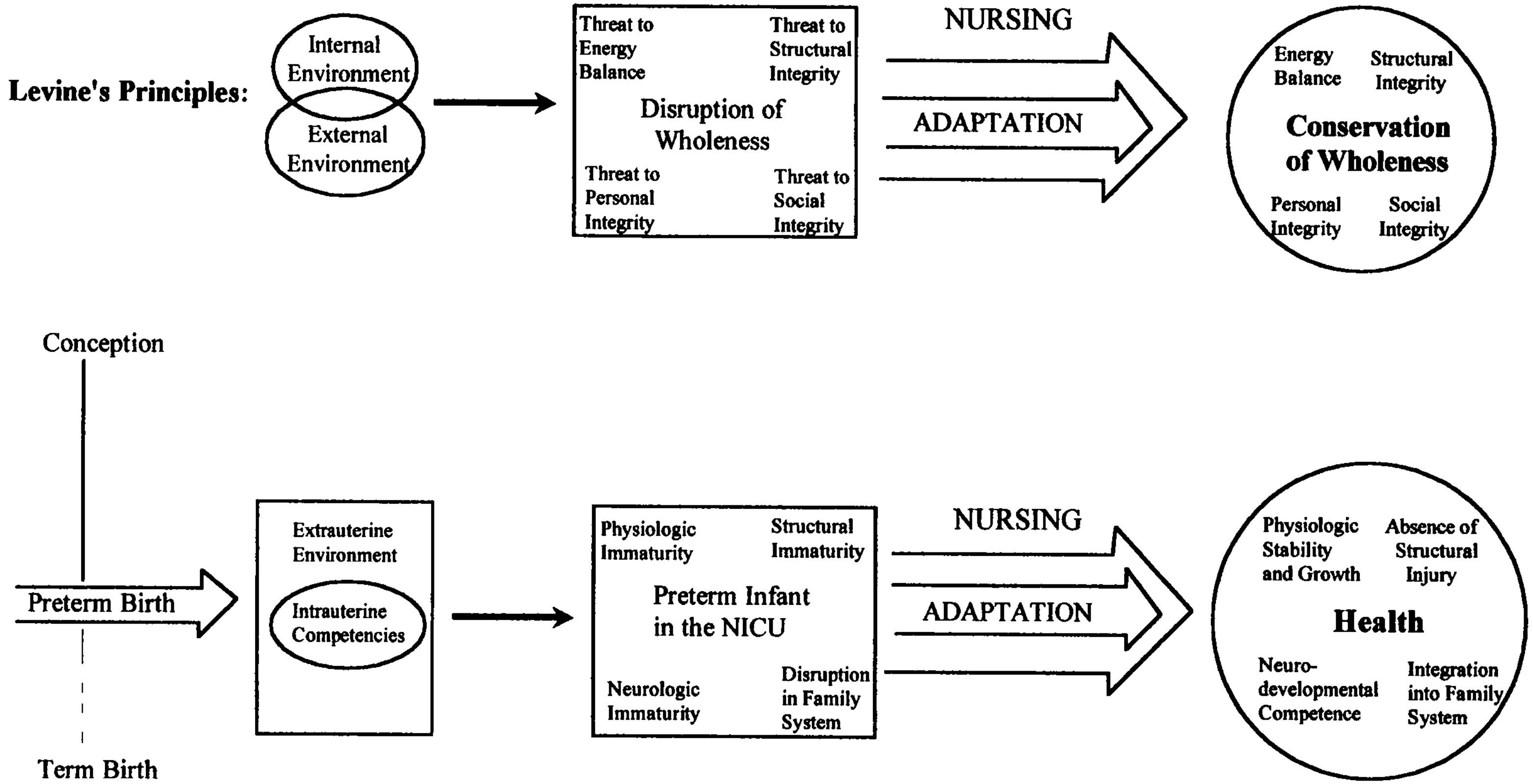

Figure 1. A Theory of Health Promotion for Preterm Infants Based on Levine's Conservation Model of Nursing.

And if this environmental challenge results in a disruption of wholeness of the infant;

And if the disruption of wholeness of the preterm infant in the NICU is characterized by:

a.) the preterm infant's lack of physiologic maturity for independent survival in the extrauterine environment (a threat to the balance of energy);

b.) the potential for reversible and/or irreversible injury during the NICU experience due to the structural immaturity of the preterm infant (threat to structural integrity);

c.) the preterm infant's lack of neurologic and sensory maturity for the modulation of external environmental stressors (threat to personal integrity); and

d.) the disruption of the family system (threat to social integrity);

And if the infant responds to the disruption of wholeness by the process of adaptive change;

And if the NICU nurse plans and implements nursing interventions which are supportive of the infant's own efforts of adaptive change;

And if these nursing interventions foster the goal of promoting wholeness through:

a.) Conservation of energy;

b.) Conservation of structural integrity;

c.) Conservation of personal integrity; and

d.) Conservation of social integrity;

Then, the outcome of nursing care is wholeness, or health, of the preterm infant, as reflected by:

a.) Physiologic stability and growth;

b.) Absence of structural injury;

c.) Neurodevelopmental competence; and

d.) Stability of the family system and integration of the infant into the family.

Outcomes Management in Neonatal Nursing

Petryshen and Stevens (1995) describe a model that is a useful perspective for exploring the relationship of nursing care practices on the outcomes of care in a neonatal intensive care environment. Based in the work of Donabedian (1992), they define outcomes as "the relationship between structure and process. Structure is the physical and organizational properties of the settings in which care is provided; process is what is done for patients. The end result of the interaction between structure and process are outcomes." (Petryshen & Stevens, 1995, p. 1043). They describe three types of outcomes which should be considered by nurse managers: administrative outcomes, economic outcomes, and clinical outcomes. Administrative outcomes include efficacy, efficiency, effectiveness, and equity of the care delivery structure and process. Economic outcomes include utilization of services and optimalization of costs. Clinical outcomes include such traditional markers as morbidity and mortality, severity of illness, quality of life, and satisfaction with care. The focus of this study was clinical outcomes, or health outcomes, as represented by the health status of the infant at the time of discharge from the NICU. A subsidiary research question examined economic outcomes as reflected by resource utilization during the NICU stay.

Research Questions

This purpose of this study was to examine the relationship of nursing care to the health status outcomes of preterm infants cared for in a neonatal intensive care unit (NICU) by testing the middle range Theory of Health Promotion for Preterm Infants based on Levine's Conservation Model of Nursing. The primary research question was:

How do the intensity of nursing care and the consistency of nursing caregivers relate to the health status of preterm infants at the time of initial hospital discharge?

Two subsidiary questions addressed were:

1.) How do the intensity of nursing care and the consistency of nursing caregivers relate to the level of morbidity of preterm infants at the time of hospital discharge?

2.) How do the intensity of nursing care and the consistency of nursing caregivers relate to the utilization of health care resources by preterm infants during the initial hospital stay?

These research questions were tested using the statistical method of structural equation modeling. Structural equation modeling was chosen for this study in part for its ability to examine multiple interrelationships of concepts simultaneously. With Levine's emphasis on the conservation of the wholeness of the person, it appeared advantageous to be able to examine the relationships among the study variables simultaneously. The research questions were therefore phrased to allow the simultaneous evaluation of the relationships of both consistency of nursing care and intensity of nursing care to the conceptual outcome endpoints of each question. In addition, structural equation modeling was determined to be an appropriate methodology for examining the influence of various levels of nursing care on infant outcomes because it provides a technique through which causal relationships can be explored without the need to randomize groups to receive varying degrees of nursing care.

Theoretical and Operational Definitions

The theoretical definitions of the major constructs examined in this study are presented below. The more specific operational definitions for these constructs are presented in chapter 3.

Energy Balance: Physiologic stability of the infant at birth. This concept reflected the capability of the infant to independently perform the physiologic processes necessary for survival in the extrauterine environment, as measured by oxygenation and ventilation status during the first 12 hours of life.

Structural Integrity: Structural maturity of the infant at birth. This concept reflected the level of structural maturity achieved by the infant "in-utero" and the readiness of the infant to survive in the extrauterine environment as measured by the post-conceptional age at birth and the infant's birth weight.

Personal Integrity: Neurodevelopmental maturity of the infant at birth. This concept reflected the infant's adaptive capacity and the competency of the central nervous system at birth, as measured by the Apgar socres at 1 and 5 minutes of age and the level of resuscitation required at the time of birth.

Social Integrity: Stability of the family system at the time of the infant's birth. This concept reflected integrity measures related to the family of the infant, such as parental age, cultural background, and socioeconomic status .

Consistency of Nursing Caregivers: The frequency with which nursing care was provided to the infant by the same nursing caregivers during the initial hospital stay. This concept reflected the assumption that caregivers who provided care for the infant on a more frequent basis should have been more attuned to the infant's unique behavioral cues and should therefore have been able to deliver nursing care in a manner that more effectively supported the infant's unique adaptive patterns.

Intensity of Nursing Care: The skill and knowledge level of nursing caregivers and the average number of other patients for whom the caregivers were also simultaneously providing care during the initial hospital stay. Higher levels of nursing skill and knowledge and fewer numbers of other patients should have facilitated the design and implementation of nursing interventions which more effectively supported the infant's unique adaptive patterns.

Health Status: The wholeness and integrity of the infant at the time of initial hospital discharge. This concept was reflected by the post-conceptional age at which the preterm infant achieved certain developmental milestones which indicate that a basic level of independent functioning in the extrauterine environment has been attained, and also by indicators of growth and morbidity.

Morbidity: The level of wholeness or integrity attained by the infant at the time of initial hospital discharge, measured by the presence and severity of certain health problems unique to the preterm infant population.

Resource Utilization: The health care resources utilized by the infant during the initial hospital stay. This concept reflected the economic outcomes achieved during the stay, as measured by the length of hospital stay and by the number of days that the infant required certain resource intensive therapeutic interventions.

Delimitations and Limitations of the Study

Delimitations

The site of data collection for this study was a Level III Neonatal Intensive Care Unit and Intermediate Care Nursery in a medium size city in the southeastern United States. The data analyzed in this study were collected from archival data records of infants admitted to the NICU from January 1996 through April 1997. The results therefore reflect both the nursing care practice patterns and patient outcome data of those units from January 1996 through mid-1997. The study results are generalizable to comparable sites. Records from the year 1996 and early 1997 were selected as the sampling frame for data collection for this study because nurse staffing and practice patterns at the proposed study site were relatively stable during that time period. A prospective study design was judged to be inappropriate for this study at this time because the rapid changes that are presently occurring in the health care delivery system often necessitate responsive changes in nurse staffing ratios and practice patterns that are influenced by factors external to the patient.

Limitations

This study was exploratory in nature, serving as a beginning study to identify elements of nursing care delivery which positively and negatively relate to infant outcomes. Since this study utilizes an ex post facto study design with data collection from existing archival records, certain variables that may have been selected for inclusion in a prospective design are not available for inclusion in this study (for example, measurement variables related to integrity of the family system, such as marital status of parents, paternal involvement, and frequency of NICU visits by parents). Because the study reflects the outcomes of preterm infants cared for during the years 1996 and 1997, the effect of technological or care advances introduced subsequent to that time are not reflected in the study findings.

Significance of the Study

This study is significant in three areas. First, it contributes to the knowledge base of nursing for both clinical nursing care and nursing administration. Second, it is relatively unique in that it used a holistic nursing theoretical perspective to examine the influence of the environment on the developing preterm infant. Third and finally, it contributes additional research findings documenting the effects of nursing care upon patient outcomes and upon the utilization of health care resources.

There is a great need for continued scientific knowledge development related to both the clinical and administrative aspects of nursing practice, to ensure that the discipline of nursing has a broad scientific knowledge base upon which to ground its practice. The discipline of nursing is at a crossroads in which nursing will either complete the transitional steps necessary to attain professional status or will remain in a vocational mode (Alligood, 1997). In order to attain professional status, it is essential that nursing practice be solidly grounded in scientific evidence. This study should contribute to the development of that nursing knowledge base.

There is also a need for the refinement of a nursing model to serve as a comprehensive guide for the planning and delivery of holistic neonatal nursing care. The delivery of holistic nursing care requires a framework which facilitates a broad view of the needs of both the infant and his/her family. The proposed study is an attempt to develop a framework drawn from an existing nursing model which may be used to guide neonatal nursing care.

Finally, the current economic climate of the health care delivery system places the continued presence of the professional registered nurse in acute care settings at great risk. The need to find innovative methods to deliver quality patient care at reduced costs is increasingly leading hospitals to question whether the same quality of patient care can be delivered by lower cost employees than registered nurses. It is essential that nursing research such as the proposed study be conducted in order to document the relationships between nursing care and both health and economic outcomes.

CHAPTER 2

REVIEW OF THE LITERATURE

The many technological advances of the past few decades have led to the increased survival of preterm infants. Along with this improved survival has come great concern regarding the health outcomes of these infants. Researchers have begun to study the long term sequelae of preterm birth, and have also begun to develop intervention programs targeted towards improving the long term health outcomes of these infants. The purpose of this study was to examine the relationship of nursing care to the health outcomes of preterm infants by testing a middle range Theory of Health Promotion for Preterm Infants based on Levine's Conservation Model of Nursing. This review of the literature examines the following: (1) health outcomes of preterm infants; (2) central nervous system development and the NICU environment; (3) the use of developmental intervention programs to improve preterm infant health outcomes; (4) successful oral feeding as a marker of health in preterm infants; and (5) the use of Levine's Conservation Model as a theoretical frame for nursing practice and research.

Health Outcomes of Preterm Infants

Most of the studies of the outcomes of preterm infants have concentrated on very low birth weight infants (birth weights less than 1500 grams). Although these infants account for only 1 % of births in the United States, this subset of preterm infants is generally considered to be at the greatest risk for poor outcome, as most preterm infants with greater birth weights do not require intensive care (Hack, Klein, & Taylor, 1995).

This review of literature related to health outcomes of preterm infants will therefore focus primarily on the very low birth weight (VLBW) preterm infant population.

Although the availability of neonatal intensive care has greatly reduced the mortality of preterm infants, many of the surviving infants are left with significant long-term developmental disabilities or handicaps. Epidemiological studies reporting infant outcomes at the time of Neonatal Intensive Care Unit (NICU) discharge have long been widely available, however longitudinal studies of developmental outcome have been more problematic to obtain, due to the difficulty of tracking patients for years after discharge. Early NICU outcome studies revealed the potentially devastating long term consequences associated with the array of medical problems which are unique to preterm infants, such as periventricular and intraventricular hemorrhages, bronchopulmonary dysplasia, and retinopathy of prematurity. However, recent studies are revealing more subtle neurodevelopmental sequelae of the NICU experience, some of which may not be detectable until many years after nursery discharge. Goldson (1996) presented a critique and summary of many of the developmental follow-up studies of infants with birth weights less than 800 grams. The cumulative research evidence is encouraging in that it indicates that only about 10% to 20% of these infants have major long-term neurologic problems (such as cerebral palsy). Somewhat disturbing however is the indication that almost 60% of these extremely low birth weight (ELBW) survivors have some type of neurodevelopmental disability which affects their school performance and psychosocial functioning. Many of these children may appear developmentally normal during the preschool period, or may present with only mild developmental delay. Williamson, Wilson, Lifschitz, and Thurber (1990) compared the developmental outcomes at 1 year of chronologic age of 61 very low birth weight (VLBW) infants without major neurological handicaps to 28 term infants. They found that even these nonhandicapped VLBW infants scored significantly lower than infants born at term on measures of adaptive behavior and gross motor, fine motor, language, and personal/social skills. The VLBW infants were also more likely to have significant discrepancies between early problem-solving skills and either fine motor or language skills. A limitation of this study was that the mean chronologic age of the VLBW infants at the time of study assessment was 53 $\pm$ 5 weeks with mean corrected age of 42 $\pm$ 5 weeks, while the mean chronologic age of the control term birth infants was 47 $\pm$ 7.5 weeks at the time of assessment.

Follow-up studies tracking VLBW infants to early childhood and school age which compare preschool and school age VLBW children to matched groups of children born at term gestation are now appearing in the literature. These studies reveal an array of later appearing subtle neurodevelopmental problems which are more prevalent among the VLBW children, including developmental delay, speech articulation immaturities, motor coordination difficulties (including problems with gross motor and fine motor skills, balance difficulties and "clumsiness," and abnormalities of muscle tone and reflexes), visual problems (including strabismus and difficulties with visual motor integration and visual-spatial abilities) and attention deficit hyperactivity disorder. These studies also indicated that a significantly higher proportion of VLBW children performed lower than children in the control groups on measures of academic achievement, including measures of intelligence, reading, spelling, mathematics, non-verbal reasoning, strategy formulation and adaptive performance (Hack, Taylor, Klein, Eiben, Schatschneider, & Mercuri-Minich, 1994; Johnson-Martin, Humphry, & Kraybill, 1991; Lowe & Papile, 1990; Saigal, Szatmari, Rosenbaum, Campbell, & King, 1991; Smedler, Faxelius, Bremme, & Lagerstrom, 1992; Szatmari, Saigal, Rosenbaum, Campbell, & King, 1990; Tepli, Burchinal, Saigal, Rosenbaum, Szatmari, & Campbell, 1991).

In a study examining the need for special education services at 7 years of age, Halsey, Collin, and Anderson (1996) studied 54 ELBW children, 30 VLBW children, and 28 children who were born at term gestation. The infants were born between the years of 1984 and 1986, which was prior to the widespread availability of surfactant therapy. The groups were matched for race, gender, and socioeconomic status. The researchers found a significant relationship between decreasing birth weight and the increased need for special education services. Ninety-three percent of the term birth children were in regular classrooms with no special educational services, as compared with 70% of the VLBW children and 50% of the ELBW children.

Sensory processing disorders are also beginning to be reported among school age children who were born prematurely. Sensory processing disorders refer to a class of problems initially described by Ayres (1972) in her theoretical work on sensory integration. Sensory processing, or sensory integration, refers to the process by which neural input from the various sensory systems and the motor system is received by the central nervous system and then integrated to generate an adaptive response. The brain must first process, or integrate, sensory inputs before the body can appropriately act upon the sensation (Ayres, 1972; DeMaio-Feldman, 1994; Harris, Atwater & Crowe, 1988).

DeMaio-Feldman (1994) reported a study in which she tested for the presence of sensory processing disorders at the age of 8 years in a group of 35 children born between August 1982 and February 1983 with birth weights of 1500 grams or less. Using a battery of sensory processing tests, she found that the mean scores of the VLBW children were significantly different from the normative test scores.

The very nature of long term follow-up studies unfortunately renders them a bit dated even before publication. Most of the studies described above involve infants born during the late 1970s and early 1980s. A great many changes have occurred in neonatal intensive care since then, including the widespread availability of surfactant replacement therapy, high frequency ventilation, and extracorporeal membrane oxygenation (ECMO). These technological advances have almost certainly influenced the developmental outcomes of NICU survivors. In an effort to quantify the impact of the rapid changes in care during recent years, two groups of researchers conducted studies comparing the developmental outcomes of infants born in the late 1970s to infants born in the 1980s. Hoffman and Bennett (1992) found a significant decrease in mortality between the two groups, from 80% mortality in the group born in the late 1970's to 64% mortality in the group born in the 1980's. Although the prevalence of major neurologic problems did not differ significantly between the two groups, the severity of problems was worse among the children born during the 1980's. They also found that the prevalence of handicaps in the second group was higher among infants with birth weights less than 750 grams and was also higher for males than for females. Robertson, Hrynchyshyn, Etches, and Pain (1992) found that the one year survival rate increased from 36% in the cohort of infants born during the 1970's to 67% in the infants born in the 1980's; however they found no significant differences in the incidences of neurodevelopmental disabilities between the two groups.

Nursing Studies Related to Outcomes of Preterm Infants

Four nursing studies were found in the review of literature which examined the long-term developmental outcomes of very-low-birth-weight (VLBW) infants. Schraeder (1986) reported a study examining the influences of medical, biological, and environmental factors upon the developmental progress of 41 VLBW infants (birth weight 1500 grams or less) at age of 1 year. She found that environmental factors such as the length of time the infant was in an intensive care nursery, the socioeconomic status of the parents, and the type of home environment had a strong influence on the developmental progress of the infants, with the environmental factors accounting for 67% of the variance in the infant development measurements. In a subsequent study of 40 VLBW infants at age 3, Schraeder, Rappaport, and Courtwright (1987) reported that environmental factors accounted for only 49% of the variance in developmental measures. Parental stimulation of language and academic behaviors were noted as having the strongest influence among the environmental factors studied.

In a study designed to evaluate the ability of three different measures of academic risk to predict which VLBW children were at greatest risk for the development of academic problems, Schraeder (1993) studied a sample of 35 VLBW children without major developmental or physical disabilities. The three risk assessment tools evaluated were the Mullen Scales of Early Learning, the Preschool Development Inventory, and the

Minnesota Child Development Inventory. The children in the study were assessed using all three measures at the age of 4 years, then were followed through the first three years of school (kindergarten through second grade). Fourteen of the 35 children experienced major academic difficulties at some time during the first three school years. The three tools had limited predictive ability, identifying only two-thirds of the children who later developed academic problems. The children who were not identified by the tools generally had either perceptual impairments or behavioral disturbances.

In a study examining whether the behavioral characteristics differed between VLBW infants assessed to be at high biologic risk at initial hospital discharge and those assessed to be at low biologic risk, Oehler, Thompson, Goldstein, Gustafson, and Brazy (1996) studied 102 VLBW infants at the ages of 6 months, 15 months, and 24 months. Risk status was assessed using the Neurobiologic Risk Score; behavioral characteristics were assessed by the Bayley Scales of Infant Development. Thirty-four of the infants were categorized as high biologic risk, with the remaining 68 infants in the low risk category. The researchers found that the infants in the higher biologic risk category demonstrated lower scores on measures of attention span and motor skills at the ages of 15 and 24 months than did the lower risk group.

Summary of Health Outcomes of Preterm Infants

In a 1993 epidemiological study, Bhushan, Paneth and Kiely developed a model to determine the influence of the improved survival rates of VLBW infants on the prevalence of cerebral palsy in the United States. They concluded that the prevalence of cerebral palsy increased from 1.9 per 1000 births in 1960 to 2.3 per 1000 births in 1986, and attributed this rise to the increased survival of VLBW infants. The authors were careful to point out, however, that "for every VLBW infant newly surviving with CP in 1986, 11 VLBW infants without CP will survive, who would not have survived in 1960" (p. 1099). The authors concluded that the key to decreasing the incidence of cerebral palsy lies in gaining a better understanding of when and how brain damage occurs in VLBW infants and in finding ways to prevent that damage from occurring. Neonatal nurses are the primary direct caregivers of preterm infants during the critical period of transition to extrauterine life. The opportunity and the challenge for nursing to contribute to the identification and implementation of care strategies to minimize brain damage and thereby improve long term outcomes of preterm infants clearly lies before us.

Central Nervous System Development and the NICU Environment

In order to better appreciate the many factors which may influence the health outcomes of preterm infants, it is important to have a basic understanding of the developmental processes that are occurring in the central nervous system during the period of time that the infant is a patient in the NICU. The initial formation of the central nervous system (CNS) occurs during the first six weeks of gestation, with the processes of dorsal induction and ventral induction. Dorsal induction is the process in which the neural tube is formed on the dorsal surface of the embryo; the neural tube ultimately evolves into the brain and spinal cord. This process primarily occurs during weeks 3 and 4 of gestation; problems with dorsal induction result in congenital anomalies such as spina bifida, myelomeningocele, encephalocele, and anencephaly. During weeks 5 and 6, the process of ventral induction takes place on the ventral surface of the embryo. During ventral induction, the embryonic structures which later become the brain undergo a series of divisions and differentiations in preparation for further evolution into specific structures. It is at this point of development that the structures that are precursors to the optic and olfactory systems are formed, and that the cerebral hemispheres, lateral ventricles, basal ganglia, thalamus, and hypothalamus are initiated (Nowakowski, 1987; Volpe, 1995).

After these basic structural divisions are formed, the process of creating the complex network of neurons begins. Neurons are the basic functional cells of the nervous system, responsible for the transmission of nerve impulse "messages" both within the nervous system itself and throughout all areas of the body. The formation of the neural network occurs in four stages: proliferation, migration, organization, and myelination. The initial stage of proliferation refers to the actual production of neurons. Neuronal proliferation occurs primarily during the 2nd to 4th months of gestation, with the peak period during the 3rd and 4th months. Neurons are produced in an area that lies just below the lining of the lateral ventricles, called the germinal matrix. Because thousands of neurons must be produced in a relatively brief time period, a tremendous amount of metabolic activity occurs within the germinal matrix. The matrix must therefore be supported with an adequate supply of nutrients and must also have an efficient means for removal of waste products; within the germinal matrix lies a complex network of very specialized capillaries which serves both of these needs. The germinal matrix is a unique embryologic structure which exists only during this time of central nervous system development. By approximately 32 weeks of gestation, the germinal matrix no longer exists as a discrete structure, having served its developmental purpose and then involuting into a normal capillary bed. However prior to this time the matrix capillaries are more prone to hemorrhage, due to the increased blood flow to meet the metabolic needs and because the structural supportive tissues of the brain are not yet fully formed. Therefore, periventricular and intraventricular hemorrhage occur almost exclusively in preterm infants, since the germinal matrix area is the site of origin of most of these hemorrhages and since it does not exist in term infants (Nowakowski, 1987; Volpe, 1995).

The second stage, neuronal migration, is the process by which the neurons which have been formed in the germinal matrix area migrate to their permanent sites of functioning within the central nervous system. The peak period during which neuronal migration occurs is from the 3rd through the 5th months of gestation. The third stage is the period of organization, the intricate process during which the thousands of neurons that have migrated to their permanent locations throughout the body become interconnected into a smoothly functioning messenger network. Neuronal organization begins at about the 5th month of gestation and continues until several years after birth. The fourth and final phase of myelination is the process in which the myelin sheath is deposited around the axons of the nerve cells, enabling nerve impulses to be transmitted much more rapidly. The peak period for myelination normally begins at the time of birth and the myelination process continues into adult life (Volpe, 1995).

Summary of Central Nervous System Development

The phase of neuronal organization is of particular importance when considering the developmental outcomes of preterm infants. With the lower limit of viability for preterm infants currently estimated to be at 22 to 23 weeks gestation, or approximately

5 1/2 months gestation, these extremely preterm infants are born at the time when the critical process of organizing the central nervous system is just beginning. All infants born prior to term are attempting to accomplish this critical task of CNS organization in the midst of the harsh NICU environment, rather than in the protected in-utero environment. It is important that neonatal nurses recognize the environmental risks to the infant's developing central nervous system and take steps to modify the NICU environment to foster optimal CNS development.

Developmental Intervention Programs and Preterm Infant Outcomes

During the past 30 years there has been a great deal of research regarding how to best support the developmental progress of preterm infants. Many intervention programs have been developed, with researchers reporting associated improvements in both short term and long term outcomes as a result of these programs. In a review of the effectiveness of intervention programs, Feldman and Eidelman (1998) point out that despite the fact that there is a "near-universal consensus" (p. 613) that intervention influences development, there appears to be a striking dichotomy in the theoretical assumptions upon which these intervention programs are based. Some intervention programs are based on the assumption that "infants suffer from the deprivation of the sensory stimuli they were programmed to receive in utero" (p. 614). Those who support this theoretical perspective favor interventions which provide increased sensory stimulation to the preterm infant, such as vestibular stimulation through the use of waterbeds, rhythmic sounds or rocking to mimic the intrauterine environment, or tactile stimulation through various "touch" interventions or massage therapy (Anderson, 1986;

Burns, Cunningham, White-Traut, Silvestri, & Nelson, 1994; Field, 1995; Resnick, Eyler, Nelson, Eitzman, & Bucciarelli, 1987).

The opposing theoretical perspective holds the primary assumption that preterm infants "are overloaded with sensory information that cannot be processed properly secondary to being deprived of the containing and buffering environment of the womb" (Feldman & Eidelman, 1998, p. 614). Supporters of this theoretical perspective advocate reduction of environmental stimuli. The most prominent example of this type of intervention program is the Neonatal Individualized Developmental Care and Assessment Program (NIDCAP), which is probably the most widely used program in the United States at this time. Several studies have been conducted which demonstrate support for the effectiveness of the NIDCAP model in improving both the developmental and the medical outcomes of infants, and in reducing hospital costs (Als et al., 1986; Als et al., 1994; Buehler, Als, Duffy, McAnulty & Liederman, 1995; Fleisher et al., 1995).

The Neonatal Individualized Care and Assessment Program (NIDCAP)

The Neonatal Individualized Care and Assessment Program (NIDCAP) is a developmental intervention program for preterm infants which is based on Als' synactive theory of development (VandenBerg, 1996). In the synactive theory, Als (1982) proposes that the preterm infant is a complex organism who is quite competent for survival in the normal in-utero environment, but who has been displaced into the extrauterine environment without the necessary competencies for survival outside of the uterus. The early introduction of the infant into the extrauterine world by a preterm birth irreversibly triggers the initiation of certain physiologic processes which are not yet mature. The synactive theory proposes that there are 5 behavioral subsystems through which the infant communicates: the autonomic, motor, state, attentional/interactive, and the self-regulatory subsystems (Als, 1984).

The implementation of the NIDCAP program is centered around a developmental specialist who has been specifically trained and certified in the NIDCAP approach. The developmental specialist performs formal assessments of the preterm infant at weekly intervals throughout the infant's hospitalization (Buehler, Als, Duffy, McAnulty & Liederman, 1995). Each NIDCAP assessment takes approximately an hour to complete — the infant is observed for 20 minutes prior to a medical or nursing caregiving intervention, during the entire caregiving intervention, and then for a 20 minute period following the completion of caregiving. The developmental specialist makes observations of 91 behaviors corresponding to the 5 behavioral subsystems of the synactive theory every 2 minutes during the entire observation period. After completing the observations, the developmental specialist writes a formal report of the infant's behavior, which includes "suggestions for restructuring and synchronizing stimulation and care giving procedures to the infant's sleep and wake cycles, in order to promote the infants' effectiveness and competence in regulating themselves" (Buehler, Als, Duffy, McAnulty & Liederman, 1995, p. 926). One research study reported that specific interventions recommended during the course of the study included the following:

> holding the infant nestled on the care giver's body for the promotion of restful sleep, relaxed alerting, and effective feeding and digestion; gently placing the infant in a flexed position and supportively holding the infant during and after procedures and taxing manipulations; instituting dark and quietness for prolonged periods around the 24-hour cycle; encouragement for use of the parent's hands in containing the infant

> during vital signs taking, diapering, etc. and gavage feeding nestled in the parent's arms and while nuzzling the mother's breast and/or sucking on a small pacifier. The care givers were encouraged to include the infant's parents in nurturing and caring for their infants from admission on. (Buehler, Als, Duffy, McAnulty & Liederman, 1995, p. 926).

The first published study reporting the effectiveness of the NIDCAP approach appeared in the journal Pediatrics in 1986 (Als, Lawhon, Brown, Gibes, Duffy, McAnulty & Blickman, 1986). This was a small study of 16 high risk very low birth weight preterm infants (8 experimental and 8 control) conducted in a nursery in which primary nursing was the nursing care delivery model. A phase lag design was used for the study instead of a random assignment methodology. This design was selected by the researchers because "the experimental manipulation entailed modification of nursing care giving based on the teaching and feedback about the behavioral cues of the infant, thus changing the care givers' behavior. Once the experimental phase started, the nurses involved with the experimental infants could not be expected to go back to preexperimental phase thinking and care giving" (Als, Lawhon, Brown, Gibes, Duffy, McAnulty & Blickman, 1986, p. 1124). The 8 infants assigned to the control group received standard care. The 8 infants assigned to the experimental group received care using the NIDCAP approach, with regular behavioral assessments performed by the developmental psychologist. The developmental psychologist reviewed the written report with a nurse who was a co-investigator on the research; the research nurse then collaborated with each infant's primary nurse to coordinate the integration of the written developmental plan into the infant's care.

When compared to the control group, infants in the experimental (NIDCAP) group were demonstrated to require fewer days on the ventilator ($p<.01$), require lower oxygen concentrations ($p<.01$), and to acquire feeding skills earlier ($p<.01$). The infants in the experimental group also were determined to have significantly better scores of behavioral regulation at an adjusted postconceptional age of 1 month as assessed using the "Assessment of Preterm Infant Behavior," a research tool developed by Als and associates, also based on the synactive theory of development (Als, Lester, Tronick, & Brazelton, 1982a & 1982b). In addition, infants in the experimental group scored significantly higher on both the Mental Developmental Index and the Psychomotor Developmental Index of the Bayley Scales of Infant Development at adjusted postconceptional ages of 3, 6, and 9 months.

Acknowledging that most Neonatal Intensive Care Units (NICUs) do not have a full time developmental specialist on staff to perform the formal NIDCAP observational assessments at regular intervals, Becker, Grunwald, Moorman, and Stuhr (1991) conducted a study in which they examined the effect of education of the nursing staff in the principles of the NIDCAP upon selected short term patient outcomes. Data were collected in two phases: subjects were enrolled as the control group and data were collected prior to providing the nursing staff with NIDCAP education. After the last control group infant was discharged from the hospital, the education of the nursing staff was begun. Each nursing staff member was trained in accordance with the NIDCAP training specifications, then the NICU's nursing standards of care were rewritten to incorporate guidelines for developmental care addressing the following five categories:

a.) reducing the stressful nature of the physical environment by reducing levels of light and sound;
b.) reducing the stressful nature of medical and caretaking interventions through provision of physical supports, aids for self-regulation (such as an object to grasp or a pacifier), and allowing a "time-out" for restabilization following periods of destabilization;
c.) promoting sleep/wake organization by clustering care to allow uninterrupted sleep periods and reducing light levels during sleep;
d.) promoting motor development by containing the infant's limbs to reduce random movement, providing support against gravity, and maintaining flexed positioning; and;
e.) facilitating development of feeding skills by providing opportunities for nonnutritive sucking during gavage feeding.

(Becker, Grunwald, Moorman, & Stuhr, 1991, p. 152).

The total number of subjects in the study was 45 (21 control, 24 experimental). The experimental subjects had significant decreases in age at first oral feeding, age at last gavage feeding, length of hospital stay, and degree of morbidity during the first four weeks of hospitalization (by the Neonatal Morbidity Scale), and a significant increase in the total score on the Neonatal Behavioral Assessment Scale (which was performed on each infant the week before discharge). There were no significant changes in degree of morbidity for the entire hospital stay, days of mechanical ventilation, days of continuous positive airway pressure, days of supplemental oxygen, incidence of chronic lung disease, incidence of intraventricular hemorrhage, or rate of weight gain. This same group of researchers reported a follow-up study focusing upon the effect of the intervention upon the behavioral organization of the infants (Becker, Grunwald, Moorman & Stuhr, 1993). Each infant was observed during an 18 minute sequence of caregiving twice weekly for the duration of the infant's hospitalization for levels of oxygen saturation, motor activity, posture, and activity states. The infants in the experimental group demonstrated significantly higher oxygen saturation levels, fewer jerking movement patterns, and were observed in flexed postures and awake states significantly more often than the control infants.

The first randomized controlled trial of the NIDCAP approach was reported by Als, Lawhon, Duffy, McAnulty, Gibes-Grossman and Blickman in the Journal of the American Medical Association in 1994. The study sample consisted of 38 high risk very low birth weight infants less than 30 weeks gestation at birth who required mechanical ventilation; 18 infants were assigned to the control group and 20 infants to the experimental group. The formal NIDCAP assessments and developmental care plans were performed by either the psychologist who had performed the assessments in the 1986 study or the research nurse from the 1986 study (who was a clinical nurse specialist with developmental training). Nursing care was provided to the infants in the experimental group by a group of nurses who had volunteered to receive developmental education. As compared to the infants in the control group, the infants in the experimental group who received care in accordance with the NIDCAP program were demonstrated to require an average of 35.5 fewer days of mechanical ventilation ($p = .06$) and 82.6 fewer days of oxygen support ($p = .05$), to achieve oral feeding an average of 44.9 days earlier ($p = .05$), to have a shorter length of hospital stay (by an average of 64 days, $p = .04$), and to have lower hospital charges (by an average of $91,000, $p = .04$) and to have improved weight gain. The incidence of intraventricular hemorrhage, pneumothorax, and of severe bronchopulmonary dysplasia were also significantly lower in the experimental (NIDCAP) group, although the total number of cases of bronchopulmonary dysplasia was increased in the NIDCAP group. The experimental group also had significantly better behavioral scores at an adjusted postconceptional age of 2 weeks as measured by the "Assessment of Preterm Infant Behavior" and significantly better scores on the Mental Developmental Index and Psychomotor Developmental Index of the Bayley Scales of Infant Development at an adjusted postconceptional age of 9 months.

In discussing the limiting factors of their 1994 study, Als et al. reported the following:

> A further factor to be considered in interpreting the results of this study is the possible differential skill, maturity, previous NICU experience, and motivation of the nursing staff who volunteered for developmental education, which might have accounted for the improved outcome in the intervention group. However, the nurses who volunteered were significantly younger (29 $\pm$ 3 vs. 32 $\pm$ 4.3 years; $p<.002$) and had fewer years of NICU experience (4.7 $\pm$ 3 vs. 7.1 $\pm$ 4.3 years; $p<.005$). Motivation is harder to measure. It will be important to study the success of developmental education for staff who are required to obtain such education, rather than who volunteer to do so. (Als et al., 1994, p. 858).

As a corollary to their 1993 study of infant behaviors, Becker et al. did examine the change in nurse practice patterns following developmental education using the NIDCAP program and found that, at least on a short-term basis during a research study situation, the nurses' practice patterns did change with respect to selected variables.

At least two other studies of the NIDCAP approach have been reported in the literature. Fleisher, VandenBerg, Constantinou, Heller, Benitz, Johnson, Rosenthal and Stevenson, (1995) examined the effectiveness of the NIDCAP approach in a sample of 35 high risk very-low-birth-weight premature infants. Seventeen infants were randomly assigned to the experimental group and 18 infants were assigned to the control group. The control group received care according to the unit's routine standards of care, including primary nursing. The experimental group received regular assessments by certified developmental specialists. Introductory level developmental training was provided to 76 of the 185 nurses of the unit; 15 of the nurses completed a more advanced behaviorally oriented training course and volunteered to serve as primary nurses for the infants in the experimental group. Parents were encouraged to be actively involved in their infant's care and were provided with support on a daily basis by the developmental specialists and primary nurses. The infants in the experimental group required significantly fewer days of ventilation and were assessed to have a lower level of "chronicity" than the control group (assessed as discharge from the hospital after 42 weeks postconceptional age). The experimental group was also assessed to have significantly better developmental outcomes as measured by the "Assessment of Preterm Infant Behavior." Buehler, Als, Duffy, McAnulty and Liederman (1995) evaluated the effectiveness of the NIDCAP approach with low risk premature infants, comparing an experimental group of 12 low risk preterm infants with a control group of 12 low risk preterm infants and a group of 12 full term infants without identified risk criteria. The preterm experimental group demonstrated behavioral and electrophysiological performances which were comparable to those of the full term infants; the performance of the preterm control group was poorer than that of the experimental group and the full term group.

Nurses' Experiences with the Implementation of the NIDCAP Approach

In order to gain insight into the effect that the implementation of a NIDCAP-based developmental care approach has upon neonatal nurses, Premji and Chapman (1997) conducted a qualitative study using grounded theory methodology to describe the experiences of nurses with the implementation of a NIDCAP-based developmental care approach (DCA) in an NICU. In the initial implementation of the program, all of the nurses were either trained in the NIDCAP assessment technique or were provided with an introduction to the philosophy of the DCA. This qualitative study was conducted four years after the initial introduction of the DCA to the nursery. Through purposive sampling, the researchers recruited a sample of eight staff nurses which included 4 subjects who were originally supportive of the implementation of the DCA and 2 nurses who were originally strongly opposed to the DCA. The finding that emerged from this study was that the staff nurses in this NICU now identified a basic social process of "putting the baby first" (Premji & Chapman, 1997, p. 101). The nurses involved in this study stated that they now acted as advocates for the needs of the baby (as perceived through the developmental perspective) and gave precedence to the perceived needs of the baby over both the demands of other health professionals and of the desires of the parents. One nurse participant explained her belief in the following words:

> So you had to be aggressive in making sure . . . you control — like you could make up the time (schedules) when the doctor could go in to see [examine] that baby — that was probably the hardest to get used to — that you were person that was in control. (Premji & Chapman, 1997, p. 106).

Another nurse participant described encounters with parents as follows:

> Sometimes there is a bit of a conflict with parents as far as them wanting to go into the isolette and touching the baby and to do things. But, our basic philosophy is to involve the parents as much as possible and . . . we explain the developmental care assessment to them. (Premji & Chapman, 1997, p. 106).

All of the nurses participating in this study reported that they encountered conflicts both with parents and other health professionals as they attempted to practice the DCA.

The authors reported that parent-nurse conflicts were at times marked by parental statements such as "This is my child and I will . . . " (Premji & Chapman, 1997, p. 106). Nurses attempted to reconcile differences with parents by providing directions to parents such as "come at such and such a time if you want to visit because the baby will be up then." (Premji & Chapman, 1997, p. 106).

The authors viewed this finding of "putting the baby first" as a paradox, since Als' model of developmental caregiving suggests that nurses using this approach should "view the infant within the larger context of the family" (Premji & Chapman, 1997, p. 107) and therefore should put the family first. The authors were not able to determine a reason that the nurses did not adopt the "family-centered" philosophy as set forth in Als' model. This paradoxical finding of "putting the baby first" associated with the implementation of a developmental care approach in an NICU is concerning and should be studied further. Since the long term goal of neonatal nursing care should be to return a healthy infant to a strong family unit, it is imperative that nurses work as a team with parents and with other health care providers throughout the infant's hospitalization, and that a family-centered care approach be utilized by all health care providers.

Summary of Developmental Intervention Programs and Preterm Infant Outcomes

The research studies of the NIDCAP approach which have been conducted thus far demonstrate support for the effectiveness of the program in improving the health outcomes of preterm infants and in reducing the utilization of health care resources by this high risk group of patients. However, the implementation of the formal NIDCAP program has not been possible for many NICUs, due in large part to the lack of available funding for the initial training costs and for maintaining an appropriately trained developmental specialist on the NICU staff to perform the formal NIDCAP developmental assessments on each patient on a regular basis. In an effort to meet the developmental needs of their patients, many of these NICUs have attempted to educate the nursing staff on developmental caregiving techniques for preterm infants and to directly integrate the basic principles of developmental caregiving into the nursing care standards of the unit. This would appear to be a logical approach, as the bedside nurse is the person who is actually administering the direct caregiving intervention in the NIDCAP program, with the developmental specialist providing recommendations and support to the nursing staff. If the professional neonatal nurse is sufficiently knowledgeable regarding developmental caregiving, then the developmental care of most patients could be effectively planned and managed by the nurse as an integral part of the infant's holistic nursing plan of care. There is a great need for outcome-based nursing studies to evaluate the effectiveness of developmental caregiving that is planned and delivered by nurses as a part of a holistic nursing plan of care.

Successful Oral Feeding as a Marker of Health in Preterm Infants

The preterm infant in the Neonatal Intensive Care Unit is confronted with a multitude of developmental tasks which must be successfully completed before discharge from the hospital. One of the most important tasks to be accomplished is successful oral feeding — the ability to obtain adequate nutritional intake for metabolic needs and growth by bottle- and/or breast-feeding alone (without volume supplementation by gavage feeding). The fact that infant feeding is such an integral and essential component of infant growth and development disguises the fact that the feeding act is actually a very complex physiologic process which must be learned by the infant, usually within the context of a nurturing parent-child relationship (Stevenson & Allaire, 1991). Preterm infants face many obstacles which are not faced by healthy term infants. These obstacles include delay of initiation of feedings due to medical complications, immaturity of the central nervous system with subsequent delay in coordination of the suck-swallow-breathe triad, and exposure to the harsh neonatal intensive care environment.

Medical Complications and Feeding

The unique physiology of the preterm infant exposes these infants to a constellation of medical problems faced by no other patient population. Respiratory problems include respiratory distress syndrome (related to essential surfactant deficiency), hypoplastic lungs (the structural absence of sufficient alveolar tissue for adequate gas exchange), and bronchopulmonary dysplasia (a chronic lung disease). Patent ductus arteriosus is a common cardiac problem among preterm infants. Evolutionary changes occurring in the cerebral circulation make the infant highly susceptible to intraventricular hemorrhages, while the immaturity of the central nervous system often leads to problems such as apnea of prematurity. The immaturity of the gastrointestinal system causes problems with nutrient absorption and the potential for the development of the life-threatening disorder necrotizing enterocolitis. Both the immune system and the integumentary system are immature, placing the preterm infant at high risk for infection, even from bacteria are usually harmless to children and adults.

Effective medical and surgical therapies are available for many of these problems, but the greatest weapon is time — time for the infant to grow and mature, and to develop the physiologic capabilities necessary for survival in the extrauterine environment. Meticulous nursing care is essential to ensure that the infant gains the needed time to grow and mature. During the acute phase of the illness, all of the infant's energy must be directed toward recovery and growth; therefore, nutritional support is provided either parenterally (through the intravenous route), or enterally via gastric or transpyloric tubes, with the initiation of oral feeding often delayed until many weeks, or even months after birth.

Central Nervous System Immaturity and the Suck-Swallow-Breathe Triad

As reviewed earlier, although the gross structural elements of the central nervous system (CNS) are in place by 6 weeks gestation, the CNS continues to develop and mature throughout gestation and into the first few years of postnatal life. The CNS is composed of two cell types: glial cells and neuronal cells. The glial cells are the structurally supportive cells, which provide form to the nervous tissue. The neuronal cells, or neurons, are the conducting cells of the nervous system, through which nerve impulses are transmitted (Friel, 1974). The incoordination of the "suck-swallow-breathe" triad in the infant born prematurely is one of the many behavioral cues which reflect the immaturity of the neuronal network.

The sucking movements of the newborn infant are strictly reflexive movements, and occur quite early in fetal life, with the initial components observed "in utero" as early as 7 to 8 weeks gestation. By 28 weeks gestation the components of sucking and swallowing appear to be present, but the coordination of sucking and swallowing does not occur until 32 to 34 weeks (Goldson, 1987; Jain, Sivieri, Abbasi, & Bhutani, 1987). Studies of preterm infants have shown that although initial coordination of suck-swallow-breathe is evident by approximately 34 weeks post-conceptual age (PCA), consistent coordination is not present until at least 37 weeks PCA (Bu'Lock, Woolridge, & Baum, 1990; Burns, Rogers, Neil, Brazier, Croker, Behnke, & Tudehope, 1987).

The sucking reflex consists of two mechanical components, expression and suction. In expression, the infant applies pressure to the nipple by elevating the tongue and moving the tongue in a backward motion. The nipple is compressed between the tongue and the hard palate, and the backward motion of the tongue stimulates flow of milk out of the nipple. The second component of the reflex, suction, occurs when the tongue is lowered back to the floor of the mouth, creating a negative pressure in the oral cavity which further stimulates milk flow (Goldson, 1987). The degree of suction generated by the infant's suck is stronger when a tight seal of the infant's tongue and lips around the nipple is present (Wolf & Glass, 1992, p. 18). To initiate the swallow reflex, the infant's tongue first forms a groove (or trough) longitudinally in the central portion, in which the milk is collected. Peristaltic action propels the bolus of milk backwards until it reaches the posterior pharyngeal wall, which activates the swallow reflex. The soft palate closes to protect the nasopharynx, the glottis closes to protect the trachea, and the bolus moves by peristalsis down the esophagus (Stevenson & Allaire, 1991).

In the coordinated suck-swallow-breathe cycle of nutritive sucking, bursts of sucking are followed by swallowing and breathing in a 1:1:1 sequential pattern (Bu'Lock et al., 1990). Infants lacking coordination of sucking, swallowing, and breathing are obviously at great risk for respiratory compromise during oral feeding attempts, with infants with preexisting respiratory problems at greatest risk. Therefore, assessment of post-conceptual age and neurologic competency is essential before initiation of oral feedings.

Nursing Research Studies Related to Preterm Infant Feeding

Many nursing research studies have been published which examine various aspects of the preterm infant bottle-feeding experience (Collinge, Bradley, Perks, Rezny, & Topping, 1982; deMonterice, Meier, Engstrom, Crichton, & Mangurten, 1992; Gill, Behnke, Conlon, McNeely, & Anderson, 1988; Gill, Behnke, Conlon, & Anderson, 1992; Hill, 1992; McCain, 1995; McCain, 1997; Medoff-Cooper, 1991; Medoff-Cooper, Weininger & Zukowsky, 1989; Pickler, Frankel, Walsh, & Thompson, 1996; Pickler, Higgins, & Crummette, 1993; Pridham, Sondel, Chang, & Green, 1993; Saunders, Friedman, & Stramoski, 1991; Shiao, 1997; Shiao, Youngblut, Anderson, DiFiore, & Martin, 1995; Schwartz, Moody, Yarandi, & Anderson, 1987; Weaver & Anderson, 1988). However, since the traditional approach has been to initiate preterm infant feedings by bottle rather than by breast-feeding, less research related to preterm infant breast-feeding has been reported (Meier, 1988; Meier & Anderson, 1987; Young, 1995).

Major Findings

A review of the results of these nursing research studies related to the preterm infant feeding reveals the following:

1. Preterm infants fed on demand schedules had fewer feedings per day, and therefore

longer rest periods between feedings. Although the total volume of oral intake was less for demand-fed infants than for schedule-fed infants, no significant difference was noted in weight gain. The demand-fed infants also demonstrated more subtle hunger cues than schedule-fed infants, and took a greater percentage of their total formula intake by bottle (i.e., required fewer gavage feedings). A decrease in days of hospitalization was also observed in the demand fed group (Collinge, Bradley, Perks, Rezny, & Topping, 1982; Saunders et al., 1991).

2. Infants provided with a period of nonnutritive sucking before bottle-feeding were in awake states at the time of initiation of bottle-feeding more often than infants not provided with a nonnutritive sucking period, particularly the alert inactive and quiet awake states (Gill et al., 1992; Gill et al., 1988; Pickler, Frankel, Walsh, & Thompson, 1996), and had fewer changes in behavioral state during the feeding (McCain, 1995). Infants receiving nonnutritive sucking also exhibited significantly greater weight gain than infants not receiving nonnutritive sucking (Gill et al., 1992; Gill et al., 1988). Infants receiving nonnutritive sucking before bottle-feeding were more likely to be in a quiet state five minutes after completion of bottle-feeding. Scores of feeding ability were higher for infants receiving nonnutritive sucking (Pickler et al., 1993). Behavioral state at initiation of feeding is believed by many clinicians to be an important predictor of successful bottle-feeding, with the drowsy, quiet awake and active awake states considered the optimal states for feeding (Gill et al., 1988; McCain, 1997).

3. Significant changes in oxygenation were exhibited by preterm infants during bottle-feedings (Meier, 1988; Meier & Anderson, 1987; Pickler et al., 1993). An inverse relationship was observed between the volume of formula consumed in the first 3 minutes of bottle-feeding and respiratory rate (Hill, 1992). Tracings of transcutaneous oxygen pressure remained more stable during breast-feeding by preterm infants than during bottle-feeding (Meier, 1988; Meier & Anderson, 1987). Preterm infants exhibited a greater number of oxygen desaturation episodes during bottle feedings as compared to breast feedings (Young, 1995).
4. Preterm infants were observed to use different sucking mechanisms with breast-feeding than with bottle-feeding, with better suck-swallow-breathe coordination noted with breast-feeding (Meier & Anderson, 1987).
5. Measurements of sucking behavior were greater for term infants than for preterm infants, with a gradual upward trend in measurements appearing at approximately 34 weeks post-conceptual age (Medoff-Cooper, 1991; Medoff-Cooper, Weininger, & Zukowsky, 1989).

Summary of Successful Oral Feeding as a Marker of Health

These research studies of feeding by preterm infants have produced a significant body of knowledge that is very relevant to the practice of neonatal nursing. Other nursing research studies have demonstrated that the presence of health problems such as bronchopulmonary dysplasia and apnea of prematurity influences the length of time required to complete the transition to oral feedings (Mandich, Ritchie, & Mullett, 1996; Pridham, Sondel, Chang, & Green, 1993). The potential positive effects of such simple interventions as consistently providing nonnutritive sucking prior to bottle-feeds and allowing demand feeding rather than scheduled feedings should not be ignored. Of concern, however, is the fact that the interventions that are most frequently recommended in the practice-oriented literature do not appear to be strongly research based, but rather appear to be based upon the individual experiences of clinicians. Examples of such recommendations include: modifying light and noise levels during feedings; eliciting specific behavioral states before initiating feedings and modifying feeding technique in response to state changes; providing consistent caregivers; providing frequent rest period during feedings; setting time limits for feeding attempts; varying the taste, temperature and consistency of formula; and guidelines for nipple selection (VandenBerg, 1990; Wolf & Glass, 1992). The common thread in all of these interventions is the nurse. Since neonatal nurses and ancillary nursing staff members are the primary caregivers for preterm infants during the period of transition to oral feeding, the success of this transition would appear to reflect not only the infant's health status, but also the effectiveness of the nursing care provided.

Levine's Conservation Model of Nursing Applied to the Care of Preterm Infants

Although Levine initially published her Conservation Model of Nursing in the 1960's, there have been few nursing research studies reported in the literature using the Conservation Model as a theoretical framework. A literature search revealed 7 nursing research studies based on the Conservation Model. Five of these studies focused on adults, with the various studies addressing oxygen consumption, cardiovascular response, and perceived exertion in healthy adults (Lane & Winslow, 1987), the onset of confusion in hospitalized non-surgical elderly patients (Foreman, 1989), the prevalence and incidence of pressure ulcers in hospice patients (Hanson, Langemo, Olson, Hunter, Sauvage, Burd & Cathcart-Silberberg, 1991), the experience of fatigue in patients with congestive heart failure (Schaefer & Potylycki, 1993) and factors related to sleep pattern disturbances in patients undergoing coronary artery bypass graft surgery (Schaefer, Swavely, Rothenberger, Hess & Williston, 1996). The final two studies applied the Conservation model to preterm infants. In an unpublished Master's thesis, Mefford (1989) explored the relationship of supine positioning versus flexed lateral positioning on the activity state, oxygen requirements, heart rate and blood pressure stability of mechanically ventilated preterm infants. Deiriggi and Miles (1995) examined the effects of the use of a waterbed on heart rate in medically stable preterm infants.

These nursing research studies provide support for the utility of Levine's Conservation Model of Nursing as a framework to guide nursing practice and research, particularly in the population of preterm infants. Levine's Conservation Model was also applied theoretically to the nursing care of preterm infants by Langer (1990), who used the model to construct a "minimal handling protocol" to guide the nursing care of high-risk neonates during the adaptation to extrauterine life.

Summary of Levine's Conservation Model of Nursing Applied to Preterm Infants

Nursing as a discipline and as a science is in a period of transition. During the 1940's and 1950's, nursing leaders identified the need to develop a nursing research knowledge base, and nursing research studies began to proliferate. During the 1980's, there was a strong emphasis on nursing theory development, and that emphasis is now shifting to one of theory utilization (Alligood, 1997). Theory can and should be used not only to guide nursing practice but also to guide the evaluation of the effectiveness of nursing practice in achieving desired patient outcomes. Additional research using the Conservation Model needs to be conducted in order to more completely evaluate the usefulness of the model as a tool to advance nursing science. The results of this study contribute useful information for the evaluation of the Conservation Model as a tool to guide the nursing care of preterm infants.

Summary of Review of the Literature

This review of the literature has summarized the current knowledge base related to: (1) health outcomes of preterm infants; (2) central nervous system development and the NICU environment; (3) the use of developmental intervention programs to improve preterm infant health outcomes; (4) successful oral feeding as a marker of health in preterm infants; and (5) the use of Levine's Conservation Model as a theoretical frame for nursing practice and research. Although a great deal of knowledge related to the care of preterm infants has been amassed, there is a need for additional research studies based within a nursing theoretical framework to promote continued development of an evidence based foundation for neonatal nursing practice.

CHAPTER 3

METHODS

The purpose of this study was to examine the relationship of nursing care to the health outcomes of preterm infants by testing a middle range Theory of Health Promotion for Preterm Infants based on Levine's Conservation Model of Nursing. Research with the goal of theory testing is essential in order to expand the scientific knowledge base of nursing and thus advance the discipline of nursing.

Research Design

This descriptive study was designed to explore the relationships among the major constructs described in Levine's Conservation Model of Nursing with respect to the health outcomes of preterm infants. The methodological approach selected for this research study was causal modeling, with the specific statistical method of structural equation modeling. An experimental design was judged to be inappropriate for this study, because the primary intervention of interest is the manner in which nursing care is provided. In order to test for the effect of the intervention of nursing in an experimental design, it would be necessary to withhold or to modify nursing care in certain ways which are theorized to be less beneficial for the patient (for example, to provide less consistency in nursing caregivers for some patients). Since this would not be an ethical practice, the decision was made to construct an observational study in which there would likely be a variety in the manner of nursing care delivery, but this would be in no way influenced by the researcher. Further, the decision to conduct the study in a retrospective manner eliminated the possibility that the nurses making the patient assignments would alter their normal decision-making processes because the research study was taking place. Structural equation modeling was selected as the methodology because it permits the researcher to test hypotheses and to make causal inferences using correlation data gathered from observation rather than using data gathered by strict experimental design (Hickey, 1993).

Methodological Assumptions

Two primary methodological assumptions related to this study were as follows:

(1) Although nursing practice at the study site was not specifically guided by the use of Levine's Conservation Model of Nursing during the study period, it was assumed that the nursing interventions which were implemented were compatible with the goals of nursing care as described in the middle range theory of health promotion for preterm infants based on Levine's Conservation Model.

(2) Although it was acknowledged that health outcomes, morbidity, and resource utilization were also influenced by the other health care providers who were simultaneously providing care to the infants described in the study sample, it was assumed that the differential effects related to health care providers other than nurses were randomly distributed within the study sample.

Overview of Statistical Methodology

The statistical technique of path analysis was developed by Sewell Wright in 1918, with techiques for structural equation modeling first developed during the 1970s by Jöreskog and Wiley (Hickey, 1993). Structural equation modeling is an explosion of the mathematical model for factor analysis which allows not only the determination of which measurement variables appropriately reflect the specific factors, but also allows conditions of causation to be imposed within the factor analysis model (for example, factor X causes factor Y, or Factor X precedes Factor Y in time). An important theoretical constraint of structural equation modeling is that causal statements are never proven using the structural equation modeling technique; the proposed causal statements of the theory are only confirmed or disconfirmed with respect to the data in the sample (Hickey, 1993).

Structural equation modeling permits the exploration of the relationships between specified latent variables (or constructs). Latent variables are concepts which are postulated to exist, but which cannot be measured by direct methods (such as intelligence or health). In the structural equation modeling method, relationships among latent variables can be examined by selecting specific manifest variables which measure the character of the latent variables. A path diagram is constructed which specifies the postulated relationships between the latent variables in accordance with the theory to be tested. The structural equation modeling computer program is then written to test whether the sample data confirm the specified paths.

As described by Hickey (1993) and Hoyle (1995), there are four steps to structural equation modeling:

1. Specification of the model.

   This step involves the drawing the path diagram which indicates the postulated relationships between the latent variables (or constructs) and selecting the measurement variables to represent each latent variable (as directed by the theory to be tested and on existing knowledge).

2. Identification.

   This step involves determining from a theoretical and statistical basis whether there is sufficient information available to perform the structural equation modeling test.

3. Estimation of the model.

   Two models must be estimated in the structural equation modeling test. First a "measurement model," or confirmatory factor analysis is performed. This model provides evidence of how well the specified manifest variables actually measure the latent variables (by calculating factor loading scores for each of the specified manifest variables, so that judgements can be made regarding how well the selected measurement variables actually reflect the latent variables). After evaluating the fit of the measurement model and making any necessary adjustments, the second model is run. The second model is the actual structural equation model. In this second model, the computer program is rewritten to force the data to interact only through the paths which have been specified in the path diagram. The computer program calculates "path weights" for each path specified in the model, which provides information as to the strength of the relationships between the latent variables. (These path weights are analogous to the Beta weights calculated by the multiple regression technique.)

4. Assessment of model fit.

   As described in # 3 above, the assessment of model fit is performed after both the measurement model and the structural equation model are run. Model fit determines whether the data in the sample confirm or fail to confirm the hypothesized path diagram. Structural equation modeling computer programs calculates several types of "goodness of fit" indices with which to evaluate the model.

Research Questions

This study explored three research questions related to the health outcomes and economic outcomes of preterm infants in an NICU. The primary research question addressed in this study was:

How do the intensity of nursing care and the consistency of nursing caregivers relate to the health status of preterm infants at the time of initial hospital discharge?

The two subsidiary questions addressed were:

1.) How do the intensity of nursing care and the consistency of nursing caregivers relate to the level of morbidity of preterm infants at the time of hospital discharge?

2.) How do the intensity of nursing care and the consistency of nursing caregivers relate to the utilization of health care resources by preterm infants during the initial hospital stay?

Three path diagrams (or structural models) were constructed to illustrate the relationships which were postulated between the variables. The path diagram for the primary research question addressing health outcomes shown as Figure 2 on page 69. The path diagram for subsidiary research question # 1, which also addresses health outcomes, is shown as Figure 3 on page 70, and the path diagram for subsidiary research question # 2, which addresses economic outcomes, is shown as Figure 4 on page 71.

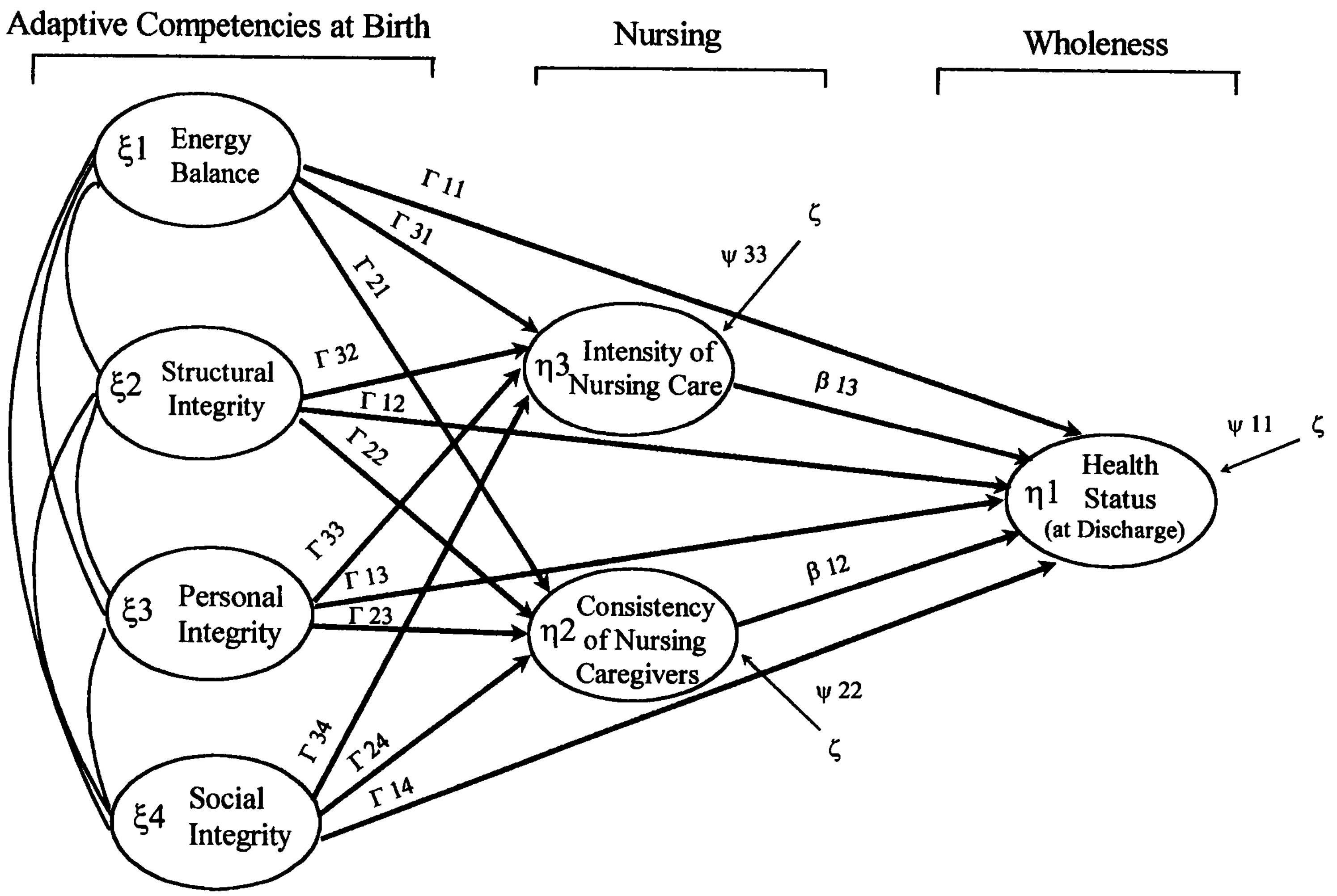

Figure 2. Path Diagram for Primary Research Question

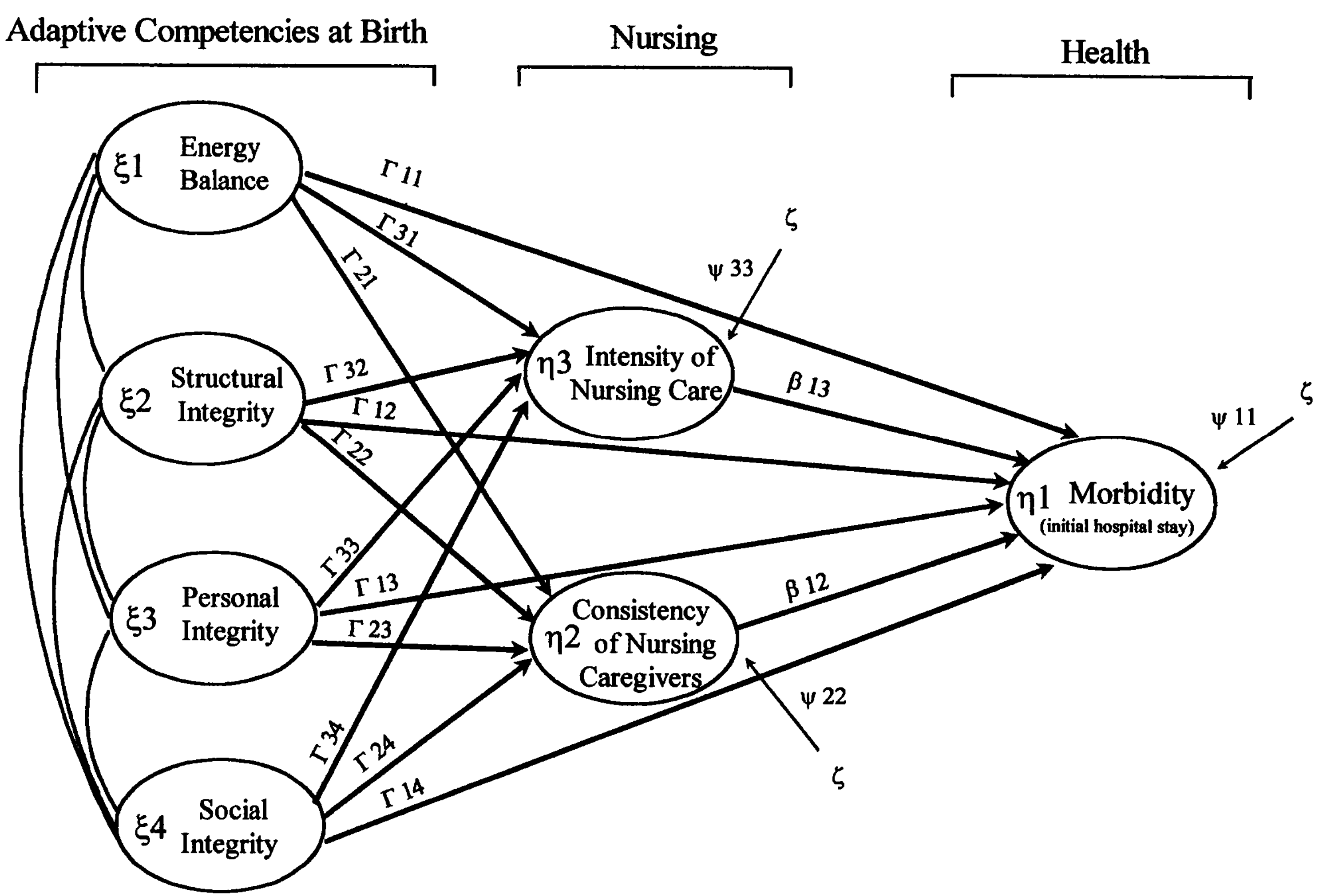

Figure 3. Path Diagram for Subsidiary Research Question # 1 (Morbidity Endpoint)

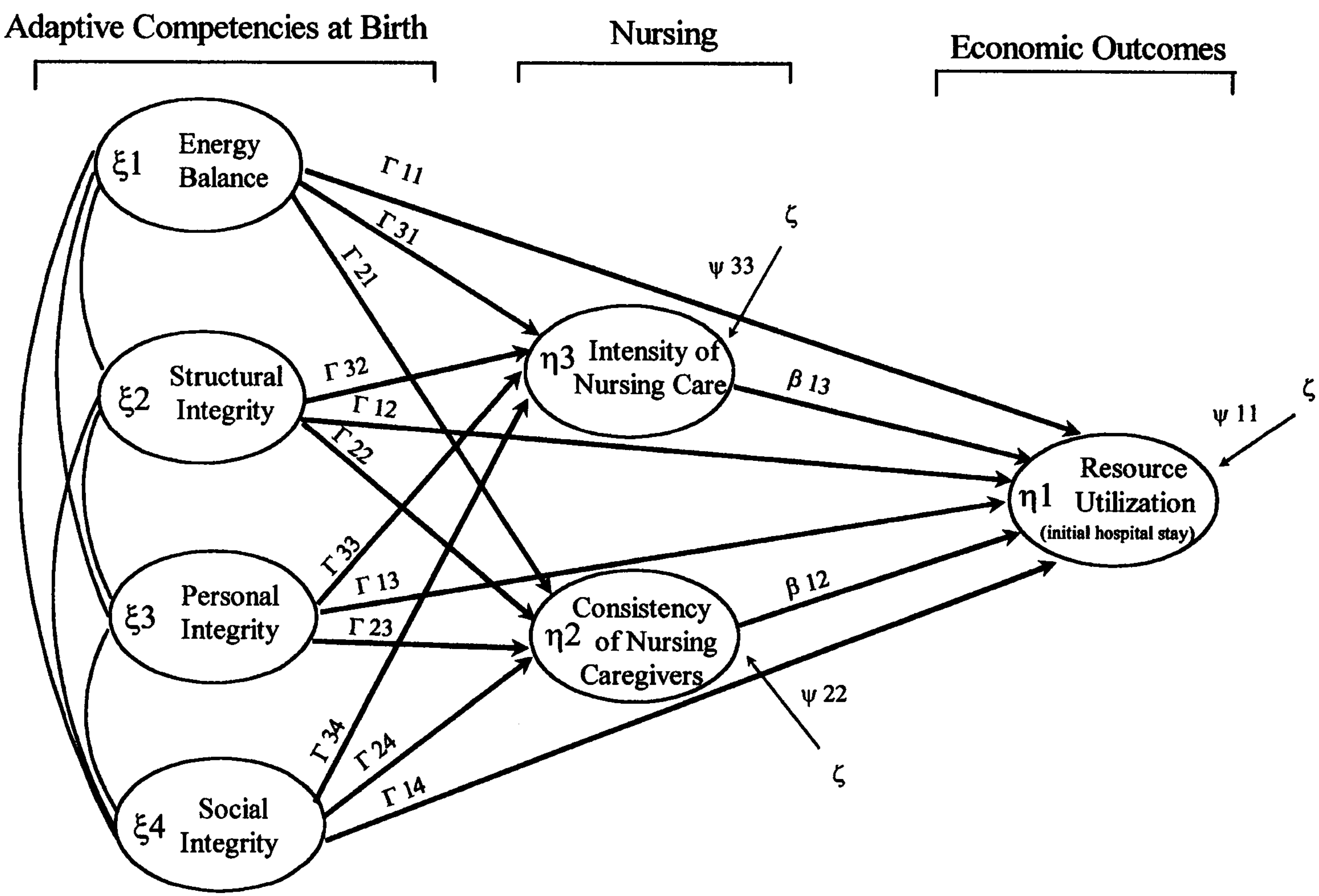

Figure 4. Path Diagram for Subsidiary Research Question # 2 (Resource Utilization Endpoint)

Study Variables

Nine latent variables were of primary concern in this study: energy balance, structural integrity, personal integrity, social integrity, intensity of nursing care, consistency of nursing caregivers, health status, morbidity and resource utilization. Since latent variables cannot be measured directly, they were measured by 35 manifest variables, which were used in the structural equation modeling tests of the three research questions. The theoretical definitions of these latent variables are listed below.

Energy Balance: Physiologic stability of the infant at birth. This concept reflected the capability of the infant to independently perform the physiologic processes necessary for survival in the extrauterine environment, as measured by oxygenation and ventilation status during the first 12 hours of life.

Structural Integrity: Structural maturity of the infant at birth. This concept reflected the level of structural maturity achieved by the infant "in-utero" and the readiness of the infant to survive in the extrauterine environment as measured by the post-conceptional age at birth and the infant's birth weight.

Personal Integrity: Neurodevelopmental maturity of the infant at birth. This concept reflected the infant's adaptive capacity and the competency of the central nervous system at birth as, measured by the Apgar socres at 1 and 5 minutes of age and the level of resuscitation required at the time of birth.

Social Integrity: Stability of the family system at the time of the infant's birth. This concept reflected integrity measures related to the family of the infant, such as parental age, cultural background, and socioeconomic status .

Consistency of Nursing Caregivers: The frequency with which nursing care was provided to the infant by the same nursing caregivers during the initial hospital stay. This concept reflected the assumption that caregivers who provided care for the infant on a more frequent basis should have been more attuned to the infant's unique behavioral cues and should therefore have been able to deliver nursing care in a manner that more effectively supported the infant's unique adaptive patterns.

Intensity of Nursing Care: The skill and knowledge level of nursing caregivers and the average number of other patients for whom the caregivers were also simultaneously providing care during the initial hospital stay. Higher levels of nursing skill and knowledge and fewer numbers of other patients should have facilitated the design and implementation of nursing interventions which more effectively supported the infant's unique adaptive patterns.

Health Status: The wholeness and integrity of the infant at the time of initial hospital discharge. This concept was reflected by the post-conceptional age at which the preterm infant achieved certain developmental milestones which indicate that a basic level of independent functioning in the extrauterine environment has been attained, and also by indicators of growth and morbidity.

<u>Morbidity:</u> The level of wholeness or integrity attained by the infant at the time of initial hospital discharge, as measured by the presence and severity of certain health problems unique to the preterm infant population.

<u>Resource Utilization:</u> The health care resources utilized by the infant during the initial hospital stay. This concept reflected the economic outcomes achieved during the stay, as measured by the length of hospital stay and by the number of days that the infant required certain resource intensive therapeutic interventions.

These latent variables were measured using 35 manifest variables. The specific manifest variables used to measure each of the latent variables in the structural equation models are described in Table 1 on page 75, Table 2 on page 76 , Table 3 on page 77, and Table 4 on page 78. Table 1 describes the exogenous variables, or independent variables. These variables represented the infant's adaptive potential at birth as viewed through the framework of Levine's four conservation principles. Table 2 describes the mediating variables which represented the construct of "nursing" as operationalized by the dimensions of intensity of nursing care and consistency of nursing caregivers. Table 3 describes the variables which were used to measure the health outcome endpoint for the primary research question (of health status at discharge). Table 4 describes the variables

Table 1. Exogenous Manifest Variables for All Research Questions. (Independent Variables).

Latent Variable	LISREL Symbol	Manifest Variable	Measurement Units	Scale
Energy Balance.	x_1	Surfactant therapy.	Categorical score: 0 = no; 1 = yes.	Ordinal.
	x_2	Minimum appropriate fraction of inspired oxygen (FiO_2) during the first 12 hours of life.	Percentage.	Continuous. (Ratio).
	x_3	Maximum appropriate fraction of inspired oxygen (FiO_2) during the first 12 hours of life.	Percentage.	Continuous. (Ratio).
	x_4	Maximum base excess during the first 12 hours of life.	Milli-osmoles per liter.	Continuous. (Ratio).
Structural Integrity.	x_5	Gestational age at birth. (Or post-conceptional age at birth).	Weeks.	Continuous. (Ratio).
	x_6	Birth weight.	Grams.	Continuous. (Ratio).
Personal Integrity.	x_7	Apgar score at 1 minute of life.	Score from 0 - 10.	Ordinal.
	x_8	Apgar score at 5 minutes of life.	Score from 0 - 10.	Ordinal.
	x_9	Resuscitation at birth.	Categorical score: 0 = None. 1 = Oxygen. 2 = Bag/mask. 3 = Endotracheal tube. 4 = Drugs.	Ordinal.
Social Integrity.	x_{10}	Maternal age.	Years.	Continuous. (Ratio).
	x_{11}	Race.	Categorical score: 0 = Caucasian. 1 = Other.	Ordinal.
	x_{12}	Prenatal care during pregnancy.	Categorical score: 0 = None. 1 = Limited. 2 = Complete.	Ordinal.
	x_{13}	Mother's health insurance status at the time of birth.	Categorical score: 0 = None. 1 = Government. 2 = Private.	Ordinal.

Table 2. Endogenous Manifest Variables for All Research Questions. (Mediating Variables).

Latent Variable	LISREL Symbol	Manifest Variable	Measurement Units	Scale
Intensity of Nursing Care.	y_6	Percent of total nursing care hours with direct care provided by an R.N. during the Neonatal Intensive Care Unit (NICU) stay.	[(# of shifts care provided by an RN during NICU stay) ÷ (total # of shifts infant cared for in NICU)] x 100.	Continuous. (Ratio).
	y_7	Percent of total nursing care hours with direct care provided by an R.N. during the Intermediate Care Nursery (IMCN) stay	[(# of shifts care provided by an RN during IMCN stay) ÷ (total # of shifts infant cared for in IMCN)] x 100.	Continuous. (Ratio).
	y_8	Average (mean) number of other patients cared for by the nursing caregiver during the NICU stay	∑ (# of other patients cared for each shift by each caregiver) ÷ total number of shifts in NICU.	Continuous. (Ratio).
	y_9	Average (mean) number of other patients cared for by the nursing caregiver during the IMCN stay.	∑ (# of other patients cared for each shift by each caregiver) ÷ total number of shifts in IMCN.	Continuous. (Ratio).
Consistency of Nursing Caregivers.	y_{10}	Percent of total nursing care hours provided by the nursing caregiver most frequently assigned to the patient during the NICU stay. (Values ≥ 25% are optimal).	[(# shifts infant cared for by the most frequent NICU nursing caregiver) ÷ (total # of shifts infant in NICU)] x 100.	Continuous. (Ratio).
	y_{11}	Percent of total nursing care hours provided by the nursing caregiver most frequently assigned to the patient during the IMCN stay. (Values ≥ 25% are optimal).	[(# shifts infant cared for by the most frequent IMCN nursing caregiver) ÷ (total # of shifts infant in IMCN)] x 100.	Continuous. (Ratio).
	y_{12}	Number of different caregivers during the NICU stay. (Fewer caregivers is optimal, with the expected minimal value of 4).	Number of different caregivers.	Continuous. (Ratio).
	y_{13}	Number of different caregivers during the IMCN stay. (Fewer caregivers is optimal, with the expected minimal value of 4).	Number of different caregivers.	Continuous. (Ratio).

Table 3. Endogenous Manifest Variables for Primary Research Question. (Outcome Variables).

Latent Variable	LISREL Symbol	Manifest Variable	Measurement Units	Scale
Health Status.	y_1	Post-conceptional age at discharge.	Weeks.	Continuous. (Ratio).
	y_2	Weight at discharge.	Grams.	Continuous. (Ratio).
	y_3	Post-conceptional age at initial bottle or breast feeding.	Weeks.	Continuous. (Ratio).
	y_4	Post-conceptional age at full bottle or breast feeding.	Weeks.	Continuous. (Ratio).
	y_5	Morbidity score. (Sum of the number of the following major NICU-related health problems diagnosed during the initial hospital stay: (a) Bronchopulmonary Dysplasia; (b) Periventricular-Intraventricular Hemorrhage; (c) Periventricular Leukomalacia; (d) Retinopathy of Prematurity; (e) Nosocomial Infection.)	Number of problems.	Continuous. (Ratio).

Table 4. Endogenous Manifest Variables for Subsidiary Research Questions. (Outcome Variables).

Latent Variable	LISREL Symbol	Manifest Variable	Measurement Units	Scale
Morbidity.	y_{14}	Bronchopulmonary Dysplasia.	Categorical Variable: 0 = No. 1 = Yes.	Ordinal.
	y_{15}	Periventricular-Intraventricular Hemorrhage.	Categorical Variable: 0 = No. 1 = Grade 1. 2 = Grade 2. 3 = Grade 3. 4 = Grade 4.	Ordinal.
	y_{16}	Periventricular Leukomalacia.	Categorical Variable: 0 = No. 1 = Yes.	Ordinal.
	y_{17}	Retinopathy of Prematurity.	Categorical Variable: 0 = No. 1 = Stage 1. 2 = Stage 2. 3 = Stage 3. 4 = Stage 4.	Ordinal.
	y_{18}	Nosocomial Infection.	Categorical Variable: 0 = No. 1 = Yes.	Ordinal.
Resource Utilization.	y_{19}	Length of hospital stay.	Days.	Continuous. (Ratio).
	y_{20}	Days on mechanical ventilation.	Days.	Continuous. (Ratio).
	y_{21}	Days in supplemental oxygen.	Days.	Continuous. (Ratio).
	y_{22}	Days on parenteral nutrition.	Days.	Continuous. (Ratio).

which were used to measure the secondary health outcome endpoint of "morbidity" and the economic outcome endpoint of "resource utilization" for the two subsidiary research questions.

Linkage of Theory and Variables

Energy Balance

Levine defined energy balance as "the supply of energy-producing nutrients measured against the rate of energy-using activities" (Levine, 1973, p. 14). Infants born prematurely are at high risk for the development of Respiratory Distress Syndrome, a medical condition in which the lungs are deficient of surfactant due to the interruption in the normal lung development processes by the premature birth. Since oxygen is an essential element necessary for the cellular release of energy (Guyton, 1987), the energy balance of the preterm infant during the adaptation to extrauterine life is linked to the degrees of lung immaturity and respiratory distress present at birth. Requirement for surfactant therapy is an indicator of the severity of lung disease. The remaining 3 variables related to the infant's supplemental oxygen requirements and to the infant's acid-base balance were selected because they are primary markers in the risk indexing scoring system for infants known as the "Clinical Risk Index for Babies," or CRIB, and because they are traditional markers of respiratory status. The CRIB scoring system has been demonstrated to be a more accurate index of neonatal risk than using birth weight alone (International Neonatal Network, 1993), therefore the use of markers from the CRIB score should add to the model. Although it is acknowledged that energy balance is a dynamic concept and involves variables other than oxygenation/ventilation status, these variables were not measured in this study due to limitations of the data set from which the study sample was drawn.

Structural Integrity

Levine's principle of conservation of structural integrity is based upon her view of healing as "the process of restoration of structural integrity" (Levine, 1973, p. 15). Gestational age at birth (or "post-conceptional age" at birth) and birth weight are traditional markers of infant risk, and are consistent with Levine's concept of structural integrity. The more premature the infant is at the time of birth and the smaller the birth weight, the greater the risk of structural injury when the infant must prematurely interact with the extrauterine environment. Infants were routinely weighed soon after birth, at the time of admission to the NICU. The assessment of post-conceptional age at birth was performed by the admitting physician or neonatal nurse practitioner at the time of admission to the NICU and was based on the clinical evaluation of the infant, the obsteterical report of completed weeks of gestation in utero and/or by performing an assessment of the infant using the Ballard Maturational Score. The Ballard Score assesses 13 measures of physical and neuromuscular maturity to produce a gestational age rating in weeks. The Ballard Score is widely used, and the validity and accuracy of the score has been demonstrated (Ballard, Khoury, Wedig, Wang, Eilers-Waisman, & Lipp, 1991).

Personal Integrity

Levine's concept of personal integrity relates to "the individual's sense of identity and self-worth" (Levine, 1973, p. 16). Since neurodevelopmental maturation is essential to the infant's ability to develop individual identity and self-worth, it was congruent with

Levine's model to operationalize personal integrity with respect to measures of neurodevelopmental maturation and neurologic risk. The Apgar scoring system was developed by Virginia Apgar in 1953 and designed to be used as a tool to assist in the evaluation of the effectiveness of the newborn infant's adaptation to extrauterine life and to identify the infant's need for resuscitation. The Apgar scoring system is a five factor scale which is used to assess the newborn infant's heart rate, respiratory effort, muscle tone, reflex irritability, and color. A score of 0, 1, or 2 is assigned on each of the 5 parameters, then the 5 scores are summed to give the final score (with a minimum value of 0 and a maximum value of 10). A low Apgar score indicates that there is an abnormality, but does not identify the cause of the problem. Certain maternal drugs or anesthetic agents can affect the central nervous system of the infant, leading to a depressed infant at birth and low Apgar scores. Preterm infants also generally have lower Apgar scores than their term counterparts, due to the immaturity of both the central nervous system and of the lungs (Letko, 1996). Separate Apgar scores are assigned at 1 minute of life and 5 minutes of life. The 1 minute Apgar score has been demonstrated to be an accurate index of intrapartum asphyxia, while the 5 minute Apgar score correlates best with the eventual long-term neurologic outcome of the infant (Cloherty and Stark, 1985). The difference between the 1-minute Apgar score and the 5-minute Apgar score is indicative of the effectiveness of both the infant's adaptive efforts and of the resuscitative efforts (Letko, 1996).

Decisions to initiate resuscitative efforts should not be delayed until the 1-minute Apgar score is obtained, but should be based on the ongoing evaluation of the infant's respirations, heart rate, and color (Bloom, Cropley & AHA/AAP Neonatal Resuscitation Program Steering Committee, 1995). The degree of resuscitation required at the time of birth is also an indicator of the infant's neurologic status at birth as it is reflective of the amount of assistance which the newborn infant required to complete the initial transition to extrauterine life. For the purposes of this study, the degree of resuscitation provided was ordered from lowest level of intervention to highest level of intervention as follows: (1) none (only normal birth interventions such as drying the infant and providing tactile stimulation to promote breathing), (2) supplemental oxygen only, (3) positive pressure ventilation by bag and mask device, (4) positive pressure ventilation by endotracheal tube, and (5) administration of resuscitative drugs. This ordering of resuscitative interventions is consistent with that recommended by the American Academy of Pediatrics and the American Heart Association in their "Neonatal Resuscitation Program" (Bloom, Cropley & AHA/AAP Neonatal Resuscitation Program Steering Committee, 1995).

Since Levine viewed the central nervous system as the major integrative system of the organism (Levine, 1966), it appeared congruent with her model to operationalize personal integrity at birth with the Apgar scores and the level of resuscitation required at birth. A limitation of the use of these measurements was that illness or structural immaturity in body systems other than the central nervous system (for example, the respiratory system) also could have influenced both the Apgar scores and the amount of resuscitation required.

Social Integrity

Levine's concept of social integrity arises from her belief that "individual life has meaning only in the context of social life" (Levine, 1973, p. 17). In discussing the concept of social integrity, Levine also stated that “An identity places one in a family, a community, a cultural heritage, a religious belief, a socioeconomic slot, an educational background, a vocational choice” (Levine, 1989, p. 335). Therefore operationalizing this construct with respect to selected maternal demographic and socioeconomic measures which have been demonstrated to be markers of risk for pregnancy outcome was conceptually congruent. The specific measures selected for inclusion in this study are maternal age, race, the extent of prenatal care during this pregnancy, and the mother’s health insurance status at the time of birth. Epidemiologic research has demonstrated that in general the best pregnancy outcomes occur when the mother is between the ages of 20 and 35 years, and that the overall infant mortality rate of nonwhite infants is twice as high as the infant mortality rate of white infants (Avery, 1991). Age would also appear to be an appropriate marker of social integrity status with respect to parenting, as in general older parents could be expected to be better prepared both emotionally and financially for childbirth and parenting than would younger parents.

Pregnancy outcome is also influenced by the socioeconomic status of the mother, with lower socioeconomic status associated with poorer outcomes (Kotelchuck & Wise, 1987). Prenatal care during pregnancy and health insurance at the time of birth should be reflective of socioeconomic status. Due to limitations of the data set used for this study, it was not possible to measure other variables which might have influenced social integrity status, such as marital status, number of other children and parent-infant interactions.

The NICU and IMCN which served as the study sites for data collection for this study both employed a family-centered approach to care in which 24 hour visitation by parents and grandparents was allowed (except during shift changes). Due to infection control concerns, young siblings were not routinely permitted to visit, however sibling visits could be individually arranged to meet specific family needs.

Consistency of Nursing Caregivers

In describing nursing, Levine stated that "nursing intervention must be designed so that it fosters successful adaptation whenever possible" (Levine, 1973, p. 13). A nursing caregiver who provides direct care to a particular preterm infant on a consistent basis should be better attuned to the infant's behavioral communication cues and should therefore be better able to identify and support the infant's unique adaptive efforts. The NICU and IMCN which served as the study sites for data collection for this study both utilized a modified primary nursing model of nursing care delivery, and both units also utilized twelve hour shift staffing patterns. In each unit there were four teams of staff, two day shift teams and two night shift teams, working rotating schedules opposite each other. Therefore the most consistency of care would have been demonstrated if a particular infant was cared for by a single full time staff member on each team (four consistent caregivers, with each caregiver providing 25% of the patient's total nursing care). Although this would have been the optimal situation, it was difficult to achieve due to staff vacations or other absences from work and because some staff members only worked part-time.

The four specific manifest indicators used to measure the latent variable "consistency of nursing care" were:

(1) the percent of total nursing care hours provided the by nursing caregiver who was most frequently assigned to provide direct nursing care to the infant during the NICU stay;

(2) the percent of total nursing care hours provided the by nursing caregiver who was most frequently assigned to provide direct nursing care to the infant during the IMCN stay;

(3) the number of different nursing caregivers during the NICU stay; and

(4) the number of different nursing caregivers during the IMCN stay.

<u>Intensity of Nursing Care</u>

Levine stated that "Nursing intervention means that the nurse interposes her skill and knowledge into the course of events that affects the patient" (Levine, 1973, p. 13). Therefore, the effectiveness of nursing care should be influenced by level of nursing knowledge and skill possessed by the direct nursing care provider. Three different levels of nursing caregivers were employed in the NICU and Intermediate Care Nursery in which the study was conducted: registered nurses (highest level), licensed practical nurses (technical care provider), and nursing technicians (lowest level; "on-the-job training"). Infants who are critically ill require intensive nursing care, with direct care provided by a registered nurse. For the purposes of this study, two categories of nursing caregiver were considered: the registered nurse and the non-registered nurse. This decision was made because only one nursing technician was employed in the NICU and IMCN at the study site during the time period from which the data were collected. This nursing technician had many years of neonatal experience and functioned at an approximately equivalent skill and knowledge level with the licensed practical nurses when providing care within the scope of practice of a nursing technician. The specific measurement variables used were the percent of total nursing care hours with direct nursing care provided by an R.N. during the NICU stay and the percent of total nursing care hours with direct nursing care provided by an R.N. during the IMCN stay.

The nursing caregiver to patient ratio was also proposed to provide an indicator of the intensity of nursing care provided — the greater the number of patients cared for by a single nursing caregiver, the less the amount of time available to spend attending to the nursing care needs of each individal patient. A potential confounding issue related to this variable is that the number of patients assigned to a single nurse can be influenced by factors other than the patient's assessed nursing care needs. For example, the number of nurses available on a particular shift to provide care for the patient acuity mix may not be what would be optimally desired. However, since the current health care economic climate continually demands that nurses find innovative ways to deliver quality patient care with fewer staff members, it is believed that this is still an essential variable to include in the model. The specific manifest variables used in this study were the average (mean) number of other patients cared for by the nursing caregivers during the NICU stay and the average (mean) number of other patients cared for by the nursing caregivers during the IMCN stay.

Health Status

In Levine's Conservation Model, the concept of wholeness is analogous to the concepts of health and integrity. For the preterm infant, a major marker of wholeness, or health, is that the infant achieve a level of independent functioning in the extrauterine environment which enables the infant to be discharged to the care of the parents on or before the date the baby had been expected to be born if the pregnancy had gone to term gestation. Therefore, since term gestation is generally considered to be 38 to 40 weeks, the goal is for preterm infants to achieve a level of health that allows them to be discharged from the hospital by the time the infant reaches a post-conceptional age of approximately 38 to 40 weeks. (The post-conceptional age is calculated by adding the number of weeks of chronologic age to the estimated gestational age of the preterm infant at the time of birth.) One of the most complex skills which must be accomplished by the infant before discharge from the hospital is the ability to obtain full nutritional needs orally by bottle or breast feeding. Therefore, the time of initiation of oral feedings and the time at which full oral feeding is accomplished should provide an additional measure of the success of the infant's overall transition from intrauterine life to extrauterine life (that is, of the infant's health). The weight at discharge is also a marker of health outcome and reflects how well the infant's needs related to energy balance were managed.

Bronchopulmonary dysplasia, periventricular-intraventricular hemorrhage, periventricular leukomalacia, retinopathy of prematurity, and infections are all serious adverse health outcomes related to preterm birth and the NICU experience, which also serve as markers for the infant's health status at the time of discharge. The pathophysiologic mechanisms of both bronchopulmonary dysplasia and retinopathy of prematurity have been related to the toxic effects from the administration of oxygen, which is necessary for the survival of these preterm infants. These health problems are potentially nurse sensitive markers since the responsibility for regulation of oxygen concentration is a joint responsiblity of nurses and respiratory therapists. Although the pathophysiologic mechanisms behind periventricular leukomalacia are still not well deliniated, changes in the blood pressure in the cerebral circulation which may contribute to periventricular-intraventricular hemorrhage have been shown to be influenced by a variety of nursing interventions, including suctioning of endotracheal tubes (Volpe, 1995). Nosocomial infection is also a potentially a nurse sensitive marker variable, as nurses are the primary caregivers who control the infant's environment. A "morbidity score" was developed by adding the sum of the number of these five health problems which were diagnosed during the hospitalization; this "morbidity score" was used as one of the measurments for the latent variable "health status."

Morbidity

Morbidity, or severity of illness, is a special subcategory of health status related to Levine's principle of structural integrity. The presence of multiple health problems (or the greater the severity of a specific health problem) the greater the challenge to the infant's structural integrity, and therefore the greater the degree of adaptation required.

Resource Utilization

In their model for outcomes management in clinical neonatal nursing practice, Petryshen and Stevens (1995) state that one of the endpoints to be considered in assessing economic outcomes is resource utilization. Preterm infants frequently require costly interventions such as mechanical ventilation, supplemental oxygen, and parenteral nutrition (nutritional solutions administered via the intravenous route). Therefore, the number of days that each of these is required, in addition to the length of the initial hospital stay should serve as appropriate indicators of the level of resource utilization by the infant during the hospitalization. As measured in this study, the number of days on mechanical ventilation included days during which only continuous positive airway pressure (CPAP) was provided. The measure of the number of days the infant received supplemental oxygen likewise included the number of days of mechanical ventilation. The measure of the total days that parenteral nutrition was received included days in which enteral feedings were given also (that is, partial parenteral nutrition).

Protection of Subjects' Rights

Approvals to conduct this study were obtained from the Institutional Review Boards of both the medical center at which the NICU and IMCN were located and of the university at which the researcher was a doctoral student. Copies of the approval letters from both Institutional Review Boards are included in Appendix A. A waiver for the requirement to obtain informed consent was requested from and granted by the Institutional Review Boards as data were collected retrospectively from existing records and no subject identifiers were recorded. Data were collected from three archival record sources (the regional neonatal database, the pediatric nutritionist's archival records, and the archival daily nursing assignment sheets.) No patient medical records were accessed during the conduct of this study.

Data collected for this study were recorded in a manner that protected patient confidentiality. Although patient names appear on the archival records, patient names were not recorded on the study records. Each study subject was assigned a unique numerical identifier which served as the subject number for the study. However, since data were collected from three different archival record sources, it was necessary to temporarily maintain a code sheet to ensure the accurate matching of data from the three sources. This code sheet was stored separately from the other study records and destroyed following completion of the data analysis for this study, so there is no way to link study data to specific patients. Study records have been stored in a secured location and will be kept for a period of 5 years following completion of the study.

Sample Frame and Sample Selection Procedures

A retrospective data collection approach was used, with data collection from the existing archival records of a 27 bed Level 3 Neonatal Intensive Care Unit (NICU) and 28 bed Intermediate Care Nursery (IMCN) of a university medical center in a medium sized city in the southeastern United States. The NICU and IMCN at the proposed study did not use the formalized NIDCAP approach to developmental caregiving during the time period from which the data were collected, but both units have integrated developmental care principles into the nursing care standards, orientation of new nursing staff members, and continuing education programs for the nursing staff. A copy of the current nursing developmental protocol is included as Appendix B.

The archival records used in this study were the regional neonatal database, the pediatric nutritionist's archival records, and the archival daily nursing assignment sheets for the NICU and the IMCN. The study site is one of five statewide regional referral centers for perinatal and neonatal care. The regional neonatal database is a computerized database consisting of data compiled on all infants treated at the regional neonatal center; this database is maintained by the regional neonatal program in accordance with the requirements set forth by the state perinatal care system (Subcommittee on Regionalization, Care Levels, Staffing, Facilities, and Professional Education of the Perinatal Advisory Committee, 1990). The regional neonatal database is used by the staff of the neonatal center for tracking and reporting purposes as well as for research and continuous quality improvement activities. The pediatric nutritionist maintains an archive of abstracted nutritional records of all infants treated in the NICU and IMCN. The nursing managers retain the daily nursing assignment sheets from the NICU and IMCN for a period of several years in an archive file. These daily nursing assignment sheets reflect nurse/patient assignments and nurse/patient ratios for each shift. The medical director of of the neonatal units, the pediatric nutritionist, and the nurse managers of the NICU and IMCN all gave written approval to the researcher to access each of these archival records for the purpose of conducting this study. Copies of these approval letters are provided in Appendix C.

In order to obtain a sufficiently large sample size to perform the structural equation modeling tests, a sample size of 260 - 300 subjects was planned, to allow for at least 10 subjects for each manifest variable included in the structural equation model. (Although data were collected on a total of 35 manifest variables, only a maximum of 26 variables were included in a single structural equation modeling test).

<u>Inclusion and Exclusion Criteria</u>

<u>Inclusion Criteria</u>

Subjects were eligible for study inclusion if the following criteria were met:

Estimated gestational age at birth less than 37 weeks.

<u>Exclusion Criteria</u>

Subjects were excluded from the study if the following criteria are met:

Infants born at other hospitals and transferred to the proposed study NICU for treatment.

Infants with acutely life threatening congenital anomalies.

Infants with known maternal history of drug or alcohol abuse.

Infants requiring major surgical intervention.

Infants with unusual medical diagnoses not typically associated with the general preterm infant population.

Infants with neurological problem other than periventricular or intraventricular hemorrhage or periventricular leukomalacia.

Infants admitted directly to the Intermediate Care Nursery.

Infants who died prior to discharge.

Sample Selection Procedure

The procedure for selection of subjects for study inclusion was as follows:

1. A master computer printout was generated by the data coordinator of the neonatal database to identify a list of all available database records for infants born at a gestational age of 37 weeks or less who were admitted to the NICU from January 1996 through April 1997 (and therefore met the study inclusion criteria.) A total of 604 subjects were identified to meet the study inclusion criteria.
2. The data coordinator of the neonatal database also generated computer listings of all available database records for infants admitted to the NICU from January 1996 through April 1997 who met the study exclusion criteria. A total of 243 subjects were identified to meet the study exclusion criteria.
3. The two computer listings were cross-checked by the researcher to identify subjects on the "inclusion criteria" list who also met the exclusion criteria. These identified subjects were "marked out" on the master "inclusion criteria" computer listing and were excluded from the study. A total of 361 subjects were identified that met the inclusion criteria but did not meet the exclusion criteria and were therefore eligible for the study.
4. The eligible subjects were numbered sequentially from 1 - 361 based on the order in which the subjects appeared on the computer listing. This "subject number" from 1 - 361 was used as the identification number on all study records.

Data Collection Procedure

Most of the data collected for this study was obtained from the archival neonatal database. The infant's age at initial bottle or breast feeding, age at full bottle or breast feeding, and the number of days the infant was on parenteral nutrition was obtained from the pediatric nutritionist's archival records. All data related to the nursing variables was obtained from the archival daily nursing assignment sheets. All study data was collected from the original source documents by the principal investigator and transcribed onto the final data collection instrument for this study. A copy of this instrument is included as Appendix D. The areas shaded grey in color indicate the items of data collected from the nutritionist's archival records. All other data on page 1 of the final data collection instrument was collected from the neonatal database. All data on page 2 of the instrument was collected from the archival daily nursing assignment sheets. Since the data related to nursing care had not been previously abstracted into an archive, a worksheet was used to abstract the raw data from the assignment sheets and convert that data into the specific measurements needed for this study. The worksheet for summarizing the nursing care delivery data is included as Appendix E.

Of the total 361 subjects which were identified as being eligible for study inclusion, 78 subjects had to be excluded because the nutritionist's data archive had no data on these subjects. Four additional cases also had to be excluded from study because the nutritionist's data archive contained information indicating that the subjects met the study exclusion criteria. Sixteen additional subjects were excluded from the study during the review of the nursing assignment sheets because it was discovered that: (a) 6 of the infants in the eligible cases were discharged to another hospital rather than to home; (b) the mother of one infant had died; and (c) 9 infants were discharged directly from the NICU, with no IMCN stay. In addition, 28 subjects were excluded from the study because the nursing assignment sheets for one of the study months could not be located. These exclusions resulted in a final sample size of 235 subjects.

During the process of collecting data from the neonatal data base, it was discovered that information for the manifest variable "maximum base excess during the first 12 hours of life" was not available for all subjects because infants who did not appear to have respiratory distress during the first 12 hours of life did not have a blood sample sent for blood gas analysis. Data for the manifest variables "minimum appropriate fraction of inspired oxygen (FiO_2) during the first 12 hours of life" and "maximum appropriate fraction of inspired oxygen (FiO_2) during the first 12 hours of life" were still available for these infants due to the use of noninvasive oxygen monitoring techiques, such as pulse oximetry. The scoring for the "base excess" variable was therefore recoded to an interval level scoring which matches the interval level scoring actually used in the "Clinical Risk Index for Babies" (The International Neonatal Network, 1993). The revised scoring for this variable is as follows:

If base excess not available or > -7.0, then score = 0.

If base excess -7.0 to -9.9, then score = 1.

If base excess -10.0 to 14.9, then score = 2.

If base excess $\leq$ -15.0, then score = 3.

After all data collection was completed, the data were input into a computer database, then each entry was checked against the raw data forms for accuracy of data entry.

Data Analysis

The Interactive LISREL® version 8.3 for Windows 95 statistical package by Scientific Software International Inc. was used to perform the statistical test procedures. The structural equation modeling testing was first performed for the primary research question and the model respecified to produce the best fit. The testing procedures were then repeated for the two subsidiary questions, using the model as it had been respecified to best fit the primary research question. (That is, to test subsidiary question # 1, the manifest variables for the "morbidity" endpoint were substituted for the "health status" endpoint variables in the refined model. To test subsidiary question # 2, the manifest variables for the "resource utilization" endpoint were substitued for the "health status" endpoint variables in the refined model.)

The structural analysis testing procedure for the primary research model was a three phase process:

(1) The raw data for the manifest variables used to measure the primary research model were prepared for analysis by the LISREL® program using PRELIS™ version 2.3, the companion pre-processing program for LISREL®.

(2.) A confirmatory factor analysis measurement model using maximum likelihood estimation was performed and refined for the path diagrams representing the primary research question.

Table 5. Univariate Distributions for Ordinal Manifest Variables of Primary Research Question. (Sample Size of 235).

Manifest Variable	Categorical Scores	Responses	
Energy Balance:			
Surfactant Therapy.	0 = no 1 = yes	0 = 163 1 = 72	
Personal Integrity:			
Apgar score at 1 minute.	Score from 0 - 10.	0 = 1 1 = 6 2 = 13 3 = 6 4 = 7 5 = 17	6 = 31 7 = 69 8 = 69 9 = 16 10 = 0
Apgar score at 5 minutes.	Score from 0 - 10.	0 = 0 1 = 0 2 = 1 3 = 1 4 = 3 5 = 7	6 = 11 7 = 30 8 = 84 9 = 97 10 = 1
Resuscitation score.	0 = None. 1 = Oxygen. 2 = Bag/mask. 3 = Endotracheal Tube. 4 = Drugs.	0 = 18 1 = 134 2 = 32 3 = 51 4 = 0	
Social Integrity:			
Race.	0 = Caucasian. 1 = Other.	0 = 208 1 = 27	
Prenatal care during pregnancy.	0 = None. 1 = Limited. 2 = Complete.	0 = 6 1 = 0 2 = 229	
Mother's health insurance status at the time of birth.	0 = None. 1 = Government. 2 = Private.	0 = 0 1 = 141 2 = 94	

Table 6. Univariate Summary Statistics for Continuous Manifest Variables of Primary Research Question. (Sample Size of 235).

Manifest Variable	Range	Mean	Standard Deviation	Skewness		Kurtosis	
				Index	P-value	Index	P-value
Energy Balance:							
Minimum oxygen level.	21 - 90	23.455	7.980	5.064	0.000	31.715	0.000
Maximum oxygen level.	21 - 100	36.689	22.220	1.508	0.000	1.298	0.003
Base excess.	0.00 - 3.00	0.106	0.473	4.727	0.000	22.071	0.000
Structural Integrity:							
PCA at birth.	24 - 36	32.396	2.374	-0.878	0.002	0.828	0.028
Birth weight.	425 - 4070	1857.953	554.085	0.145	0.221	0.520	0.112
Social Integrity:							
Maternal age.	15 - 40	25.047	6.296	0.468	0.018	-0.744	0.000
Nursing Intensity:							
% NICU care by R.N.	13.040 - 100	90.070	11.655	-2.158	0.000	8.124	0.000
% IMCN care by R.N.	0 - 100	53.574	19.699	-.058	0.562	-.212	0.592
Mean # other patients cared for in NICU.	1 - 2	1.439	0.233	0.136	0.240	-0.605	0.012
Mean # other patients cared for in IMCN.	1.38 - 3.00	2.167	0.253	0.004	0.964	0.276	0.310
Nursing Consistency:							
% care by most frequent NICU caregiver.	7.41 - 60.00	19.903	7.739	1.637	0.000	4.606	0.000
% care by most frequent IMCN caregiver.	7.14 - 57.14	20.167	8.018	2.128	0.000	5.920	0.000
# caregivers in NICU.	2 - 60	16.272	10.828	1.344	0.001	1.694	0.001
# caregivers in IMCN.	2 - 42	16.17	7.562	0.525	0.013	0.331	0.249
Health Status:							
PCA at discharge.	33.57 - 48.86	37.524	2.439	1.834	0.000	4.176	0.000
Weight at discharge.	1750 - 4520	2499.047	494.38	1.515	0.000	3.153	0.000
PCA at initial PO feed.	31.29 - 45.14	34.947	1.971	1.549	0.000	4.174	0.000
PCA at full PO feed.	32.57 - 47.86	36.205	2.205	1.850	0.000	5.076	0.000
Morbidity score.	0 - 5	0.536	0.984	2.126	0.000	4.209	0.000

(3.) A structural equation model test was performed for the refined measurement models for the primary research question, using maximum likelihood estimation.

Data Screening and Preparation for Analysis

The raw data used to test the primary research question were first screened for univariate and multivariate normality, and for detection of extreme outliers in the data set. The distributions of the ordinal manifest variables included in the model for the primary research question are listed as Table 5 on page 97. The univariate summary statistics for the continuous manifest variables included in the model for the primary research question are listed as Table 6 on page 98. Fifteen of the 19 continuous variables demonstrated significant levels of skewness and/or kurtosis when compared to the skewness/kurtosis levels of a normal distribution. A normal distribution should have a skewness index within the range of -1.00 to +1.00 and a kurtosis index of 0.00 (Tabachnick & Fidell, 1989). The tests of multivariate normality for the continuous variables also indicated significant multivariate skewness and kurtosis with the following results:

Multivariate skewness: Value 151.209 with z-score 49.926 and p-value 0.000.

Multivariate kurtosis: Value 154.952 with z-score 16.904 and p-value 0.000.

Multivariate skewness and kurtosis: Chi-Square 2778.353 with p-value 0.000.

These univariate and multivariate distributions indicated that the distribution of the sample data differed significiantly from a normal distribution. Since an assumption of structural equation methodology is that the sample data be normally distributed, the data were examined to determine if any data transformations could be performed which might create a more normal distribution. The following actions were taken:

(1) The ordinal variable for "prenatal care during pregnancy" was deleted because it had little variability, since 229 of the 235 cases received complete prenatal care.

(2) The two continuous variables for "minimum oxygen level within the first 12 hours of birth" and "base excess within 12 hours of birth" were both deleted due to excessive kurtosis indices (kurtosis of 31.715 for minimum oxygen level and kurtosis of 22.071 for base excess).

(3) The continuous variable for "percent of NICU care provided by an R.N." was defined as being "censored above" in the PRELIS™ program, as this variable was noted to have 137 of the 235 cases with 100 percent of nursing care provided by an R.N. Using the "censored above" designation directs PRELIS™ to use the normal scores calculated from the distribution in order to lessen the effects of the non-normality (Jöreskog & Sörbom, 1996b).

(4) The continuous variables for "maximum oxygen level within the first 12 hours" and "morbidity score" were both defined in PRELIS™ as being "censored below." The "maximum oxygen level" variable had 129 of the 235 cases with a maximum oxygen level of 21 percent. The "morbidity score" variable had 162 of 235 cases with a score of zero.

The combination of these actions did improve the normality of the distribution somewhat, but did not produce a completely normal distribution.

Computation of Matrix to be Analyzed by LISREL®

Since the listing of manifest variables to be analyzed includes ordinal scale variables as well as continuous scale variables, a polychoric correlation matrix of the manifest variables for the primary research question was computed by the PRELIS™ version 2.3 statistical program, and then input into LISREL® for analysis. The confirmatory factor analysis measurement model was respecified to produce the best attainable fit for these variables, then the structural equation modeling test of the primary research question was performed. The data screening process was then repeated for the manifest variables used to measure the latent variables "morbidity" and "resource utilization" in the two subsidiary models. The response distributions for the categorical manifest variables used to measure the latent variable "morbidity" are presented as Table 7 on page 102. The univariate summary statistics for the continuous manifest variables used to measure the latent variable "resource utilization" in subsidiary question # 2 are presented as Table 8 on page 103. The variables "ventilator days," "oxygen days," and "total parenteral nutrition" were all defined as "censored below" in the PRELIS™ matrix, which improved the skewness and kurtosis indices for each of these variables, although the distributions remained non-normal. Finally, the confirmatory factor analysis measurement models and structural equation tests were performed to test the two subsidiary research question, again inputing a polychoric correlation matrix and using the structure which had provided the best fit for the primary research question. The results of the confirmatory factor analysis measurement models and the structural equation modeling tests are presented in the following chapter.

Table 7. Univariate Distributions for Ordinal Manifest Variables of Subsidiary Research Question # 1. (Sample Size of 235).

Manifest Variable	Categorical Scores	Responses
Morbidity		
Bronchopulmonary Dysplasia	0 = No.	0 = 212
	1 = Yes.	1 = 23
Intraventricular Hemorrhage	0 = No.	0 = 217
	1 = Grade 1.	1 = 8
	2 = Grade 2.	2 = 6
	3 = Grade 3.	3 = 2
	4 = Grade 4.	4 = 2
Periventricular Leukomalacia	0 = No.	0 = 228
	1 = Yes.	1 = 7
Retinopathy of Prematurity	0 = No.	0 = 209
	1 = Stage 1.	1 = 16
	2 = Stage 2.	2 = 7
	3 = Stage 3.	3 = 1
	4 = Stage 4.	4 = 2
Nosocomial Infection.	0 = No.	0 = 183
	1 = Yes.	1 = 52

Table 8. Univariate Summary Statistics for Continuous Manifest Variables of Subsidiary Research Question # 2 (Sample Size of 235).

Manifest Variable	**Range**	**Mean**	**Standard Deviation**	**Skewness**		**Kurtosis**	
				Index	**P-value**	**Index**	**P-value**
Resource Utilization							
Length of Stay (Days)	6 - 139	35.740	26.374	1.619	0.000	2.421	0.000
Ventilator Days	0 - 85	3.745	9.353	4.827	0.000	30.422	0.000
Oxygen Days	0 - 139	11.179	23.623	2.934	0.000	8.588	0.000
Parenteral Nutrition Days	0 - 101	11.923	14.883	2.919	0.000	11.956	0.000

CHAPTER 4

RESULTS

The purpose of this study was to examine the relationship of nursing care to the health outcomes of preterm infants by testing a middle range theory of health promotion for preterm infants based on Levine's Conservation Model of Nursing. The statistical technique of structural equation modeling was used to address the three research questions that were proposed based on the theory. Structural equation modeling tests were performed according to the relationships specified in the three path diagrams which represent the three research questions, illustrated as Figure 2, Figure 3, and Figure 4 on pages 69, 70, and 71 in chapter 3. This constituted a test of the middle range theory of health promotion for preterm infants because the path diagrams were drawn to reflect the relationships among the latent variables as specified in the theory.

Four measures of fit were examined to assess the fit of the sample data to the models:

(1) Chi-Square Goodness of Fit Measure.

(2) Goodness of Fit Index (GFI).

(3) Adjusted Goodness of Fit Index (AGFI).

(4) Comparative Fit Index (CFI).

The Chi-Square measure tests the null hypothesis that the covariance (or correlation) matrix estimated from the specified model is equal to the covariance (or correlation) matrix of the population from which the data were sampled (Hu and Bentler, 1995). A Chi-square "p-value" greater than .05 was predetermined as the criterion level indicating a good fit of the data to the model, as "p-values" in this range would indicate that the difference between the sample data and the parameter specifications estimated by the structural equation modeling tests was no greater that the difference that would be produced by chance alone.

While the Chi-Square measure provides a dichotomous indicator of the significance of the difference between the estimated model and the sample data matrix, the various goodness of fit indexes provide tools for assessing the degree of variance accounted for by a model (Hu and Bentler, 1995). Two classes of fit indexes have been described: absolute fit indexes and incremental fit indexes. Absolute fit indexes provide a direct assessment of how well the specified model reproduces the sample data, in a manner that is analogous to the R^2 statistic in a multiple regression model. Incremental fit indexes compare the specified model with a baseline null model, then assess the degree of improvement of fit over the null model that is attained by using the specified model (Hu and Bentler, 1995).

The Goodness of Fit Index (GFI) and the Adjusted Goodness of Fit Index (AGFI) are both classed as absolute fit indexes. The AGFI makes an adjustment for the degrees of freedom in the specified model. The Comparative Fit Index (CFI) is an incremental fit index. It is generally accepted that a fit index of greater than 0.90 indicates a very good fit of the model to the sample data (Hu and Bentler, 1995).

Results for Primary Research Question

The primary research question addressed in this study was:

How do the intensity of nursing care and the consistency of nursing caregivers relate to the health status of preterm infants at the time of initial hospital discharge? This originally proposed analysis of this question involved 7 latent variables measured by 26 manifest variables, as described in Tables 1, 2, and 3 on pages 74, 75, and 76 of chapter 3. However, the actual model tested contained only 23 manifest variables, as three variables were deleted due to extreme non-normality (base excess within the first 12 hours, minimum appropriate oxygen within the first 12 hours, and maternal prenatal care).

Results of Confirmatory Factor Analysis Measurement Model

The first step of a structural equation modeling test is to test and refine a confirmatory factor analysis measurement model of the latent and manifest variables being investigated. The purpose of the confirmatory factor analysis measurement model is to determine how well the manifest variables in the sample data set actually measure the latent variables under investigation. The polychoric correlation matrix of the data input into the LISREL® program resulted in a nonpositive definite matrix, which was not an appropriate matrix for analysis. In structural equation modeling, it is essential that both the sample data matrix and the matrices produced as parameter estimates remain positive definite in order for certain necessary mathematical processes, such as matrix inversion, to be possible. The mathematical iterations also did not converge, indicating that LISREL® was unable to solve for acceptable parameter estimates for the specified model. The error messages produced by LISREL® for this computation stated that both the Phi and Theta Delta matrices were not positive definite. The Phi matrix is a symmetric matrix of the factor intercorrelations (in this case, the intercorrelations of the 7 latent variables energy balance, structural integrity, personal integrity, social integrity, intensity of nursing care, consistency of nursing care, and health status.) The Theta Delta matrix is a vector representing the measurement errors of each of the manifest variables used in the model. Possible causes of parameter estimate matrices which are not positive definite include overparameterization of the model, (meaning that more latent variables were specified in the model than were supported by the amount of systematic information contained in the sample data matrix), collinearities among the measurement variables (that is, two or more manifest variables are essentially measuring the same thing), non-normalities in the sample data, and/or a poor fit of the sample data to the proposed model (Wothke, 1993).

Although the LISREL® program was not able to successfully solve for final solutions, the program did produce intermediate estimates for use in "troubleshooting" the problems with the analysis. These intermediate estimates indicated problems with the manifest variables "surfactant therapy" (Lambda X loading 1.073 and Theta Delta value - 0.150) and "maternal age" (Lambda X loading 9.238 and Theta Delta value -84.311). In addition, the factor intercorrelation matrix (Phi matrix) produced the following improper correlations:

(1) "Consistency of Nursing Caregivers" and "Intensity of Nursing Care" - 2.561

(2) "Energy Balance" and "Intensity of Nursing Care" 1.039

(3) "Structural Integrity" and "Intensity of Nursing Care" - 1.232

(4) "Structural Integrity" and "Consistency of Nursing Caregivers" 1.030

These improper correlations with values greater than +1.0 or less than -1.0 indicate that a latent variable correlates more strongly with another latent variable than with itself. Because the confirmatory factor analysis measurement model could reach an acceptable solution, it was concluded that the sample data did not support the model as originally specified for the test of the theory. Therefore, the proposed primary research question could not be answered as originally stated.

Respecification of the Measurement Model

The information obtained from the intermediate estimates produced by the LISREL® program along with the conceptual interrelationships in Levine's Conservation Model of Nursing and the middle range Theory of Health Promotion for Preterm Infants were used to respecify a measurement model to provide a test of the primary research question. From the intermediate estimates, it appeared that the model was indeed overparameterized, and since Levine's model focuses on the concept of "wholeness," it appeared logical to collapse the four latent variables "energy balance," "structural integrity," "personal integrity," and "social integrity" into one single latent variable representing "integrity at birth." However, the collapsing of these four latent variables into a single latent variable did not completely resolve the problems with the factor intercorrelation Phi matrix. Various model respecifications were performed with separate deletions of specific manifest variables which were thought to be interacting with other variables (collinearity), or which the LISREL® modification indexes indicated were trying to "load" with a different factor than the factor which the model proposed that they were measuring. (For example, both "weight at discharge" and "morbidity score" had moderately low factor loadings for the latent variable of "health status," while the modification indices indicated that they had a stronger affinity for the newly created latent variable "integrity at birth." Since it was not theoretically sound to move those manifest variables to the latent variable for "integrity at birth," both manifest variables were removed from the model). In addition, the manifest variables which were originally proposed to measure the construct of "social integrity" produced both very low factor loadings and improper measurement error estimates (Theta Delta estimates), leading to a nonpositive definite Theta Delta matrix. Due to the mathematical incompatibility of the sample measurements with the LISREL® statistical method, these "social integrity" variables had to be deleted from the respecified model. Although social integrity was still viewed theoretically as an essential component of wholeness, the sample measures obtained just were not suitable to the statistical method. It was therefore assumed for the purpose of the respecification that the social integrity status of the infant would be reflected in an indirect manner through the remaining measures of the infant's integrity at birth.

The manifest variables proposed to measure "number of different caregivers during the NICU stay," "number of different caregivers during the IMCN stay," "mean number of other patients cared for in NICU," and "mean number of other patients cared for in IMCN" were mathematically unstable in their original form. All four of these variables were therefore transformed to variables which controlled for the length of stay in each unit, as follows:

(1) Percent of shifts with a first time caregiver in NICU =

(Number of caregivers in NICU ÷ number of shifts in NICU) X 100

(2) Percent of shifts with a first time caregiver in IMCN =

(Number of caregivers in IMCN ÷ number of shifts in IMCN) X 100

(3) Mean number of other patients cared for in NICU adjusted for NICU length of stay

= Mean number of other patients cared for in NICU ÷ number of shifts in NICU

(4) Mean number of other patients cared for in IMCN adjusted for IMCN length of stay

= Mean number of other patients cared for in IMCN ÷ number of shifts in IMCN.

These data transformations were successful in stabilizing these variables. However, the latent variable "intensity of nursing care" remained problematic in every respecification of the model, consistently having improper factor intercorrelation (Phi matrix) values greater than +1.0 or less than -1.0. Therefore, the latent variable "intensity of nursing care" was eliminated from the model.

Collinearities in the sample data set appeared evident among the following variables:

(1) Post-conceptional age at discharge;

(2) Post-conceptional age at full oral feeding;

(3) Post-conceptional age at initial oral feeding;

(4) Post-conceptional age at birth;

(5) Birth weight.

(7) Apgar score at 1 minute.

(8) Apgar score at 5 minutes.

(9) Resuscitation at birth.

(10) Surfactant therapy.

(11) Maximum appropriate FiO_2 within the first 12 hours of birth.

To correct these problems, a new variable called the "CRIB score" was created by transforming the raw data representing base excess within 12 hours of birth, minimal oxygen level within 12 hours of birth, maximal oxygen level within 12 hours of birth, post-conceptional age at birth, and birth weight into a single variable. This transformation was done in accordance with the instructions for assigning a "Clinical Risk Index for Babies" (CRIB) score published by the International Neonatal Network (1993). The procedures for assigning this score are included as Table 9 on the following page. In addition, the variables for Apgar score at 1 minute and resuscitation at birth were deleted from the respecified model.

<u>Results of the Respecified Structural Equation Model Test</u>

The changes described in the section above produced a respecified model containing the following 3 latent variables measured by 10 manifest variables as described below:

(1) Integrity at birth.

Measured by the manifest variables (a) "surfactant therapy," (b) "CRIB score," and (c) "Apgar score at 5 minutes."

(2) Consistency of nursing caregivers.

Measured by the manifest variables (a) "percent of shifts with a first time caregiver in NICU," (b) "percent of shifts with a first time caregiver in IMCN," (c) "percent of total nursing care hours provided by the nursing caregiver most frequently assigned to the patient during the NICU stay," and (d) "percent of total nursing care hours provided by the nursing caregiver most frequently assigned to the patient during the IMCN stay."

Table 9. Scoring Criteria for the Clinical Risk Index for Babies, or CRIB score. (The International Neonatal Network, 1993).

Factor	Score
Birth weight (grams)	0
> 1350	1
851 - 1350	4
701 - 850	7
≤ 700	
Gestation (weeks)	
> 24	0
≤ 24	1
Congenital malformations (Non-lethal)	
None	0
Non acutely life-threatening	1
Acutely life-threatening	3
Maximum base excess in first 12 hours (millimoles/liter)	
> - 7.0	0
- 7.0 to -9.9	1
- 10.0 to 14.9	2
≤ -15.0	3
Minimum appropriate FiO_2 in first 12 hours of life	
≤ 0.40	0
0.41 - 0.60	2
0.61 - 0.90	3
0.91 - 1.00	4
Maximum appropriate FiO_2 in first 12 hours of life	
≤ 40	0
0.41 - 0.80	1
0.81 - 0.90	3
0.91 - 1.00	5

(3) Age at which health was attained.

Measured by the manifest variables (a) "post-conceptional age at initial oral feeding," (b) "post-conceptional age at full oral feeding," and (c) "postconceptional age at discharge." This latent variable was renamed to more appropriately reflect the measured construct, as only the 3 post-conceptional age variables remained in the model.

The path diagrams for the confirmatory factor analysis measurement model and for the final structural equation modeling test are provided on the following pages as Figure 5 and Figure 6. The path weights and the level of significance for each path are included on each diagram. The models were estimated using maximum likelihood estimation. With the number of manifest variables reduced to 10, the sample size became proportionately large enough to compute an asymptotic covariance matrix in order to produce the Satorra-Bentler Chi-square statistic, which is corrected for the non-normality of the sample data (Hu and Bentler, 1995; West, Finch and Curran, 1995; LISREL® 8.30 On-Line Help File, 1999). Both the confirmatory factor analysis and the structural equation test of the respecified model produced a Satorra-Bentler Scaled Chi-Square value of 5.77 with 32 degrees of freedom (p-value = 1.00000), which meets the predetermined level of significance of $p \geq 0.5$. The Goodness of Fit Index (GFI) for both models was 0.905 and the Adjusted Goodness of Fit Index (AGFI) was 0.836 for both models. The Comparative Goodness of Fit Index (CFI) was 0.928 for both models. Since the Scaled Chi-Square test and two of the three fit indices met the predetermined significance level criterion, and since the directionality and strengths of the paths are consistent with the theory, then it

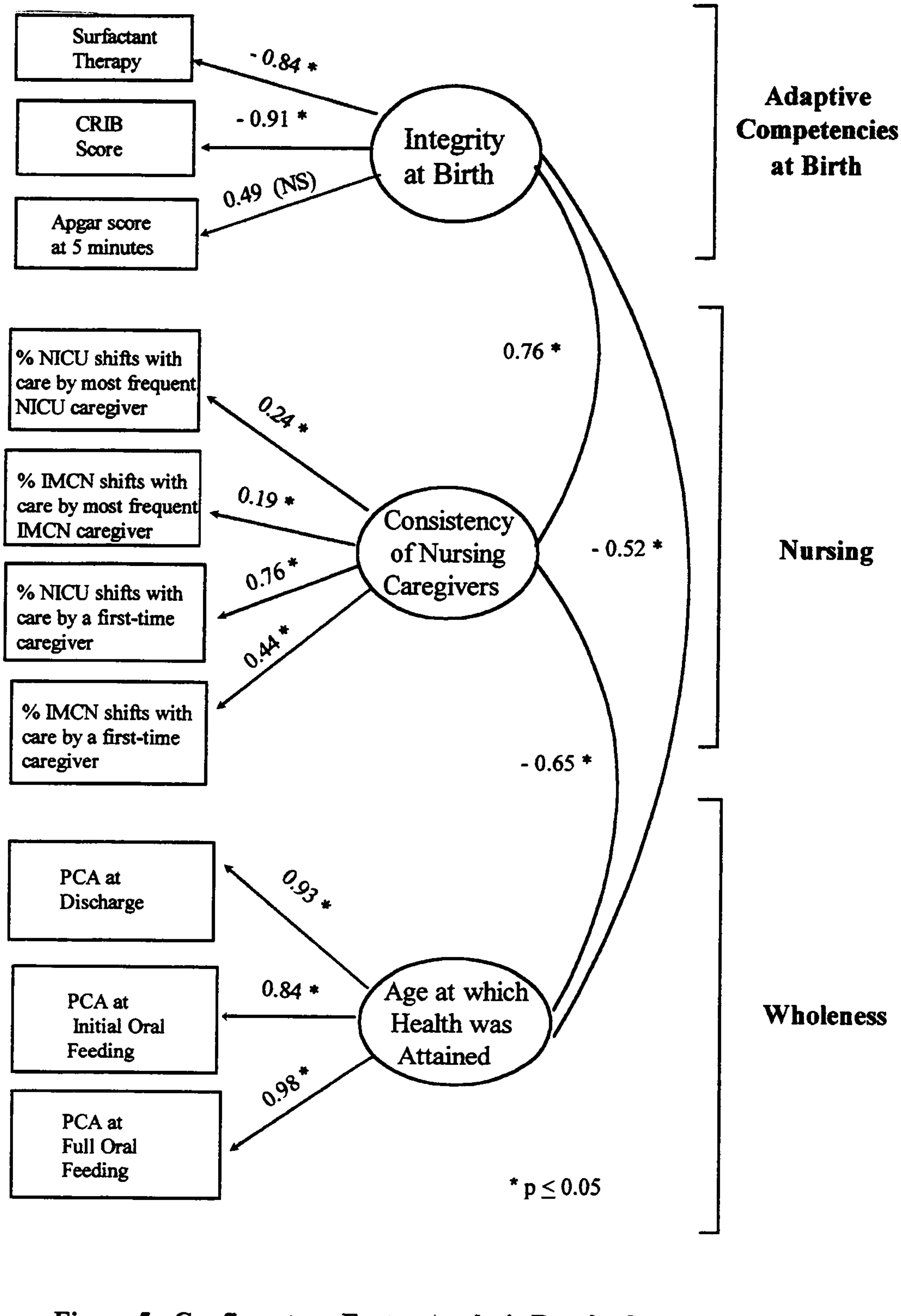

Figure 5. Confirmatory Factor Analysis Results for Primary Research Question (Standardized Solution).

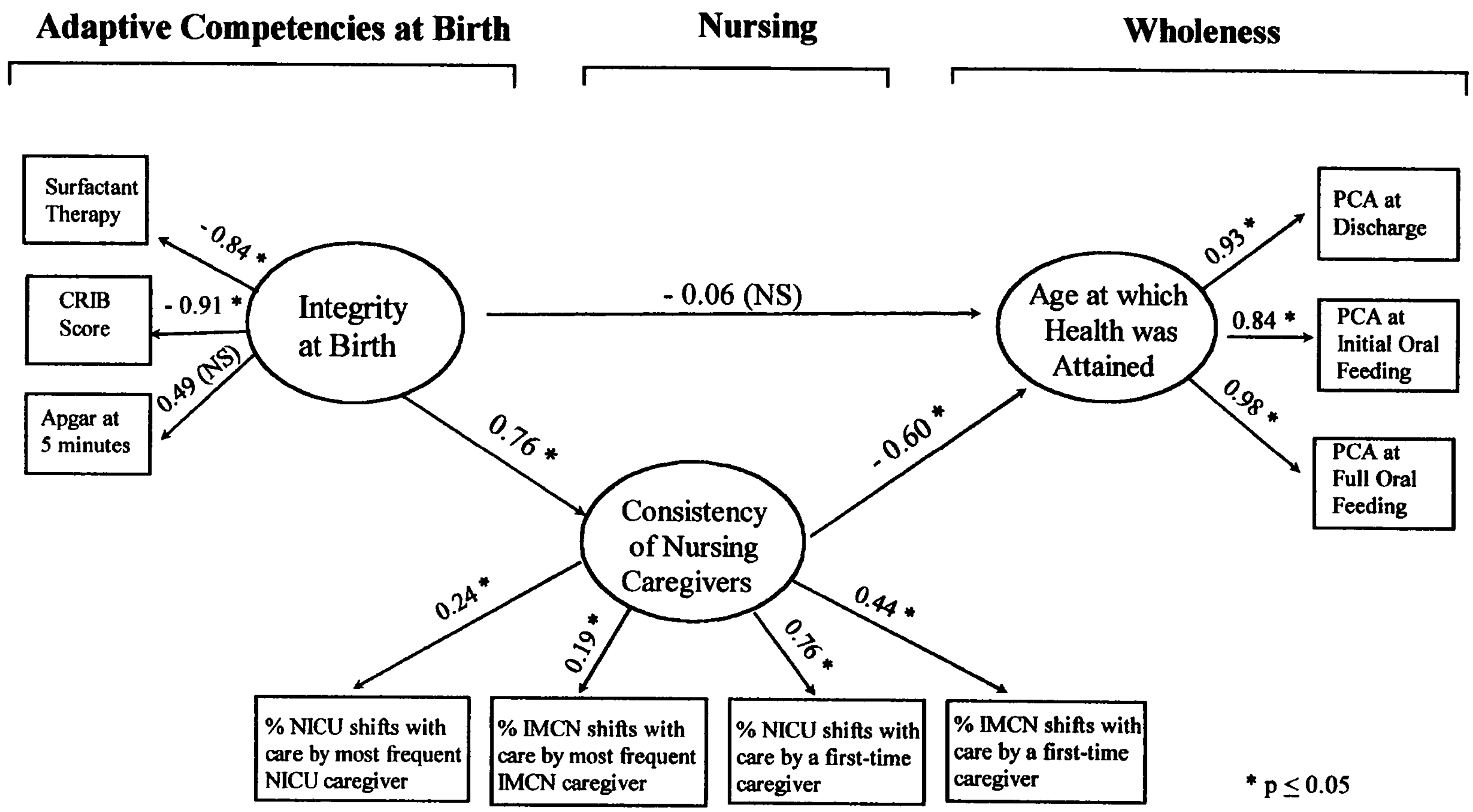

Figure 6. Structural Equation Modeling Results for Primary Research Question (Standardized Solution).

was concluded that there was a reasonably good fit of the sample data to the respecified model. Therefore, the sample data provide support for the validity of the path diagram model of the primary research question and for the theory from which the model was derived.

Results for Subsidiary Research Question # 1

Subsidiary research question # 1 addressed in this study was:

How do the intensity of nursing care and the consistency of nursing caregivers relate to the level of morbidity of preterm infants at the time of hospital discharge?

Results of Confirmatory Factor Analysis Measurement Model Test

A measurement model confirmatory factor analysis was performed for this question using the latent variables "integrity at birth" and "consistency of nursing care" as respecified in the test of the primary research question. The new latent variable "morbidity" was substituted for the previous outcome endpoint of "age at which health was attained." The "morbidity" construct was measured by the 5 manifest variables (a) "bronchopulmonary dysplasia," (b) "periventricular-intraventricular hemorrhage," (c) "periventricular leukomalacia," (d) "retinopathy of prematurity," and (e) "nosocomial infection," giving the model a total of 12 manifest variables.

The sample polychoric correlation data matrix which was generated and input into LISREL® to be analyzed was not positive definite, and the LISREL® program applied the "ridge" option to "smooth" the matrix to allow an intermediate level analysis to be performed. If a matrix is nonpositive definite, then one or more of the eigenvalues are equal to or less than zero. In the LISREL® "ridge" option, the diagonal of the sample matrix is repeatedly multiplied by a constant until the negative eigenvalues disappear. This does not correct the problem in the data, but does allow an intermediate analysis to proceed so that a diagnostic evaluation of the data problem may be performed. (Wothke, 1993; Jöreskog and Sörbom, 1996a).

A path diagram illustrating the intermediate solution of the confirmatory factor analysis test is provided as Figure 7 on the following page. The intermediate solution produced extremely strong factor intercorrelations in the Phi matrix, with a correlation of -1.02 between the latent variables "consistency of nursing care" and "morbidity," indicating that that the strength of the correlation between these two latent variables (or factors) is greater than the strength of the correlation of each factor with itself. Standardized parameter estimates with values of greater than 1.0 or less than -1.0 are improper estimates; this estimate in conjunction with the nonpositive definite sample correlation matrix indicate that the model is unsuitable for the sample data. As seen in Table 7 on page 101 of chapter 3, the manifest variables measuring the latent variable morbidity did not have a great deal of variability, with the majority of the cases having none of the specified morbidity outcomes. Several attempts were made to respecify the model in an attempt to find a model which was acceptable for structural equation modeling with the sample data, but each attempt was unsuccessful. Therefore, it was concluded that the sample data did not support the path diagram model for subsidiary question # 1.

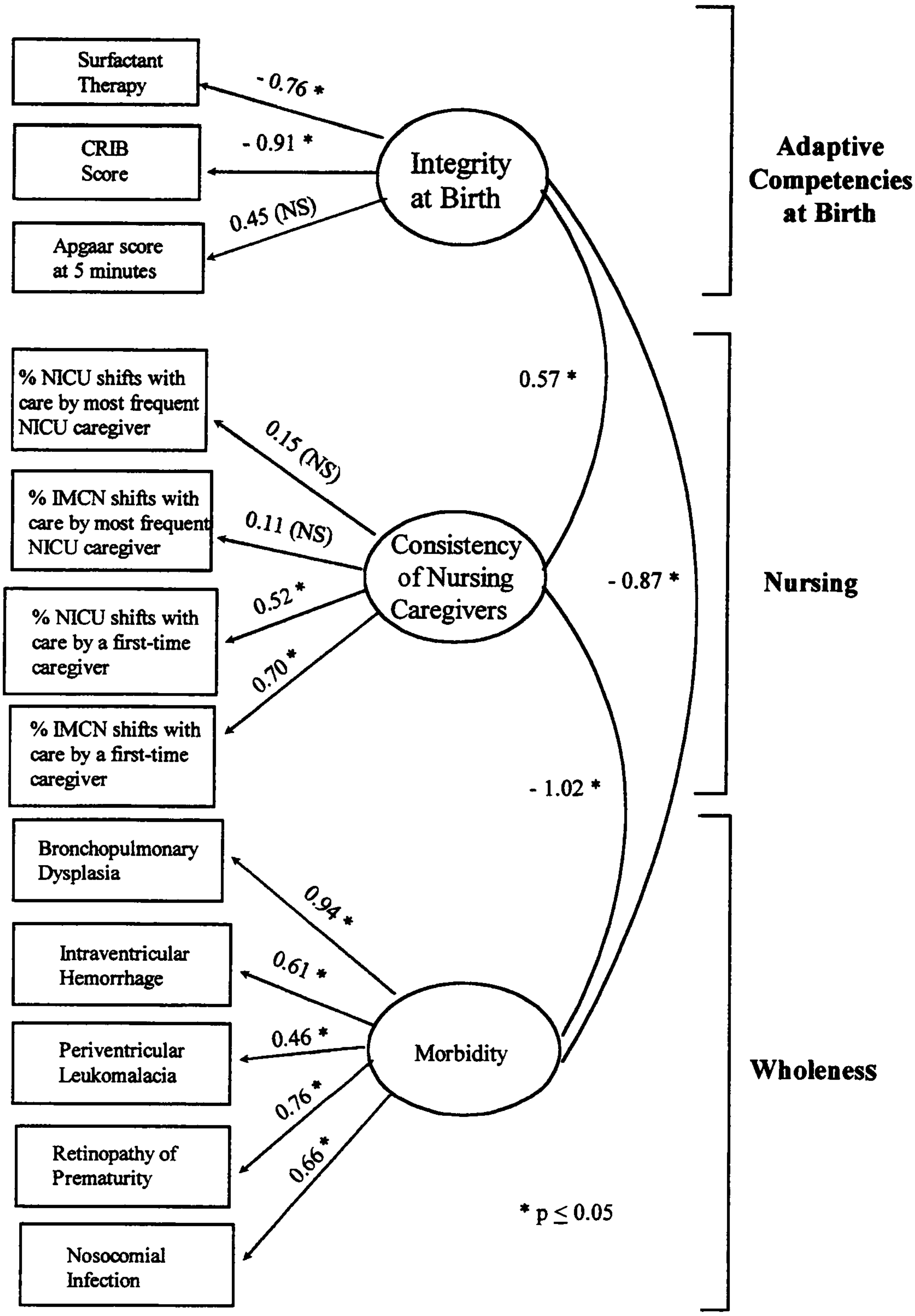

Figure 7. Intermediate Solution, Confirmatory Factor Analysis Results for Subsidiary Research Question # 1 (Standardized Solution).

Results for Subsidiary Research Question # 2

Subsidiary research question # 2 addressed in this study was:

How do the intensity of nursing care and the consistency of nursing caregivers relate to the utilization of health care resources by preterm infants during the initial hospital stay?

Results of Confirmatory Factor Analysis Measurement Model Test

A confirmatory factor measurement analysis was performed for this question using the latent variables "integrity at birth" and "consistency of nursing care" as respecified in the test of the primary research question. The new latent variable "resource utilization" was substituted for the previous outcome endpoint of "age at which health was attained." The "resource utilization" construct was measured by the four manifest variables (a) "length of stay," (b) "days on mechanical ventilation," (c) "days in supplemental oxygen," and (d) "days on parenteral nutrition," giving a total of eleven manifest variables.

The path diagrams illustrating the results of the confirmatory factor analysis test and the structural equation modeling test are provided as Figure 8 and 9 on the following pages. A polychoric correlation matrix was again produced as the sample matrix, and an asymptotic covariance matrix was also computed. Estimation was performed using maximum likelihood estimation. The fit measures for both the confirmatory factor analysis measurement model and the final structural equation model were as follows:

Satorra-Bentler Scaled Chi-Square value of 14.15 with 41 degrees of freedom (p-value = 0.99997);

Goodness of Fit Index 0.811;

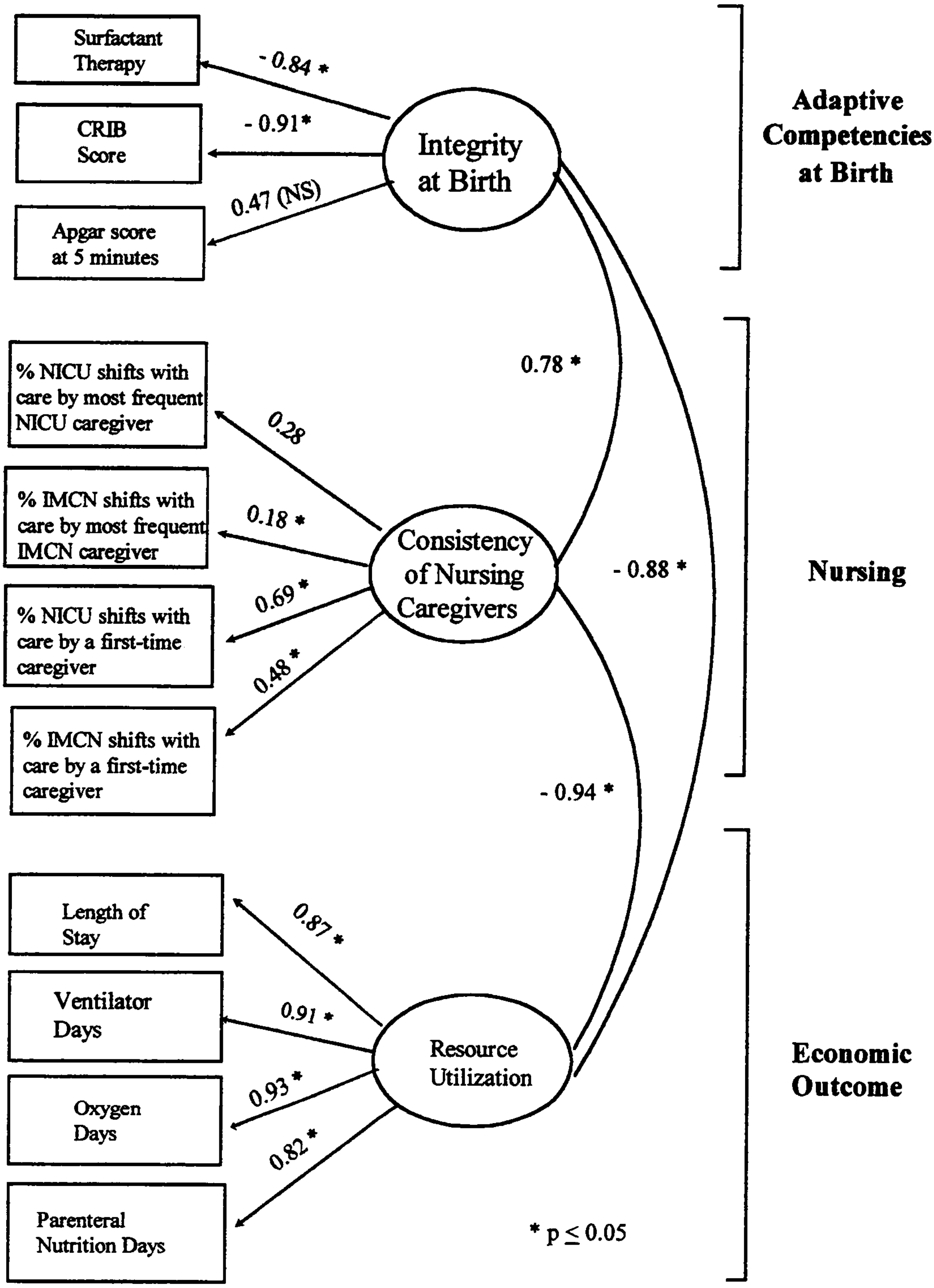

Figure 8. Confirmatory Factor Analysis Results for Subsidiary Research Question # 2 (Standardized Solution).

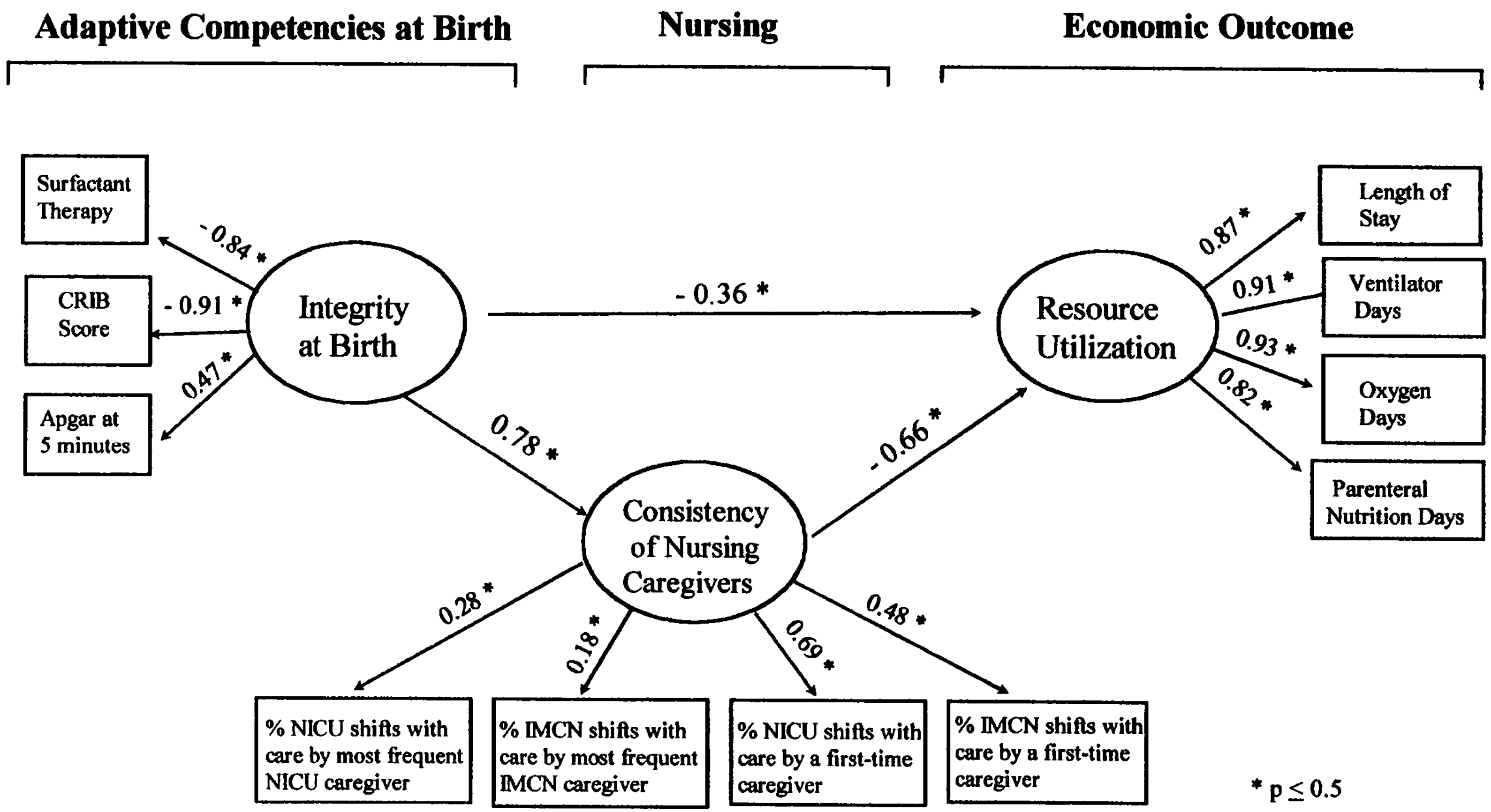

Figure 9. **Structural Equation Modeling Results for Subsidiary Research Question # 2 (Standardized Solution).**

Adjusted Goodness of Fit Index 0.696; and

Comparative Fit Index 0.837.

The Scaled Chi-Square test of model fit reached the predetermined level of significance for acceptance of the model, indicating that the correlation matrix estimated by the specified model is not significantly different from the sample correlation matrix. All of the model paths were also significant at the .05 level of significance. Both the directionality and strength of the paths related to "consistency of nursing caregivers" were in agreement with the specified theory. The fit indices indicate only a fair fit of the sample data to the model as reflected by the amount of variance that was accounted for by the specified model parameters. Therefore, it was concluded that the sample data indicate that the model has promise, but is an incomplete representation of the sources of variance contributing to resource utilization.

Conclusion

The original models as proposed in this study were not supported by the sample data. However, a respecification of the model for the primary research question which was driven by both the theoretical framework of the study and the modifications suggested by the LISREL analysis did produce a reasonably good fit of the model to the data. Although the structural equation testing method did not prove to be an appropriate method for testing subsidiary question # 1 (morbidity endpoint), the respecified model for the second subsidiary research question (resource utilization endpoint) provides a promising foundation for future research. However, since both tests were performed on respecified models, the results should be considered as tentative results until a priori testing of the models is performed.

CHAPTER 5

DISCUSSION

The purpose of this study was to examine the relationship of nursing care to the health outcomes of preterm infants by testing a middle range Theory of Health Promotion for Preterm Infants based on Levine's Conservation Model of Nursing. This study explored three research questions related to the health outcomes and economic outcomes of preterm infants in an NICU, using the statistical method of structural equation modeling. This chapter will discuss the meaning of the study findings with respect to the theoretical framework and nursing practice.

Was the Theory of Health Promotion for Preterm Infants Supported?

The Theory of Health Promotion of Preterm Infants was supported in this study, with the strongest support evident in the results of the structural equation modeling test of the primary research question. The dimension of nursing care tested most extensively in the respecified models was "consistency of nursing caregivers." The results of the tests of each of the three research questions will be discussed with respect to the congruence of the study findings to the theoretical framework.

Theoretical Interpretation of Test of Primary Research Question

The primary research question for this study was:

> How do the intensity of nursing care and the consistency of nursing caregivers relate to the health status of preterm infants at the time of initial hospital discharge?

This research question served as the primary test of the Theory of Health Promotion for Preterm Infants derived from Levine's Conservation Model of Nursing (presented on pages 23 through 26 of chapter 1). The path diagram proposed to test this research question is illustrated as Figure 2 on page 69 of chapter 3. This model could not be tested as originally specified because the intercorrelations between the latent variables were stronger than is compatible with the structural equation modeling methodology. The following extremely high correlations were noted between four of the latent variables:

"Intensity of Nursing Care" and "Consistency of Nursing Caregivers" -2.561

"Energy Balance" and "Intensity of Nursing Care" 1.039

"Structural Integrity" and "Intensity of Nursing Care" - 1.232

"Structural Integrity" and "Consistency of Nursing Caregivers" 1.030

Although the strength of these interrelationships prohibited the structural equation modeling test of the primary research question as originially specified, the finding of these improper, extremely high factor intercorrelations in itself provides support for the Theory of Health Promotion for Preterm Infants. The theory proposes that the preterm infant in the NICU is confronted with environmental challenges which threaten the infant's level of health (or wholeness) due to threats to energy balance, structural integrity, personal integrity, and social integrity. The infant responds to these environmental challenges by the process of adaptive change. The NICU nurse should plan and implement nursing interventions which are supportive of the infant's own efforts of adaptive change and which foster the goal of promoting health (or wholeness) through the conservation of energy, structural integrity, personal integrity, and social integrity. The extremely high factor intercorrelations between the latent variables "energy balance" and "intensity of nursing care" provide support for the hypothesis that the infant's needs related to energy balance were considered when decisions were made regarding the level of intensity of nursing care which was provided. Similarly, the strong intercorrelations between the latent variable "structural integrity" and the variables "intensity of nursing care" and "consistency of nursing caregivers" indicate that the infant's needs with respect to the conservation of structural integrity were taken into account when decisions were made regarding both the level of intensity of nursing care which was provided and the consistency of nursing caregivers. The fact that the latent variables "intensity of nursing care" and "consistency of nursing caregivers" were so strongly correlated was not surprising, since these variables represented two dimensions of the more abstract global concept of nursing care. It was, however, disappointing that the factor "intensity of nursing care" was so strongly intercorrelated with other variables in the model that it was not possible to further explore the influence of that factor through the use of the structural equation modeling methodology. However, the influences of nursing knowledge and skill levels were indirectly included in the construct "consistency of nursing caregivers," as infants receiving higher levels of consistency were more frequently cared for by nursing staff members who were employed in the NICU or IMCN on a full-time basis, and who may therefore have had higher levels of neonatal nursing knowledge and skill than staff who were employed on a more part-time basis.

Based on the results of the unsuccessful structural equation modeling test of the primary research question, a new model was constructed to test the implied research question: "How does the consistency of nursing caregivers relate to the health status of preterm infants at the time of initial hospital discharge?" The results of the structural equation modeling test of this respecified model are illustrated as Figure 6 on page 115 of chapter 4. The respecified model reached the predetermined level of significance for the Chi-Square measure and also produced reasonably good fit statistics, with both the Goodness of Fit Index (GFI) and the Comparative Fit Index (CFI) reaching the predetermined level for good fit of the model to the data. With the finding of good model fit on three of the four measures, it was concluded that the respecified model does provide support for the validity of the Theory of Health Promotion for Preterm Infants.

In addition, the direction and strength of the paths are congruent with the theoretical propositions. The path from the latent variable "integrity at birth" to the latent variable "consistency of nursing caregivers" had a standardized path weight of 0.76, which was statistically significant at the 0.05 level of significance. This positive path weight indicates that as "integrity at birth" increased, then "consistency of nursing caregivers" also increased. The range for standardized path weights is from a minimum value of -1.0 to a maximum value of +1.0, with a path weight value of 0 indicating the absence of a relationship between the two latent variables. A path weight of 0.76 indicates a strong positive relationship; in this sample data therefore it appears that infants with higher levels of integrity at birth tended to receive higher levels of consistency of nursing care as measured by the manifest variables. However, the squared multiple correlation for this structural equation was 0.571 (possible range of a minimum of 0 to a maximum of 1.0), indicating that only 57.1 percent of the variance representing the construct "consistency of nursing caregivers" was accounted for by the manifest variables selected for use in this study. Therefore, many of the possible sources of variance related to consistency of nursing care were not accounted for in the model.

The path from the latent variable "consistency of nursing caregivers" to the endpoint variable "age at which health was attained" revealed a moderately strong inverse relationship with a path weight of - 0.60, which was statistically significant at the 0.05 level of significance. This inverse relationship implies that an increase in the "consistency of nursing caregivers" led to a decrease in the "age at which health was attained." The squared multiple correlation for the structural equations leading to the latent variable "age at which health was attained" was 0.426, indicating that only 42.6 % of the variance was accounted for by the measures included in the model.

An interesting and exciting finding is that the path weight leading directly from the latent variable "integrity at birth" to the outcome variable of "age at which health was attained" was of very low strength at - 0.06 and did not reach statistical significance. The confirmatory factor analysis of this model (illustrated as Figure 5 on page 114) indicated that the direct correlation between the variables "integrity at birth" and "age at which health was attained" was - 0.52; this is a moderately strong correlation and was significant at the 0.05 level. Therefore, in the structural equation modeling test, the path from "integrity at birth" to "resource utilization" was also expected to be statistically significant and to have a path weight of approximately - 0.52. Instead, however, this path was nonsignificant with an extremely low path weight of - 0.06, indicating that in this model "integrity at birth" had essentially no influence on the "age at which health was attained." In contrast, the paths through the mediating variable "consistency of nursing caregivers" were both high and reached statistical significance. In addition, the path weight of 0.76 leading from the latent variable "integrity at birth" to the latent variable "consistency of nursing caregivers" was equal to the correlation of 0.76 between these two constructs in the confirmatory factor analysis measurement model. (See Figure 5 on page 114.) Similarly, the path weight of -0.60 leading from "consistency of nursing caregivers" to "age at which health was attained" was approximately equal to the -0.66 correlation found in the confirmatory factor analysis measurement model. (See Figure 5 on page 114.)

The unexpected extremely low, nonsignificant path weight of -0.06 leading from the latent variable "integrity at birth" to the latent variable "age at which health was attained" indicate that this path diagram model is a complete mediation model. That is, the anticipated effects of "integrity at birth" on "age at which health was attained" were completely mediated by the variable "consistency of nursing caregivers." Therefore, the results of this study indicate that providing consistency of nursing caregivers to preterm infants during the initial hospital stay has a great influence on reducing the age at which health was attained (that is, the age at which the infant is healthy enough to be discharged from the hospital). The findings of this test of the primary research question therefore provide strong support for the validity of the Theory of Health Promotion for Preterm Infants.

Theoretical Interpretation of Test of Subsidiary Research Question # 1

Subsidiary research question # 1 was:

How do the intensity of nursing care and the consistency of nursing caregivers relate to the level of morbidity of preterm infants at the time of initial hospital discharge? The path diagram model created to serve as a structural equation modeling test of this question is illustrated as Figure 3 on page 70 of chapter 3. This question could also not be tested as originally specified due to the presence of extremely strong intercorrelations between the latent variables. A new path diagram was therefore respecified to test the implied research question "How does the consistency of nursing caregivers relate to the level of morbidity of preterm infants at the time of hospital discharge?" The results of the confirmatory factor analysis measurement model test of this respecified research question are illustrated as Figure 7 on page 118 of chapter 4. The presence of an improper high correlation of - 1.02 between the latent variables "morbidity" and "consistency of nursing caregivers" as well as the fact that the sample correlation matrix was not positive definite prevented the performance of a structural equation modeling test of this respecified model.

The fact that the relationship between these two latent variables was so strong is of interest. Since relationships among latent variables in a confirmatory factor analysis model are non-directional, it is not possible to assess whether (1) "consistency of nursing caregivers" influenced the level of "morbidity" at the time of hospital discharge, or (2) the infant's level of "morbidity" influenced "consistency of nursing caregivers," or (3) "morbidity" and "consistency" each influenced the opposite factor. The measures of "morbidity" used in this study were bronchopulmonary dysplasia, intraventricular hemorrhage, periventricular leukomalacia, retinopathy of prematurity, and nosocomial infection. These measures are not actually discrete markers that occur near the time of discharge, but in fact these morbidities may develop gradually throughout the hospitalization. The two manifest variables measuring the average number of different nursing caregivers were the strongest measurements of the variable "consistency of nursing caregivers" in this model, having the following factor loading scores:

"Percent of NICU shifts with care by a first time caregiver" Factor loading 0.52

"Percent of IMCN shifts with care by a first time caregiver" Factor loading 0.70

As the strongest factor loading is related to the IMCN stay, it is possible that the infant's level of morbidity at the time of transfer to the IMCN actually influenced the consistency of nursing care provided during the IMCN stay (that is, it is possible that decisions regarding consistency of caregivers in IMCN took into account the infant's morbidity, or level of health, at the time of transfer to IMCN). It is also still possible that the level of consistency could have influenced morbidity level, however since many of these conditions are diagnosed during the NICU stay, it would be more likely that only the level of nursing care consistency during the NICU would have exerted causal effects on morbidity. Therefore, it is very likely that the strong interrelationship between these two factors may actually be a bidirectional relationship, rather than unidirectional. To better determine the nature of the relationship between consistency of care and morbidity, it may be more appropriate to consider the concept of consistency of care during the NICU stay separately from the concept of consistency of care during the IMCN stay.

Even though the directionality of the relationship is not clear, the existence of this strong intercorrelation between "consistency of nursing caregivers" and "morbidity" does provide some support for the Theory of Health Promotion for Preterm Infants. The theory states that nursing care should be delivered in a manner that promotes the conservation of wholeness, or health, of the infant; it also states that the infant's level of health should be taken into account when planning and implementing nursing care measures. Therefore, either direction of relationship between these variables is congruent with the theory.

Theoretical Interpretation of Test of Subsidiary Research Question # 2

Subsidiary research question # 2 was:

> How do the intensity of nursing care and the consistency of nursing caregivers relate to the utilization of health care resources by preterm infants during the initial hospital stay?

The path diagram model created for the structural equation modeling test of this question is illustrated as Figure 4 on page 71 of chapter 3. This subsidiary research question was not a specific test of the Theory of Health Promotion of Preterm Infants, but was instead intended to provide a beginning level of knowledge regarding the relationship between the various dimensions of nursing care and the economic outcomes related to the initial hospital stay of preterm infants. Again, it was not possible to test the research question as originally proposed, therefore a model was respecified to test the implied research question: "How does the consistency of nursing caregivers relate to the utilization of health care resources by preterm infants during the initial hospital stay?" The path diagram illustrating the results of the structural equation modeling test of this question is illustrated as Figure 9 on page 121 of chapter 4.

Although the Chi-Square measure of goodness of fit for the respecified model did reach the predetermined level of significance, the three goodness of fit indexes indicated only a “fair” fit of the model to the data, implying that many of the sources of variation were not included in the model. The suboptimal fit may also have been due in part to the persistent non-normality of the data used to measure the outcome variable “resource utilization.” Although the manifest variables “ventilator days,” “oxygen days,” and “parenteral nutrition days” were coded in PRELIS™ as being “censored below,” the skewness and kurtosis indexes for the manifest variables used to measure “resource utilization” remained highly non-normal with the following values:

Length of Stay	Skewness 1.619 ($p=0.00$)	Kurtosis 2.421 ($p=0.00$)
Ventilator Days	Skewness 2.565 ($p=0.00$)	Kurtosis 10.877 ($p=0.00$)
Oxygen Days	Skewness 1.837 ($p=0.00$)	Kurtosis 3.955 ($p=0.00$)
Parenteral Nutrition Days	Skewness 2.017 ($p= 0.00$)	Kurtosis 7.595 ($p=0.00$)

The tests of multivariate normality resulted in a value for multivariate skewness of 79.808 ($p=0.00$) and multivariate kurtosis of 89.366 ($p=0.00$). The paths in this model all reached statistical significance. The squared multiple correlations for the structural equations for the latent variable “resource utilization” was 0.939, indicating that a high amount of variance was accounted for in the equations for this variable. In contrast, the squared multiple correlations for the structural equations for the latent variable “consistency of nursing caregivers” was only 0.614.

The path from the latent variable “integrity at birth” to “consistency of nursing caregivers” had a strong path weight of 0.78, indicating that increased levels of integrity at birth resulted in increased levels of consistency of nursing caregivers. The path from “consistency of nursing caregivers” to “resource utilization” had a moderately strong path weight of - 0.66, indicating that increased levels of consistency of nursing caregivers resulted in decreased levels of resource utilization. The strength, directionality, and statistical significance of these paths is congruent with the theoretical premise that providing greater levels of consistency of nursing caregivers can decrease resource utilization by preterm infants during the initial hospital stay.

Another exciting finding is that although the path from "integrity at birth" to "resource utilization" is statistically significant, the path weight is relatively weak at - 0.36. The paths through the mediating variable "consistency of nursing caregivers" were again strong and of statistical significance. The confirmatory factor analysis of this model (illustrated as Figure 8 on page 120) indicated that the direct correlation between the variables "integrity at birth" and "resource utilization" was - 0.88; this is a very strong correlation and was significant at the 0.05 level. Therefore, the path from "integrity at birth" to "resource utilization" was expected to be statistically significant and to have a path weight of approximately - 0.88. The introduction of the mediating variable "consistency of nursing caregivers" resulted in a decrease of the path weight from "integrity at birth" to "resource utilization" from the expected value of approximately - 0.88 to only - 0.36. Therefore, the effects of "integrity at birth" on "resource utilization" were also very strongly mediated by providing consistency of nursing caregivers. Therefore, the results of this study indicate that providing consistency of nursing caregivers to preterm infants can reduce the resource utilization during the initial hospital stay, and therefore should reduce the cost of providing care to these infants.

Integration of Study Findings with Review of Literature

Health Outcomes of Preterm Infants

The results of this study indicate that nursing care does have the potential to positively influence the health outcomes of preterm infants. The test of the primary research question indicated that an increase in the level of consistency of nursing caregivers was related to a decrease in the post-conceptional age at which health was attained by preterm infants. In fact, the level of consistency of nursing caregivers completely mediated the influence of the infant's integrity at birth on the age at which health was attained. The strong factor intercorrelations between the latent variables "morbidity" and "consistency of nursing care" indicate that the consistency of nursing care may influence the degree of morbidity experienced by these infants, and may therefore influence their long term health outcomes. Additional research is needed to determine whether a causal link is indeed present between the consistency of nursing care and level of infant morbidity.

Central Nervous System Development and the NICU Environment

The finding that the consistency of nursing caregivers was related to a decrease in the age at which health was attained by preterm infants indicates that the provision of greater levels of consistency of nursing care may decrease the initial length of hospital stay, thereby decreasing the length of the infant's exposure to the NICU environment. Interventions which decrease the exposure of preterm infants to the noxious stimulation associated with the NICU may foster optimal central nervous system development, potentially improving the long term neurodevelopmental outcome of these infants.

Developmental Intervention Programs and Preterm Infant Outcomes

A major theoretical assumption for the inclusion of the latent variable "consistency of nursing caregivers" in this study was that greater consistency of nursing caregivers would allow the caregivers to become better attuned to the unique behavioral cues by which the infant communicates. Since nurses are the primary direct caregivers for preterm infants, nurses who have received education in basic developmental caregiving principles and who are highly attuned to the infants unique behavioral cues should be able to quickly and effectively implement "developmentally supportive" interventions as a integral part of the holistic, individualized nursing care provided for every infant and family on a routine basis, 24 hours a day. The finding that "consistency of nursing caregivers" was related to a decrease in the "age at which health was attained" provides support for the argument that "developmentally supportive care" can be effectively implemented by nurses who have been educated in basic developmental care principles.

Successful Oral Feeding as a Marker of Health in Preterm Infants

The latent variable "age at which health was attained" was measured by the manifest variables (a) "post-conceptional age (PCA) at discharge," (b)"post-conceptional age at initial oral feeding," and (c) "post-conceptional age at full oral feeding." The sample correlation matrix indicated the following correlations between these variables:

"PCA at discharge" and "PCA at initial oral feeding"	Correlation 0.761
"PCA at discharge" and "PCA at full oral feeding"	Correlation 0.911
"PCA at initial oral feeding" and "PCA at full oral feeding"	Correlation 0.835

Each of these manifest variables also had very strong factor loading scores on the latent variable "age at which health was attained," as listed below:

"PCA at discharge"	Factor loading 0.93
"PCA at initial oral feeding"	Factor loading 0.84
"PCA at full oral feeding"	Factor loading 0.98

In addition, the squared multiple correlations (SMCs) of these measurement variables in the primary model were all strong markers of "age at which health was attained," as listed below:

"PCA at discharge"	SMC 0.858
"PCA at initial oral feeding"	SMC 0.712
"PCA at full oral feeding"	SMC 0.969

The strong intercorrelations among these three variables along with the factor loading scores and SMCs indicating their strength as marker variables provide support for the argument that successful oral feeding is a marker of health in preterm infants.

Levine's Conservation Model of Nursing Applied to the Care of Preterm Infants

The study findings indicate that Levine's Conservation Model is indeed appropriate as a tool to guide the planning and delivery of nursing care for preterm infants. The results of the structural equation modeling test of the middle range Theory of Health Promotion for Preterm Infants based on Levine' Conservation Model of Nursing provided support for the validity of the theory as a framework through which to design nursing care.

Meaning of Study Findings for Nursing Practice

The results of this study indicate that consistency in nursing care is an important component of providing effective nursing care to preterm infants. As this is a beginning study, the strength and directions of the relationship between the latent variables "consistency of nursing caregivers" and both the health and ecnonomic outcome endpoints need to be explored further in future studies. However, it is clearly evident that the provision of consistency of nursing caregivers provides potential benefits both for the health outcomes of infants and their families and for the economic endpoints of the organization. This finding is congruent with the support in the literature for the use of the Primary Nursing model of nursing care delivery in NICUs (as presented in chapter1).

Four manifest variables were used to measure the latent variable "consistency of nursing caregivers" in the respecifications of the models: (1) "percent of shifts with a first time caregiver in NICU," (2) "percent of shifts with a first time caregiver in IMCN," (3) "percent of total nursing care hours provided by the nursing caregiver most frequently assigned to the patient during the NICU stay," and (d) "percent of total nursing care hours provided by the nursing caregiver most frequently assigned to the patient during the IMCN stay." The examination of the factor loadings and the squared multiple correlations for these variables revealed that the variable "percent of shifts with a first time caregiver in NICU" was the strongest marker variable for this construct (indicating that of the four manifest variables, the level of nursing consistency during the NICU stay had the strongest influence on decreasing the "age at which health was attained"). Nursing administrators should therefore perhaps place a higher level of priority on staffing measures to promote consistency of nursing caregivers during the NICU stay. This could be a cost-effective strategy, as any additional expense incurred to promote nursing consistency could be offset by reducing the age at which health is attained (and therefore reducing the length of hospital stay).

Recommendations for Future Research

The manifest variables selected to measure the latent variables in the theory incompletely captured the theoretical constructs and relationships as specified in the Theory of Health Promotion for Preterm Infants. Further tests of the theory should attempt to identify and include additional sources of variance in order to gain a better understanding of these concepts and their interrelationships. This study was a retrospective beginning study, and was limited to a great extent by the information available in the existing data sets. It will be important to see if future prospective studies can provide more complete measurements of the theoretical constructs and therefore provide a more thorough test of the theory. Future studies should also explore the strong intercorrelations evident between the constructs "consistency of nursing caregivers" and "morbidity," using a different methodology which does not prohibit the analysis of strongly intercorrelated variables. More accurate measures of nursing consistency in the NICU and the IMCN should be identified, and the measures should be examined separately in order to try to determine the directionality of the relationships (specifically with respect to the "morbidity" construct). It will also be important to identify more appropriate marker variables for the construct "social integrity" and to test for their influence on health outcomes.

Because the original "a priori" models were not supported by the data set, the structural equation modeling tests were performed on respecified models. An inherent risk in the testing of respecified models is that the models may be driven by the sample data rather than by theory, and therefore may be reflective only of the sample subjects and not generalizable to the population of interest. Although care was taken to assure that the respecified models were guided by the Theory of Health Promotion of Preterm Infants, the results of the tests of these respecified models should be considered as tentative results until they are replicated in "a priori" fashion.

Conclusions

In order to advance the discipline of nursing and to improve patient outcomes, it is essential that a strong theory and research foundation upon which to base nursing practice is developed. The Theory of Health Promotion for Preterm Infants based on Levine's Conservation Model of Nursing holds promise as a theoretical framework to guide neonatal nursing practice. Further research needs to be done to determine if the use of the theory as a guide for nursing practice can improve the health outcomes of nursing's tiniest patients.

REFERENCES

REFERENCES

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APPENDICES

APPENDIX A

Approvals from Institutional Review Boards

THE UNIVERSITY OF TENNESSEE
MEDICAL CENTER AT KNOXVILLE

• *University Memorial Hospital*
• *Graduate School of Medicine*

Office of Institutional Review Board
1924 Alcoa Highway
Knoxville 37920-6999
(423) 544-9781

December 3, 1997

Linda Mefford, RNC, MSN, PhD(c)
Intensive Care Nursery/Intermediate Care Nursery
The University of Tennessee Medical Center
at Knoxville
1924 Alcoa Highway
Knoxville, TN 37920

RE: **IRB #0842 "The Relationship of Nursing Care to Health Outcomes of Preterm Infants"**

Dear Ms. Mefford:

Your above referenced research study has been administratively reviewed and approved.

Because the signed informed consent document would be the only identification of participants, this requirement is waived. This institution has an approved MPA on file with the OPRR (M1056).

Your research application will be reviewed in one year, and you are reminded that you have individual responsibility for reporting to the committee in the event of any adverse reactions of the study.

We appreciate your informing us of this project.

Sincerely,

Joseph E. Fuhr

Joseph E. Fuhr, PhD
Chairman
Institutional Review Board

JEF:rl

Exceptional medicine. Exceptional people.

THE UNIVERSITY OF TENNESSEE
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March 4, 1998

IRB #: 5521 B

Title: The Relationship of Nursing Care to Health Outcomes of Preterm Infants: Testing a Theory of Health Promotion for Preterm Infants Based on Levine's Conservation Model of Nursing

Linda C. Mefford
Nursing
8805 Mill Run Drive
Knoxville, TN 37922

Dr. Martha Alligood
Nursing
1200 Volunteer Blvd.
Campus

Thank you for your Form B submission. Even though your protocol was reviewed and approved at UT Medical Center, we are required to maintain a copy of the protocol on file here as well. Consequently, we must follow up with an approval letter from this office.

Responsibilities of the investigator during the conduct of this project include the following:

1. To obtain prior approval from the Committee before instituting any changes in the project.

2. To retain signed consent forms from subjects (when required) for at least three years following completion of the project.

3. To submit a Form D to report changes in the project or to report termination at 12-month or less intervals.

We appreciate your cooperation in complying with the policies and procedures of both UT Medical Center and this office.

Sincerely,

Brenda Lawson

Brenda Lawson
Compliances

cc: Dr. Joan Creasia
Dr. Sandra Thomas

APPENDIX B

Nursing Developmental Protocol of Study Site

The University of Tennessee Memorial Hospital
Nursing Manual – ICN/IMCN

Devised: 2/99 **Subject:** ICN/IMCN Developmental Protocol
Revised:
Reviewed:

Purpose: Infants in ICN/IMCN will receive care in a manner that is appropriate for their developmental age and that promotes optimal developmental progress.

Policy Statements:

1. Use supportive boundary rolls to position the infant in a manner that:
   (a) maintains proper body alignment;
   (b) promotes flexion of extremities;
   (c) prevents shoulder retraction and "arching" of the back and neck;
   (d) promotes hand-to-midline and hand-to-mouth movements.

   Refer to the "ICN/IMCN Positioning Guidelines" for specific positioning techniques.

2. Offer the infant a pacifier during awake/alert periods (particularly during bolus tube feedings) and to assist in calming an agitated infant. The pacifier size should be increased as the infant grows. If the parents have brought a pacifier for their infant, then this "home pacifier" should be used exclusively as soon as the infant is large enough to use it.

3. Minimize adverse stimuli to the oral area:
   - Use feeding tubes that can remain in place for 1 week to decrease the frequency of feeding tube changes.
   - Minimize the use of tape around the oral area.
   - Suction OP only when clearly indicated; use bulb syringe instead of catheter whenever possible.
   - Avoid any type of painful or unpleasant stimulation inside the mouth or to the area around the mouth.

4. Identify the infant's approach/avoidance cues and post on developmental card at the bedside (see copy included with this protocol). Update the bedside card as infant's cues change. (For preterm infants, refer to the listing of preterm infant cues included as page 3 of this protocol or on the reverse side of the bedside developmental card.) Teach parents the infant's cues and encourage the parents to assist with updating the bedside card.

5. Minimize unnecessary environmental noise. Shield isolettes with a thick blanket to minimize environmental light. (If blankets are placed as a "tent" over an open crib, they should be taped securely to prevent the blanket from falling and should be kept well away from the infant's face to assure adequate air circulation.)

6. Provide appropriate sensory stimulation as indicated by the infant's level of maturity and tolerance (using the infant's adjusted gestational age as a guide). When providing sensory stimulation to preterm infants:
   - Offer only one type of sensory stimulation at a time and assess the infant's tolerance;
   - Provide stimulation only during periods of alertness and for brief periods of time;
   - Stop the stimulation if the infant begins displaying avoidance cues (indicating overstimulation).

7. Refer to the guidelines below for examples of appropriate types of sensory stimulation for preterm and newborn infants. When selecting appropriate sensory stimulation techniques, remember that the "in utero" maturation of the sensory systems progresses in the following order:
   - Tactile (touch) -- earliest to develop;
   - Vestibular (movement);
   - Olfactory (smell) and Gustatory (taste);
   - Auditory (hearing) -- matures during last trimester;
   - Visual (seeing) -- the last sense to mature; continues to develop after birth.

Tactile:

Place and hold your hand on the infant firmly but gently.
Provide alternate textures next to the infant's skin (blanket, wash cloth, toy, etc.)
Stroke infant's skin slowly and gently. Begin with the infant's trunk and move to more sensitive areas, such as the face, palms of hands, and soles of feet.

Vestibular:

Slowly change position during handling.
Hold infant and rock gently.
Passive range-of-motion exercises.
"Nature's Cradle" rocking bed (for selected infants).
Infant swing (for infants who have reached term gestation or older).

Olfactory:

Allow infant to smell breast milk, formula, or the mother's perfume.

Gustatory:

Encourage nonnutritive sucking on a pacifier or the infant's own hand (especially during tube feedings).
Place a few drops of milk in the infant's mouth during a tube feeding.

Auditory:

Softly talk to the infant, using a variety of speech inflections.
Softly play music or recordings of parents' or siblings' voices.

Visual:

Place pictures of parents/siblings in the infant's bed.
Initiate eye contact with the infant during alert periods.
Alternate placing small toys in the infant's visual field.
Place mobiles on the cribs of older infants.

8. When infant's have reached an adjusted gestational age of term gestation (approximately 40 weeks) and have achieved developmental progress consistent with a term newborn, they should be provided with appropriate sensory and developmental play interventions to promote continued progress through the developmental milestones for the first year of life (as allowed by their medical condition.) The Pediatric Rehabilitation Staff or the Pediatric Child Life Specialist should be consulted as indicated for assistance with planning developmental interventions for these infants.

   The Primary R.N./Patient Care Manager should work with the parents to establish a consistent 24 hour routine for these older infants, with all caregivers following this routine as much as possible.

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Preterm Infant Behavioral Cues

Signs of Stability in Preterm Infants (Approach Cues)

Autonomic:

Color pink.
Respirations regular.
Heart rate regular.
GI system stable (no gagging, emesis, bowel movements, straining, grunting, etc.).

Motor:

Relaxed, flexed posture.
Normal reflexive responses.
Strong suck.
Grasping.
Softly folded fingers.
Smooth, controlled movements.
Good, consistent muscle tone.
Bracing against a firm surface.

State:

Well-defined sleep states (little movement or vocalization when asleep).
Clear alert state (brief at first, length increases with maturity).
Animated facial expressions (smile, frown, 'ooh' face).
Facial muscles soft, relaxed.

Attentional/Interaction:

Attends to stimuli ((quiets, turns toward stimuli, etc.):
Tactile Oral
Auditory Olfactory
Visual Vestibular/Kinesthetic
Reaches out to caregiver.
Looks at caregiver.
Nestles against caregiver.

Self-Regulatory:

Quiets self, or easily consoled.
Braces foot/body against firm surface.
Tucks body into flexion.
Changes state in response to disturbing stimuli, or when overstimulated (i.e., lowers state from alertness to sleep; begins crying).
Hand-to-midline movements, clasping hands together.
Hand-to-mouth movements, sucking.

Signs of Stress in Preterm Infants (Avoidance Cues)

Autonomic:

Color changes --
pale, grey, dusky, flushed, mottled.
Respiratory changes --
Apnea, increased or decreased respiratory rate, gasping, yawning, sneezing, sighing, hiccups.
Cardiac changes --
Bradycardia or tachycardia, irregular heart rate.
Gastrointestinal changes --
Gagging, emesis, grunting, bowel movements, straining.

Motor:

Increased or decreased muscle tone (sudden limpness or stiffness).
Arm/leg extensions.
Saluting.
Finger/toe splays.
Arching.
Making fists.
Jerking movements.

State:

Glassy eyed.
Staring.
Fussiness.
Panicked/worried cry.
Irritable.
Abrupt changes of state.

Attention/Interaction:

Gaze aversion, or turning away from stimuli.
'Shutting down' to avoid stimuli.

Self-Regulatory:

Inability to console self with previously effective means.

APPENDIX C

Approvals to Access the Archival Records

THE UNIVERSITY OF TENNESSEE
MEDICAL CENTER AT KNOXVILLE

- *University Memorial Hospital*
- *Graduate School of Medicine*

1924 Alcoa Highway
Knoxville, TN 37920-6999
(423) 544-9000

November 26, 1997

Joseph E. Fuhr, Ph.D.
Chairman, Institutional Review Board
University of Tennessee Medical Center at Knoxville
1924 Alcoa Highway
Knoxville, TN 37920-6999

Dear Dr. Fuhr:

I have reviewed Linda Mefford's research proposal "The Relationship of Nursing Care to Health Outcomes of Preterm Infants: Testing a Theory of Health Promotion for Preterm Infants Based on Levine's Conservation Model of Nursing" and have discussed this project with her. She has approval to access the records of the UTMCK neonatal center database for this project.

Sincerely,

Vichien Lorch, M.D.
Medical Director
Intensive Care Nursery
Intermediate Care Nursery

THE UNIVERSITY OF TENNESSEE
MEDICAL CENTER AT KNOXVILLE

• *University Memorial Hospital*
• *Graduate School of Medicine*

1924 Alcoa Highway
Knoxville, TN 37920-6999
(423) 544-9000

December 1, 1997

Joseph E. Fuhr, Ph.D.
Chairman, Institutional Review Board
University of Tennessee Medical Center at Knoxville
1924 Alcoa Highway
Knoxville, TN 37920-6999

Dear Dr. Fuhr:

I have discussed with Linda Mefford her research proposal "The Relationship of Nursing Care to Health Outcomes of Preterm Infants: Testing a Theory of Health Promotion for Preterm Infants Based on Levine's Conservation Model of Nursing." I grant approval for her to use the archived nutrition records from the ICN and IMCN for this project.

Sincerely,

Joan Dawson

Joan Dawson, M.S., R.D., F.A.D.A., L.D.N.
Pediatric Nutritionist
Intensive Care Nursery
Intermediate Care Nursery

THE UNIVERSITY OF TENNESSEE
MEDICAL CENTER AT KNOXVILLE

• *University Memorial Hospital*
• *Graduate School of Medicine*

1924 Alcoa Highway
Knoxville, TN 37920-6999
(423) 544-9000

MEMORANDUM

TO: Linda Mefford, RN, MSN, PhD(c)

FROM: Janet Hill, RN, MSN
Clinical Manager, Nurseries

Nancy Scheurer, RN
Head Nurse, ICN

DATE: November 25, 1997

RE: Permission to conduct research as outlined in Dissertation

We have read your research proposal and want to extend our authorization for your use of assignment sheets and other data that will facilitate the completion of your Dissertation Proposal "The Relationship of Nursing Care to Health Outcomes of Preterm Infants: Testing a Theory of Health Promotion for Preterm Infants Based on Levine's Conservation Model of Nursing." We support you and your study and will be anxious to see what the findings will show. Once you have received IRB approval, let us know if we can be of assistance as the project progresses.

APPENDIX D

Final Data Collection Instrument

Case # __________

Energy Balance

x_1 Surfactant Therapy: 0 = no; 1 = yes

x_2 Minimum appropriate FiO2 during the first 12 hours of life: ______ %

x_3 Maximum appropriate FiO2 during the first 12 hours of life: ______ %

x_4 Maximum base excess during the first 12 hours of life: ______ milli-osmoles per liter.

Structural Integrity

x_5 Gestational age (PCA) at birth: ______ weeks. x_6 Birth weight: ________ grams.

Personal Integrity

x_7, x_8 Apgar scores: 1 minute______ 5 minute________

x_9 Resuscitation at birth: 0 = None; 1 = Oxygen; 2 = Bag/mask; 3 = Endotracheal Tube; 4 = Drugs.

Social Integrity

x_{10} Maternal age: _______ years.

x_{11} Race: 0 = Caucasian; 1 = Other.

x_{12} Prenatal care during pregnancy: 0 = none; 1 = limited; 2 = complete.

x_{13} Mother's health insurance status at the time of birth: 0 = none; 1 = Government; 2 = Private.

Health Status

y_1 Post-conceptional age at discharge: __________ + (_______ ÷ 7)
GA at birth in weeks + (LOS in days ÷ 7) = ______ weeks.

y_2 Weight at discharge: _________ grams.

y_3 Post-conceptional age at initial bottle or breast feeding:

__________ + (__________ ÷ 7)
GA @ birth in weeks + (chronologic age in days at first po feed ÷ 7) = ________ weeks.

y_4 Post-conceptional age at full bottle or breast feeding:

__________ + (__________ ÷ 7)
GA @ birth in weeks + (chronologic age in days at full po feed ÷ 7) = ________ weeks.

y_5 Morbidity Score: _________.

(Sum of the number of illnesses identified in the "Morbidity" factor below; range 0 to 5).

Morbidity

y_{14} Bronchopulmonary Dysplasia: 0 = no; 1 = yes.

y_{15} Periventricular/Intraventricular Hemorrhage: 0 = no; 1= Grade 1; 2 = Grade 2; 3 = Grade 3; 4 = Grade 4.

y_{16} Periventricular Leukomalacia: 0 = no; 1 = yes.

y_{17} Retinopathy of Prematurity: 0 = no; 1 = Stage 1; 2 = Stage 2; 3 = Stage 3; 4 = Stage 4.

y_{18} Nosocomial Infection: 0 = no; 1 = yes.

Resource Utilization

y_{19} Length of initial hospital stay: ________ days.

y_{20} # days on mechanical ventilation: ________ days.

y_{21} # days in supplemental oxygen: _________ days.

y_{22} # days on parenteral nutrition: _________ days.

Case # __________

Intensity of Nursing Care

y_6 **Percent of total nursing care hours with direct care provided by an R.N. during NICU stay.**

[(__________) ÷ (__________)] X 100 = __________ %

(# of shifts with care provided by an RN during NICU stay.) ÷ (Total # of shifts infant cared for in NICU.)

y_7 **Percent of total nursing care hours with direct care provided by an R.N. during IMCN stay.**

[(__________) ÷ (__________)] X 100 = __________ %

(# of shifts with care provided by an RN during IMCN stay) ÷ (Total # of shifts infant cared for in IMCN.)

y_8 **Average (mean) number of other patients cared for by nursing caregiver during the NICU stay.**

$\sum$ (# of other patients cared for each shift by each caregiver in NICU) ÷ total # of shifts in NICU = _____

y_9 **Average (mean) number of other patients cared for by nursing caregiver during the IMCN stay.**

$\sum$ (# of other patients cared for each shift by each caregiver in IMCN) ÷ total # of shifts in IMCN = _____

Consistency of Nursing Care

y_{10} **Percent of total nursing care provided by the most frequent nurse caregiver during the NICU stay.**

$$\frac{\text{(\# of shifts infant cared for by the most frequent NICU caregiver)}}{\text{(total \# of shifts infant in NICU)}} \times 100 = \_\_\_\_\_\_\_\_ \%$$

y_{11} **Percent of total nursing care provided by the most frequent nurse caregiver during the IMCN stay.**

$$\frac{\text{(\# of shifts infant cared for by the most frequent IMCN caregiver)}}{\text{(total \# of shifts infant in IMCN)}} \times 100 = \_\_\_\_\_\_\_\_ \%$$

y_{12} **Number of different caregivers during the NICU stay** = __________.

y_{13} **Number of different caregivers during the IMCN stay** = __________.

APPENDIX E

Worksheet for Summarizing Nursing Care Delivery

Case # ________

Worksheet for Summarizing Nursing Care Delivery

Neonatal ICU

y_{10} Total # of shifts the infant was cared for in the NICU: ________

Total # of shifts during the NICU stay with care provided by an R.N.:__________

y_{12} $\sum$ (total # of other patients cared for each shift by each caregiver during NICU stay) = _____

y_{14} # shifts care provided by the most frequent nursing caregiver during the NICU stay = ______

y_{16} Total # of different caregivers during the NICU stay = _________.

Intermediate Care Nursery

y_{11} Total # of shifts the infant was cared for in the IMCN: ________

Total # of shifts during the IMCN stay with care provided by an R.N.:__________

y_{13} $\sum$ (total # of other patients cared for each shift by each caregiver during IMCN stay) = ______

y_{15} # shifts care provided by the most frequent nursing caregiver during the IMCN stay = _______

y_{17} Total # of different caregivers during the IMCN stay = _________.

	Date	Shift	Unit	Census	# RNs (Actual/ Desired)	Total # Caregivers (Actual/ Desired)	Caregiver	Title	# of other pts.
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

Case # ________ Page _____

	Date	Shift	Unit	Census	# RNs (Actual/ Desired)	Total # Caregivers (Actual/ Desired)	Caregiver	Title	# of other pts.
1									
2									
3									
4									
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VITA

Linda Carol Mefford was born in Louisville, Kentucky on November 18, 1957. She attended elementary and secondary schools in Louisville, Kentucky, Winston-Salem, North Carolina, and Morristown, Tennessee. She graduated with highest honors from Morristown-Hamblen High School East in June 1975. In June 1979, she graduated with high honors from the University of Tennessee at Knoxville and received the Bachelor of Science in Nursing degree. After working as a staff nurse in the Intensive Care Nursery at the University of Tennessee Medical Center at Knoxville for 10 years, she received the Master of Science in Nursing degree with a clinical focus in pediatrics from the University of Tennessee at Knoxville in May 1989. She was awarded a "Chancellor's Citation for Extraordinary Professional Promise" from the University of Tennessee at Knoxville in April 1989. She has been employed since 1989 as a Clinical Nurse Specialist in the Intensive Care Nursery at the University of Tennessee Medical Center at Knoxville. In May 1999 she received the Doctorate of Philosophy in Nursing degree from the University of Tennessee at Knoxville.

The author is nationally certified in Neonatal Intensive Care Nursing, and is a member of Sigma Theta Tau International Honor Society of Nursing, the Honor Society of Phi Kappa Phi, the National Association of Neonatal Nurses, the Southern Nursing Research Society, and the American Nurses Association. In 1998 she was awarded the "Dissertation Award for Excellence in Doctoral Research" by the Gamma Chi Chapter of Sigma Theta Tau and the "Award for Professional Nursing Clinical Excellence" by the Regional Cooperative for Professsional Nurses' Week in Knoxville, Tennessee.