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Abstract: *Neonatal nurses play an essential role in supporting preterm infants during their critical adaptation to extrauterine life. The study's purpose was to test a middle range Theory of Health Promotion for Preterm Infants based on Levine's Conservation Model of Nursing, which is well suited to the needs of these fragile patients. Structural equation modeling was used in an ex post facto study design with a convenience sample of 235 preterm infants. Testing and refinement of a path diagram produced a complete mediation model in which consistency of nursing caregivers during the hospital stay completely mediated the effects of physiologic immaturity at birth on the age at which initial health was attained. Predetermined criteria for good model fit were met. The study supported utility of the middle range Theory of Health Promotion for Preterm Infants as a framework to guide neonatal nursing practice and research and highlighted the importance of consistent nursing caregivers to promote health in preterm infants.*

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

Preterm infants face unique challenges during their adaptation to extrauterine life due to immaturities in many major organ systems. This adaptation can take weeks or even months to complete, especially if an infant is extremely preterm, and complications arising during the transition to extrauterine life can lead to long-term disabilities for surviving infants. Because neonatal nurses play an essential role in supporting preterm infants and their families through this critical postnatal transition, theoretical frameworks to guide planning and delivery of holistic neonatal nursing care need refinement and testing. The purpose of this study was to perform an exploratory test of a middle range Theory of Health Promotion for Preterm Infants based on Levine's Conservation Model of Nursing.

Theoretical Framework

Using Levine's Conservation Model to view the plight of the preterm infant in the Neonatal Intensive Care Unit, Mefford (2004) developed and described a middle range Theory of Health Promotion for Preterm Infants. This theory proposes that the crisis event of a preterm birth creates environmental challenges for both the infant and the family and survival of both the infant and the family system requires rapid and ongoing engagement with the process of adaptive change. According to Levine (1996), "There must be a bridge which 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" (p. 38). In Levine's model, the goal of this adaptive change is the conservation of health, a term which is linguistically analogous to the terms wholeness, integrity, and unity (Levine, 1991). In Levine's view, "The internal environment and the external environment are joined through adaptive patterns, and the individual's wholeness is a function of their harmonious interaction" (Levine, 1996, p. 38). The goal of nursing care in Levine's model is conservation of health and wholeness via therapeutic and supportive nursing interventions guided by four conservation principles: conservation of energy, conservation of structural integrity, conservation of personal integrity and conservation of social integrity (Levine, 1967).

A preterm infant is both physically small and structurally immature presenting the risk for injury with transition from intrauterine to extrauterine life (a threat to structural integrity). Preterm physiologic systems also are not completely developed. This physiologic immaturity is pervasive, yielding immaturities in various cellular biochemical and metabolic pathways and suboptimal functioning of major organ systems including the lungs, heart and gastrointestinal tract (threats to the balance of energy). A critical organ system that is both structurally and functionally immature is the central nervous system (CNS). The CNS is the body's major integrating system (Levine, 1966) and a major mediating system in the development and emergence of the "unique personhood" (Levine, 1991, p. 8) of an individual. A preterm infant's immature CNS is extremely susceptible to damage (a threat to structural and personal integrity). The family system is also at high risk due to the psychosocial stresses associated with a preterm birth and the need for neonatal intensive care (a threat to social integrity).
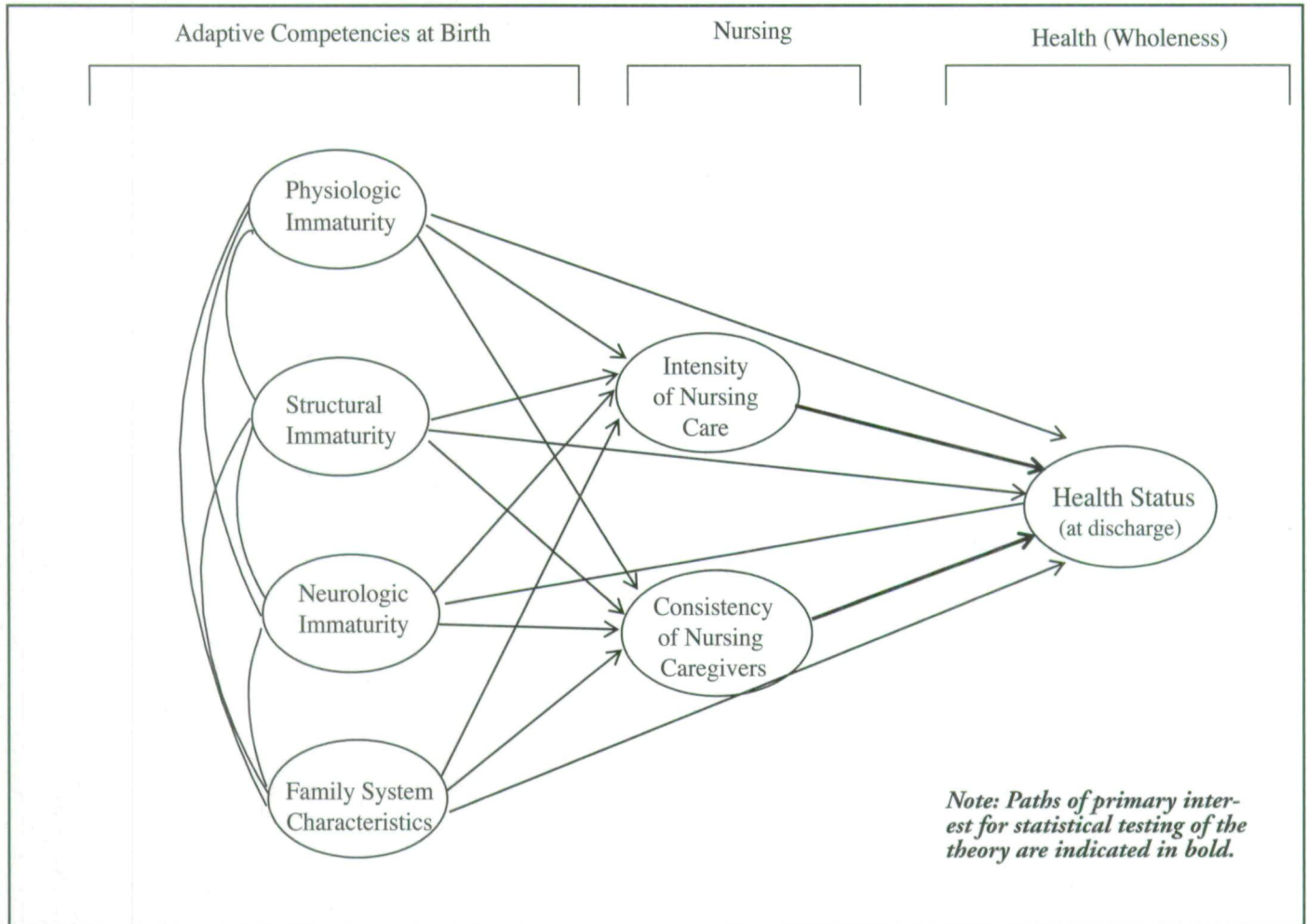
The preterm infant and family experience a disruption in health or wholeness, reflected specifically by physiologic immaturity, structural immaturity, neurologic immaturity and a disrupted family system. Both the infant and the family attempt to adapt to environmental challenges presented by a preterm birth, with the twin goals of both a healthy infant and a healthy family system. The role of the neonatal nurse is to support adaptive efforts of both the infant and family by implementing therapeutic and supportive nursing interventions directed towards conserving energy, structural integrity, personal integrity and social integrity, with the ultimate goal of health or wholeness of the infant and family system (Mefford, 2004).

Purpose

The purpose of this study was to perform an exploratory test of the middle range Theory of Health Promotion for Preterm Infants based on Levine's Conservation Model of Nursing. A path diagram model was constructed to reflect selected relationships among primary concepts (latent variables) in the theory. This path diagram model is shown as Figure 1. Measurement (manifest) variables were selected to translate conceptual meanings into

Figure 1. Path diagram of the originally hypothesized model

Adaptive Competencies at Birth   Nursing   Health (Wholeness)

Physiologic Immaturity

Structural Immaturity

Neurologic Immaturity

Family System Characteristics

Intensity of Nursing Care

Consistency of Nursing Caregivers

Health Status (at discharge)

Note: Paths of primary interest for statistical testing of the theory are indicated in bold.

numbers. Relationships among variables in the path diagram model were tested using the statistical technique of structural equation modeling.

Method

This was a descriptive correlational *ex post facto* study design with data collected from existing data bases of a Level III Neonatal Intensive Care Unit and the associated Intermediate Care Nursery, a "step-down" unit where patients were transitioned for convalescent care. Prior to data collection, the study was reviewed and approved by the Institutional Review Boards of the medical center in which the neonatal units were located and the associated university.

Selection of Measurement Variables

The primary theoretical concepts and their corresponding measurement variables are listed in Table 1. Clinical measures were selected based upon two criteria: (1) their theoretical congruence with the Theory of Health Promotion for Preterm Infants based on Levine's Conservation Model of Nursing, and (2) their established reliability and validity as indicators of neonatal clinical health status or as measures of nursing care delivery processes.

Physiologic immaturity at birth. Physiologic immaturity at birth links to the concept of energy balance in Levine's conceptual model and reflects the infant's ability to independently perform physiologic processes necessary for survival in the extrauterine environment. The primary physiologic challenges for a preterm

infant at birth are to establish effective ventilation, oxygenation and circulation. Physiologic immaturity at birth was measured by the infant's need for surfactant therapy and by three of the components of the Clinical Risk Index for Babies (or CRIB) Score that measure oxygenation and ventilation within the first 12 hours after birth. The CRIB scoring system is a good index of neonatal risk (International Neonatal Network 1993).

Structural immaturity at birth. Structural immaturity at birth links to Levine's concept of structural integrity. Because preterm infants have a level of structural maturity suited to the intrauterine environment rather than to extrauterine life (Als, 1982), they must continue to grow and develop to establish compatibility between their internal physiologic competencies and the extrauterine environment. Structural immaturity was measured by birth weight and postconceptional age at birth, two traditional markers of infant risk which are also components of the CRIB scoring system.

Neurologic immaturity at birth. Attainment of neurodevelopmental competence for survival in the extrauterine environment (Als, 1982) is a critical factor in the conservation of personal integrity, described by Levine (1973) as "the individual's sense of identity and self-worth" (p. 16). Efficacy of the preterm infant's adaptive responses at birth reflects the integrative function of the CNS and the level of neurologic immaturity. Neurologic immaturity at birth was measured by Apgar scores and the need for resuscitation at the time of birth. Apgar scores summarize the infant's transition to extrauterine life and responses to resuscita-
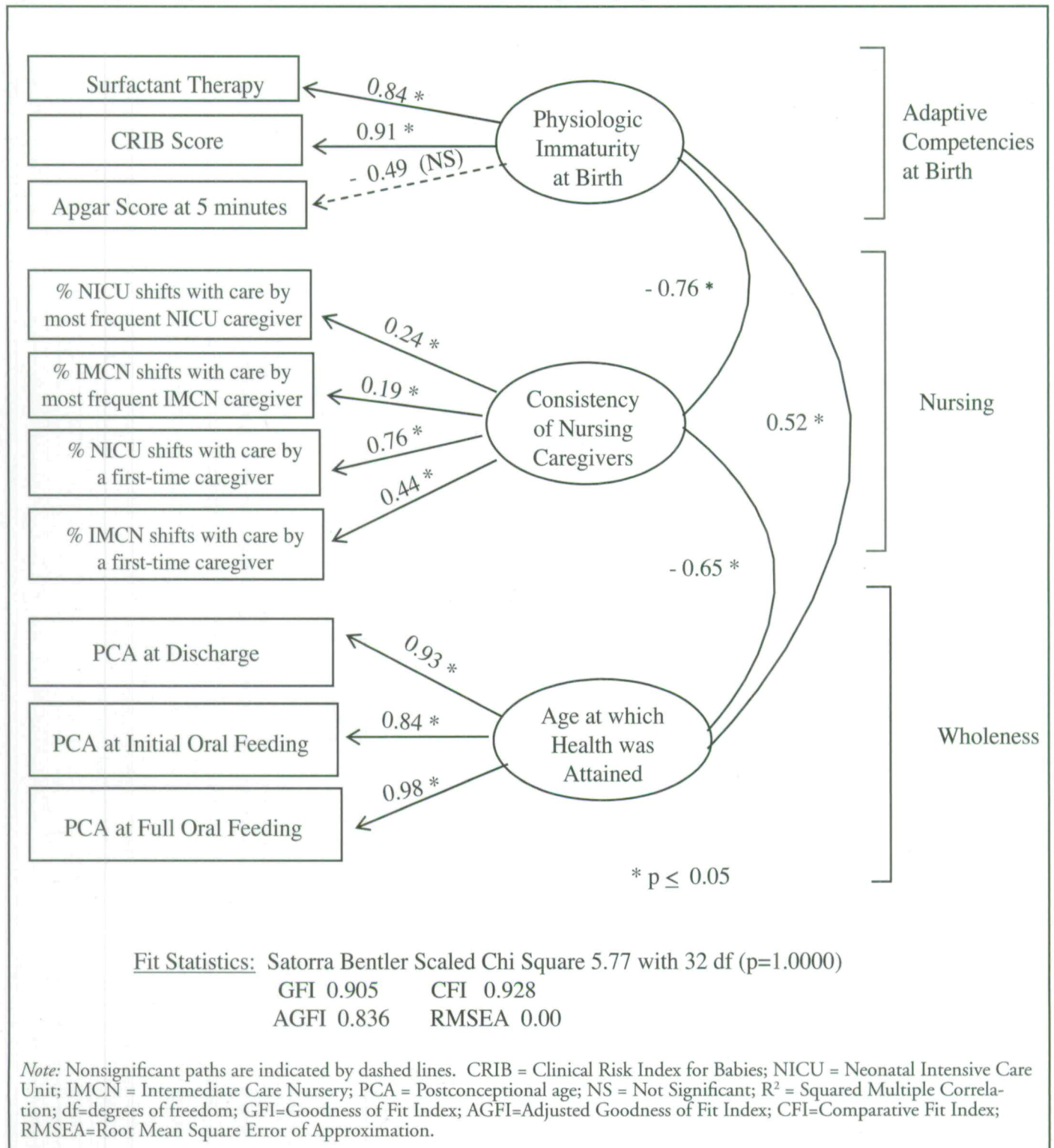
Table 1. *Theoretical Concepts and Measurement Variables for the Original Model*

Theoretical Concepts (Latent Variables)	Measurement (Manifest) Variables
Adaptive Competencies at Birth:	
(1) Physiologic Immaturity	Surfactant therapy Minimum appropriate Fraction of inspired O_2 (FiO_2) within first 12 hours of life Maximum appropriate Fraction of inspired O_2 (FiO_2) within first 12 hours of life Maximum base excess within first 12 hours of life
(2) Structural Immaturity	Postconceptional age at birth Birth weight
(3) Neurologic Immaturity	Apgar score at 1 minute Apgar score at 5 minutes Degree of resuscitation at birth
(4) Family System Characteristics	Maternal age Race Prenatal care during pregnancy Mother's health insurance status at birth
Nursing:	
(1) Consistency of Nursing Caregivers	% of NICU shifts with care by most frequent nursing caregiver % of Intermediate Care Nursery shifts with care by most frequent nursing caregiver % of NICU shifts with care by a first time nursing caregiver % of Intermediate Care Nursery shifts with care by a first time nursing caregiver
(2) Intensity of Nursing Care	% of total direct care hours provided by an RN during NICU stay % of total direct care hours provided by an RN during IMCN stay Mean number of other patients cared for per shift by nursing caregiver during NICU stay Mean number of other patients cared for per shift by nursing caregiver during IMCN stay
Health or Wholeness:	

(1) Health Status	Postconceptional age at discharge
	Weight at discharge
	Postconceptional age at initial oral feeding
	Postconceptional age at full oral feeding
	Morbidity score, defined as the number of the following:
	  • Bronchopulmonary dysplasia
	  • Intraventicular hemorrhage
	  • Periventricular leukomalacia
	  • Retinopathy of prematurity
	  • Nosocomial infection

NICU = Neonatal intensive care unit
IMCN = Intermediate care nursery

Figure 2. *Confirmatory factor analysis (CFA or measurement model) test of the respecified model, standardized solution*

Fit Statistics: Satorra Bentler Scaled Chi Square 5.77 with 32 df (p=1.0000)

GFI 0.905   CFI 0.928

AGFI 0.836   RMSEA 0.00

Note: Nonsignificant paths are indicated by dashed lines. CRIB = Clinical Risk Index for Babies; NICU = Neonatal Intensive Care Unit; IMCN = Intermediate Care Nursery; PCA = Postconceptional age; NS = Not Significant; R^2 = Squared Multiple Correlation; df=degrees of freedom; GFI=Goodness of Fit Index; AGFI=Adjusted Goodness of Fit Index; CFI=Comparative Fit Index; RMSEA=Root Mean Square Error of Approximation.
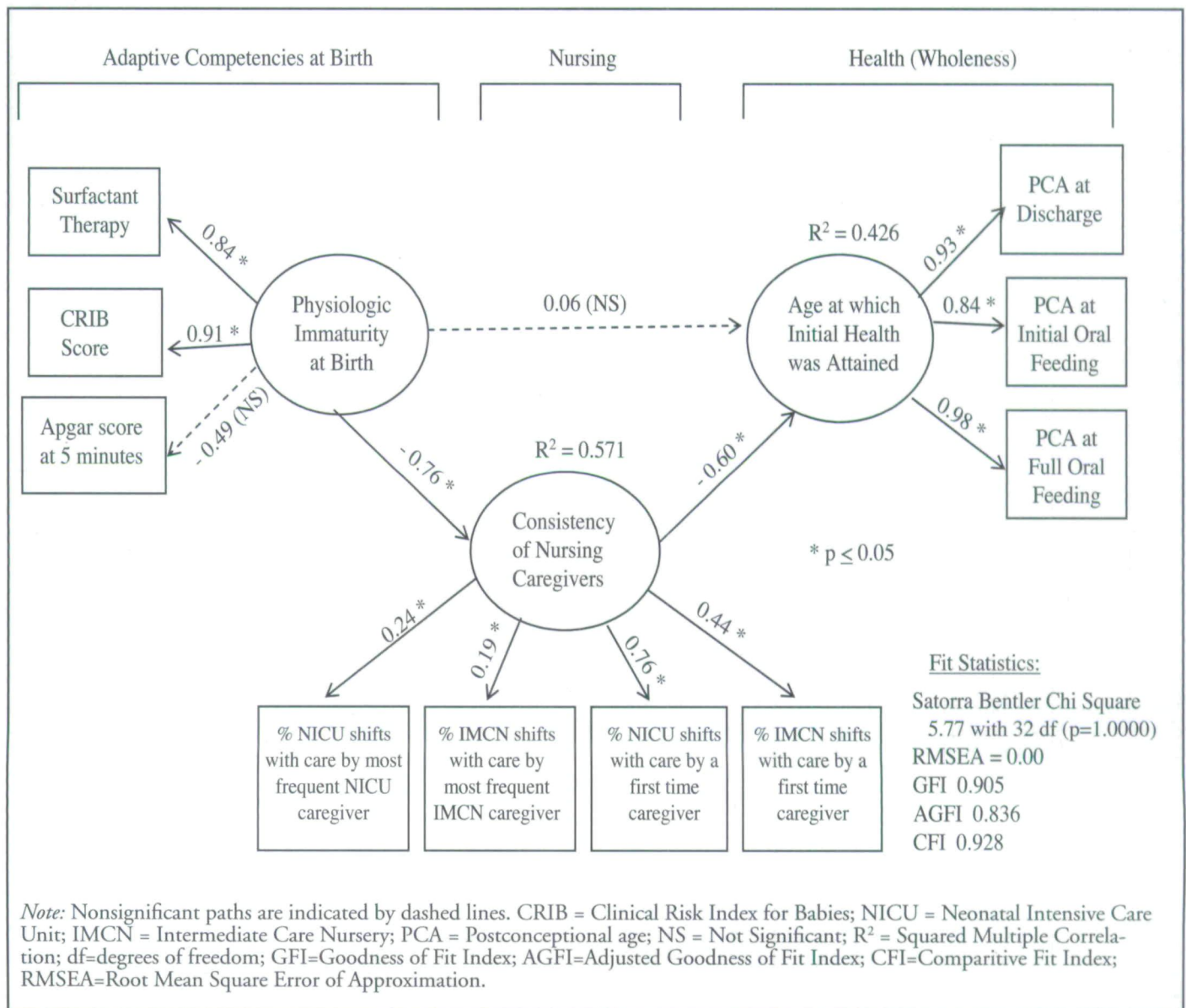
tive efforts (Kattwinkel, 2006). Need for extensive resuscitation measures has been associated with less favorable neurologic outcomes (Volpe, 2001).

Family system characteristics at birth. Preterm birth is a family crisis that disrupts usual family functioning (McGrath, 2007). The family's capacity to adapt to this crisis is influenced by characteristics of the family system and reflects Levine's concept of social integrity. Characteristics of the family system at birth included maternal age, race, and socioeconomic status, measures known to be markers of risk for pregnancy outcome (Institute of Medicine, 2007). Health insurance status at the time of birth and the extent of prenatal care were proxy measures for socioeconomic status.

Consistency of nursing caregivers and intensity of nursing care. Levine stated "Nursing intervention means that the nurse interposes her skill and knowledge into the course of events that

Figure 3. *Structural equation modeling (SEM) test of the respecified model, standardized solution*

Adaptive Competencies at Birth   Nursing   Health (Wholeness)

Surfactant Therapy

CRIB Score

Apgar score at 5 minutes

Physiologic Immaturity at Birth

0.84 *

0.91 *

-0.49 (NS)

0.06 (NS)

$R^2 = 0.426$

Age at which Initial Health was Attained

0.93 *

0.84 *

0.98 *

PCA at Discharge

PCA at Initial Oral Feeding

PCA at Full Oral Feeding

-0.76 *

$R^2 = 0.571$

Consistency of Nursing Caregivers

-0.60 *

* p ≤ 0.05

0.24 *

0.19 *

0.76 *

0.44 *

% NICU shifts with care by most frequent NICU caregiver

% IMCN shifts with care by most frequent IMCN caregiver

% NICU shifts with care by a first time caregiver

% IMCN shifts with care by a first time caregiver

Fit Statistics:

Satorra Bentler Chi Square
   5.77 with 32 df (p=1.0000)
RMSEA = 0.00
GFI 0.905
AGFI 0.836
CFI 0.928

Note: Nonsignificant paths are indicated by dashed lines. CRIB = Clinical Risk Index for Babies; NICU = Neonatal Intensive Care Unit; IMCN = Intermediate Care Nursery; PCA = Postconceptional age; NS = Not Significant; R^2 = Squared Multiple Correlation; df=degrees of freedom; GFI=Goodness of Fit Index; AGFI=Adjusted Goodness of Fit Index; CFI=Comparitive Fit Index; RMSEA=Root Mean Square Error of Approximation.

affects the patient" (Levine 1973, p. 13). Individuals who care for an infant on a more frequent basis should be better attuned to the infant's unique physiologic and behavioral cues and to unique needs of the family. Familiarity and consistency should enable these caregivers to deliver nursing care in a manner that more effectively supports the unique adaptive patterns of the infant and family. Higher levels of nursing knowledge and skill along with fewer numbers of other patients should facilitate design and implementation of individualized nursing interventions for the infant and family.

Health or wholeness at discharge. A preterm infant confronts many health challenges during the adjustment to extrauterine life. The level of health attained by the infant at the time of discharge should be influenced by the nursing care provided during the hospital stay. Levine states that "nursing must view the individual so that the 'best fit' available can be sustained" (Levine 1989, p. 331). Preterm infants may be viewed as attaining an initial level of health when they have achieved developmental milestones that allow a basic level of independent functioning in the extrauterine environment. Family status is also reflected in the restoration of the infant's health. The family system should attain

a degree of integrity that allows family members to assume the role of primary caregivers for the infant.

For the preterm infant, a significant marker of health is that both the infant and family attain a level of independent functioning that enables the infant to be discharged on or before the expected due date for a term pregnancy. One of the most complex neurodevelopmental skills for preterm infants is the establishment of oral feedings (Hawdon, Beauregard, Slattery & Kennedy, 2000). Bronchopulmonary dysplasia, retinopathy of prematurity, and periventricular leukomalacia are pathophysiologic conditions of neonates which have been related to toxic effects from oxygen administration, alternating periods of hypoxia and hyperoxia, and the production of free radical molecules due to oxidative stress (De Fiore et al., 2010, Gressens, Rogido, Paindaveine, & Sola, 2002; Kakita et al., 2009, Phelps, 2002; Saugstad, 2010). Because the responsibility for regulating oxygen concentration is a primary responsibility of nurses, these morbidity endpoints are potentially nurse sensitive markers. Both intraventricular hemorrhage and periventricular leukomalacia have been associated with alterations in cerebral blood flow and cerebral blood flow velocity (Ballabh, 2010; Kusters, Chen, Follett & Dammann, 2009; O'Leary et al.,

2009; Volpe, 1997) which is influenced by a variety of nursing interventions (Volpe, 2001). Nosocomial infection is also a nurse sensitive marker because nurses have primary control of the infant's environment during the neonatal ICU stay.

Sample

The sample was a convenience sample of 235 infants with a gestational age at birth of less than 37 weeks who were treated in the study Neonatal Intensive Care Unit (NICU) and associated Intermediate Care Nursery (IMCN) from January 1996 through April 1997. Infants were included if the databases had complete data for all measurement variables and were excluded based on these criteria: (1) born at an outlying hospital and transferred to the study NICU; (2) known to have a maternal history of drug or alcohol, congenital anomalies, an unusual medical diagnosis not typical of preterm infants, or neurological problems other than periventricular/intraventicular hemorrhage or periventricular leukomalacia; (3) required major surgery; (4) admitted directly to the Intermediate Care Nursery; or (5) died before hospital discharge.

Data Analysis

Data analysis was performed using the LISREL 8.3 for Windows statistical package. The measurement variables were initially screened for both univariate and multivariate normality then the data were submitted to the LISREL program for structural equation modeling (SEM). Step 1 of the SEM process was a confirmatory factor analysis (CFA) of the 7 latent variables with their corresponding measurements (as described in Table 1) to assess adequacy of the measures. Despite use of data transformation techniques, non-normality of some distributions prevented a complete analysis of the original 7 factor model; however, an intermediate CFA was computed to guide model respecification.

Guided both by theory and by the intermediate CFA, investigators synthesized the CFA model into a more concise form consisting of three latent variables and ten manifest variables (see Figure 2). The intermediate CFA of this respecified model indicated that the best measures of the latent variable *physiologic immaturity at birth* were surfactant therapy, Apgar score at 5 minutes, and a restructured measure including all components of the CRIB score as a single measure rather than broken down into component parts. Measures of *consistency of nursing caregivers* remained unchanged, but the concept *intensity of nursing care* was eliminated from analysis in this model due to presence of extremely strong correlations of this variable with other variables in the model. Three age-related variables were retained in the revised model to reflect health outcome; this concept was renamed *age at which health was attained.*

Findings

The CFA measurement model and the SEM test of the respecified path diagrams were performed using maximum likelihood estimation. Results of these tests and the model fit statistics for each are shown as Figures 2 and 3. To correct for persistent non-normality of some sample data, an asymptotic covariance matrix was generated to compute a Satorra-Bentler Scaled Chi-Square statistic. The fit statistics indicated an overall good fit of the model to the data with a non-significant Satorra-Bentler Scaled Chi-Square (indicating that the sample data did not differ significantly from the hypothesized model), a Goodness of Fit Index of 0.905, Adjusted Goodness of Fit Index of 0.836, Comparative Fit Index of 0.928, and Root Mean Square Error of Approximation of 0.00. The SEM model was a complete mediation model, in which *consistency of nursing caregivers* completely mediated the effects of *physiologic integrity at birth* on *age at which health was attained.*

In the final SEM test (Figure 3), the squared multiple correlation ($R^2 = 0.571$) for the equation leading to *consistency of nursing caregivers* indicated that the model accounted for 57.1% of the measurement variance for that concept. The path from *physiologic*

immaturity at birth to *consistency of nursing caregivers* had a statistically significant standardized path weight of -0.76, indicating a strong inverse relationship. Although it was anticipated that infants who were less physiologically mature at birth would have received the greatest degree of nursing care consistency, in fact the reverse was found. Infants who were more physiologically mature tended to receive more consistency of nursing caregivers. This is a paradoxical finding, which deserves exploration in future research. It may be explained partially by the fact that more mature infants tended to have shorter hospital stays. Shorter stays translate into fewer nursing shifts, increasing the mathematical likelihood of achieving consistency of nursing caregivers as defined by the measurement equation used in this study.

The path from *consistency of nursing caregivers* to *age at which health was attained* revealed a moderately strong, statistically significant inverse relationship (path weight $= -0.60$) demonstrating that greater consistency of nursing caregivers led to a younger age at which initial health was attained. The R^2 for the structural equations leading to the concept *age at which initial health was attained* was 0.426, indicating that 42.6% of the variance was accounted for by the measures included in the model.

Discussion

This study is an example of how to use Fawcett's (2005) conceptual-theoretical-empirical structure for nursing knowledge development with linkages from a nursing conceptual model to a middle range theory that is operationalized and tested empirically (Alligood, 2010; Fawcett and Garity, 2009). An especially interesting and exciting finding of the study is that SEM testing of the theory yielded a complete mediation model. The CFA (shown as Figure 2) revealed that the relationship between *physiologic immaturity at birth* and *age at which health was attained* was statistically significant and moderately strong at 0.52. However in the SEM test (see Figure 3) this path was nonsignificant with an extremely low path weight of 0.06, indicating that *physiologic immaturity at birth* had essentially no influence on *age at which health was attained* when a simultaneous test for the influence of *consistency of nursing caregivers* was performed. In contrast, SEM paths leading to and exiting from the mediating variable *consistency of nursing caregivers* were both approximately equal to the corresponding values in the CFA model, and both reached statistical significance. If replicated in future studies, this finding of a complete mediation model will provide strong support for the importance of providing consistent nursing caregivers to improve preterm infant health outcomes.

The measurement indicators used in this study are classic indicators of infant health status and remain in widespread clinical use, but this study's retrospective nature is a limitation. Providing consistent nursing caregivers remains a great challenge in acute care settings of all types; therefore, the finding that *consistency of nursing caregivers* demonstrated such a strong mediating influence is clinically significant. Use of existing archival databases limited selection of indicators to measure dynamic concepts of the theory, particularly the family system construct. Prospective testing of the theory is needed in future research. Although successful testing was performed on a simplified model, it should be noted that mathematical constraints limited testing of the originally specified *a priori* model. A potential risk in testing a respecified model is that the model may be driven by the sample data rather than by the theory. These study findings are preliminary until the next step in the theory testing process, which is the *a priori* test of the final model performed with an independent sample (Hoyle & Panter, 1995). An *a priori* replication study is in progress.

Conclusion

The middle range Theory of Health Promotion for Preterm Infants based on Levine's Conservation Model of Nursing was supported in this study. The model fit and path directions and strengths were congruent with relational propositions of the

theory. The complete mediation model revealed that *consistency of nursing caregivers* significantly reduced the age at which the infant and family were healthy enough for hospital discharge. This finding validates the theoretical assertion that nursing care supports adaptive efforts of the infant and family and facilitates attainment of health.

Findings of this study indicate that *consistency of nursing caregivers* is an important component of health promotion for preterm infants and suggests that neonatal nurses should emphasize and promote consistent caregiving. Nurses highly attuned to an infant's unique modes of communication and who know the family should be better able to design and implement holistic nursing care interventions supporting adaptive efforts of the infant and family, and therefore restoring health. To advance the discipline of nursing and to improve patient outcomes, it is essential to develop a strong theory and research foundation upon which to base nursing practice. This study provides evidence that 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 and improve the health outcomes of nursing's tiniest patients.

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