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AN EXPLORATION OF THE RELATIONSHIP BETWEEN STRESS PHYSIOLOGICAL SIGNALS AND STRESS BEHAVIORS IN PRETERM INFANTS DURING PERIODS OF ENVIRONMENTAL STRESS IN THE INTENSIVE CARE UNIT.

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Abstract

The purpose of this descriptive study was to examine relationships between stress physiological signals and stress behaviors in preterm infants during periods of environmental stress. The study used a repeated-measures design to examine the relationships between environmental stressors, sleep-wake states, and both stress physiological signals and stress behavioral responses in one group of preterm infants. Measurements of these variables for each preterm infant were recorded every two minutes during four 60-minute observation periods (two in the morning and two in the afternoon) conducted over two days (one morning and one afternoon observation each day). The sample was 37 preterm infants who were born at less than 37 weeks gestational age and were less than 28 days of age. Data collection took place in two Level III Neonatal Intensive Care Units at medical teaching hospitals in a city in central Taiwan. A generalized estimating equation approach was used to address the research hypotheses. It was found that there was a significantly significant ($p<0$) relationship between nine stress behavioral responses and a change in heart rate (seven increased, two decreased); between four environmental stressors (nursing interventions levels 2,3,4,5) and an increases in heart rate; between four environmental stressors (nursing interventions levels 1,2,3,4) and an increase in respiratory rate; between 11 stress behavioral responses and a change in oxygen saturation; and between two environmental stressors (nursing interventions levels 2,3) and decreases in oxygen saturation in the preterm infants. When environmental stressors of noise, light and nursing interventions were analyzed together there was a significant relationship (seven positive, one negative) between environmental stressors and nine behavior responses. The benefits of recognizing preterm infant's behavioral responses and stress physiological signals to environmental stressors allow for early intervention to reduce the possibility of a more serious physiological or

pathological change in the status of the preterm infant.

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Chapter 1

Introduction

This chapter describes the background, significance, research purpose, research questions and hypotheses of this investigation. The background and significance sections describe the prevalence of prematurity and provide a historical perspective on nursing care in neonatal intensive care units, as well as describing recent changes in neonatal nursing care.

Research Background

Preterm infants are defined as infants born before 37 weeks of gestational age. According to statistics by the Centers for Disease Control (CDC), the preterm infant mortality rate in the United States has dropped from 118.6 per 100,000 live births (17.3%) in 1992 to 94.5 per 100,000 live births (14.9%) in 2003 (CDC, 2006). Although the mortality rate has declined, babies born before 32 weeks have the greatest risk of poor health outcomes, and those born between 32 to 36 weeks are also at increased risk for health and developmental problems when compared to those infants born full term (CDC, 2004). It clearly is important to improve neonatal medical and nursing care in order to improve the quality of developmental outcome in preterm infants.

The preterm infant has many physiologic limitations owing to immaturity of all major body systems, especially the cardiorespiratory system and central nervous system. Therefore, preterm infants need to rely on sophisticated medical technologies and intensive nursing interventions for survival before they reach developmental maturity (Farrell, Inturrisi, Bergman, Kenner, & Howell, 2003). The neonatal intensive care unit (NICU) is the place that provides these treatments for maintaining vital functions in preterm infants.

In utero, the fetus enjoys a comfortably warm, dark, and fluid-filled environment with rhythmic background sounds and physical containment with vestibular stimulation from the movement of the mother (Avery & Glass, 1989; Field, 1990; VandenBerg, 1995). With the abrupt, often traumatic transition at birth to extrauterine life, the preterm infant is thrust into an incubator in an environment filled with cold air, bright light, and loud noise for which the infant is totally unprepared, but is dependent upon for survival (VandenBerg , 1995).

The preterm period is a time of rapid brain maturation; therefore, environmental stimulation and medical problems can affect brain organization more easily in preterm infants than in older infants, children or adults (Blackburn, 2005; Catlett & Holditich-Davis, 1990). Although the infant's genetic background has made a permanent contribution to the infant's development, the environment can be manipulated to support optimal developmental outcome (Blackburn, 2005). Several studies have found that the NICU environment may influence preterm neurodevelopment just as the intrauterine environment influences fetal neurological development (Field, 1990; Als, 1998). Different researchers postulate that the differences between the NICU and intrauterine environments may adversely influence brain development through the infant's sensory experiences as he or she attempts to cope with the environmental demands of the NICU (Als, 1998; Blackburn, 1998; Catlett & Holitch-Davis, 1990). Some researchers (Als, 1999; Field, 1990) have pointed out that the NICU environment involves sensory overload and is a mismatch to the requirements of the developing nervous system in preterm infants. In order to not only assure survival but also foster the development of preterm infants, an understanding of their functioning and progression is critical. In response to this need, Als and Duffy (1983) developed the Synactive Theory of Development and applied developmental interventions based on this theory to preterm infants. The purpose of applying such developmental interventions is to reduce the environmental stressors to the lowest possible level and to provide appropriate opportunities for optimal development of preterm infants (Young, 1996).

Significance

Considerable research has demonstrated that the NICU is a stressful environment for preterm and high risk infants (Als,1986, 1996, 1998; Blackburn, 1998; Hall, Ballweg & Howell, 1996; Lotas, 1992; Robinoson & Fielder, 1992; Shogan & Schumann, 1993). Chronic exposure to stressors might decrease the preterm infant's ability to cope with illness and interfere with growth and development. Therefore, studies that examine the stressors present in the NICU environment and the responses to these stressors by preterm infants are very important (Damato, 2004). Nevertheless, behaviors are the only way infants can communicate their needs and responses to their environment (Holditch-Davis, Blackburn, & VandenBerg, 2003), and many sudden physiologic crises might be preventable if the caregiver recognizes and responds to the preterm infant's behavioral cues and provides interventions to allow infant recovery and reorganization. VandenBerg (1995) has argued that observing and quantifying the behaviors of preterm infants should become a major component of nursing care in the NICU. Reducing stress in NICU infants through observation and provision of appropriate intervention strategies can optimize medical status and developmental outcomes (VandenBerg, 1995).

In order to provide a protective, nurturing environment that will help preterm and very-low-birth-weight infants conserve energy and achieve physiological stability, there is a need for neonatal nurses to understand the stress behavior cues of preterm infants so that they can modulate the stressful stimulations in the NICU environment before the infant shows physiological stress. However, there is little research validating the suspected relationships between infant behaviors and environmental stress, and few studies have reported relationships between behavioral and physiological responses during the infant stress situation (Morison, Grunau, Oberlander, & Whitfield, 2001). Peters (1998) has reported that behavioral cues presumably indicating stress often precede physiologic changes in very-low-birth-weight infants, but these findings have not been widely replicated. Therefore, there is a need for additional research examining relationships between environmental stressors in the NICU and the behavioral responses of infants, and the relationships between behavioral cues suggestive of stress in the infant and physiological stress responses.

Statement of the Problem

Nurse clinicians and researchers attempt to identify specific behaviors that indicate the preterm infant's response to stressful stimulation in the NICU. The problems are: (a) the behavioral signs of stress in preterm infants have not been clearly identified; (b) the relationships between infant behaviors and environmental stress have not been clearly identified; and (c) it has not been established whether and how preterm infant behaviors are related to physiological responses to environmental stress (Morison, et. al., 2001).

Research Purposes

The purpose of this exploratory descriptive analysis was to examine relationships between stress physiological signals and stress behaviors in preterm infants during periods of environmental stress.

Research Questions

1. What are the relationships between stress physiological signals (HR, RR, and O_2 Sat level), stress behavioral cues and changes in sleep-wake states in a group of preterm infants under conditions of environmental stress (light, noise, uncomfortable touch) in the NICU?
2. Is there any priority of response between physiological and behavioral responses to environmental stress in preterm infants?
3. What is the most common physiological response of the preterm infant to environmental stress?
4. What is the most common behavioral response of the preterm infant to environmental stress?
5. Are there differences in the relationship between stress physiological signals and stress behavioral responses when preterm infants are in different sleep-wake states?

Research Hypotheses

1. Increases in environmental stress will result in increases in heart and respiration rate (HR, RR), and decreases in oxygen saturation (O_2 Sat.) level in preterm infants.
2. Increases in environmental stress will result in specific behavioral responses (e.g., finger or toes splay, frown, sit on air, tongue extension, extend arms or legs) in preterm infants.

3. There will be reliable relationships between physiological indicators of stress and specific behavioral responses of preterm infants during periods of environmental stress.
4. The observed relationships between physiological signals of stress and behavioral responses to environmental stress will be stronger when preterm infants are in a wake state.

Chapter II

Review of Literature

This chapter discusses the theoretical framework for the investigation of stress responses of newborn infants in the neonatal intensive care unit (NICU) and reviews the relevant literature. First, the basic conceptual model will be presented. This model describes the environmental sources of stress in the NICU environment and the possible impacts of these stressors on the preterm infant. Following the description of the model and its theoretical derivation, the empirical research on environmental stressors in the NICU and the responses of preterm infants to these stimuli will be reviewed.

Conceptual Framework

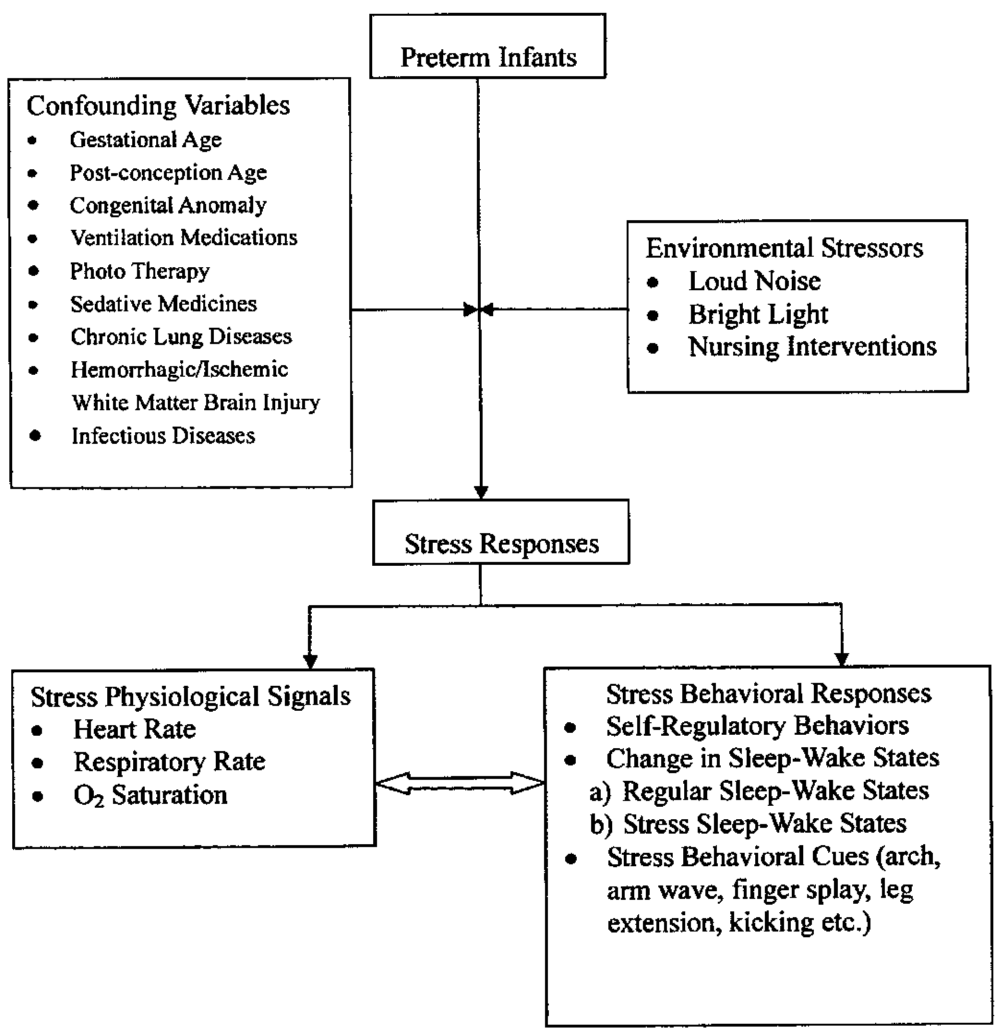
The conceptual model for this research draws upon Epstein's (2005) model of stress responses in newborn infants, Levine's Conservation Model (Schaefer, Pond, 1991), and the Synactive Theory of Development (Als, 1982, 1986). Epstein discusses the concept of stressors and the organism's response to stress, noting that stressors can be either internal to the organism or in the external environment, and that the organism's response to stress is directed toward maintaining system stability. Levine's model defines stressors as threats to the organism's energy resources, and describes responses to stressors as involving either self-regulatory behaviors or, when self-regulatory actions are not sufficient for adaptation to stressors, physiological changes and behavioral symptoms indicative of the expenditure of energy resources. Levine defines the purpose of nursing interventions as the conservation of the organism's energy resources through reductions in stressors and improvements in self-regulatory mechanisms. Finally, the Synactive Theory of Development focuses on the threats to optimal growth and development of the preterm infant posed by their immature neurobehavioral systems and the environmental conditions of the NICU, and identifies care practices that promote healthy development.

The general conceptual framework is outlined in Figure 1. It describes the environmental sources of stress in the NICU environment and their impact on the preterm infant born before 37 weeks of gestational age. The most common environmental stressors in the NICU are bright lights, loud noises, and uncomfortable touch resulting from nursing and medical procedures. These conditions induce physiological and behavioral responses in the infant, which may be influenced by various medical conditions and complications (confounding variables). The physiological responses to stressors include elevated heart and respiration rate and reduced oxygen saturation. Behavioral responses include self-regulatory behaviors, such as sucking, suck search, grasp; and behaviors indicative of the failure of self-regulatory mechanisms, such as arching, finger splay, leg extension, kicking and arm waving. Stressors also may result in changes in the infant's sleep-wake state and stress behavioral cues.

Epstein's Model of Stress Responses in Newborn Infants

Epstein (2005) focused on the stress response in newborn infants, combining elements of Selye's stress theory (Selye, 1978) and the model of stress and human health proposed by Ellitor and Eisdorfer (Ellitor & Eisdorfer, 1982). Epstein defined stressors as internal (inside the human body) or external (outside environment) factors that have the potential for disrupting system stability, and discussed several characteristics of stress: (1) stressors are ubiquitous in nature; (2) the stress response is initially a normal protective response; (3) the stress response cannot be maintained over extended periods; (4) mediators can affect stress responses directly or indirectly; (5) the stress response includes both physiological and behavioral changes; (5) ultimately, there are negative consequences for the organism from prolonged stress; and (6) the interactions among stressors, responses to stress, mediators, and consequences can be complex.

Figure 1. Stress Responses of Preterm Infants



Levine's Conservation Model

In this model, all life processes involve the production of energy. The individual's ability to function depends upon the availability of energy that is a fundamental entity of nature. Energy is transferred between parts of a system, in the production of physiological change within the system, and is usually regarded as the capacity for doing work (Merriam-Webster's Collegiate Online Dictionary, 2006-2007). Levine (1991) stressed that energy resources need to be conserved and directed by nursing interventions to ensure the maintenance of the individual's overall integrity. In addition to conservation of energy, Levine discussed three additional conservation principles: the conservation of structural integrity, the conservation of personal integrity, and the conservation of social integrity. Only the conservation of structural integrity is relevant to the present investigation as it is specifically related to the preterm infant's ability to maintain bodily integrity or health—to defend itself or to heal.

Levine's Conservation Model is one of an interaction between individual and environment. Specifically, Levine views the interaction between person and environment as a process of adaptation. The person responds (adapts) to internal and external environmental factors. This adaptation involves an exchange of energy which is directed toward the maintenance (conservation) of the individual's overall integrity (Levine, 1991). Conservation (of energy and integrity) is thus the result of adaptation.

Levine's theory includes four levels of response to the environment, of which two are particularly relevant to this investigation. The first level is the most primitive level of organismic response, the "fight-or-flight" mechanism. The self-regulatory behavioral responses of the preterm infant are based on this fight-or-flight mechanism.

They represent a marshalling of the organism's energy resources in preparation for responding to a threat to organismic integrity. The second level of environmental response relevant to this study is the stress response. Levine (1991) stated the stress response is developed over time and is influenced by the accumulated experience of the individual. The accumulated experiences of the preterm infant with environmental stressors in the NICU thus influence the stress response, which is generally expressed through physiological signals and stress behavioral signals.

Levine's model of nursing is thus focused on conservation. Through the process of conservation, energy is spent carefully, with essential organismic priorities served first. In this investigation we use this concept to describe the importance of nursing interventions to improve of self-regulatory behaviors to conserve the preterm infants' energy.

Synactive Theory of Development

The Synactive Theory of Development was developed to help the neurological growth and development of preterm infants by offering developmental care to preterm infants. This specialized care is required because of the immature neurobehavioral systems of the preterm infant. Important concepts from the Synactive Theory of Development include the central nervous system organization of preterm infants, the NICU environment, and the organism-environment transaction.

Central nervous system organization. The CNS is one of the last systems to mature and is quite immature at birth. CNS organization is a particularly sensitive stage in preterm infants. The stages of CNS development include neurulation, prosencephatic development, neurogenesis, migration of neurons and glia, organization, and myelinization (Blackburn, 2005). Neurulation, prosencephatic development, neurogenesis, and migration of neurons and glia occur before six months of gestational age. The preterm infant might be born during the critical time of CNS organization and myelinization. The CNS organizational processes are important for cell-to-cell communication and integrated activity and a critical growth spurt occurs at 30 to 32 weeks gestation. The organizational processes during this period are sometimes referred to as the "writing" of brain (Blackburn, 1998). Another process is cell death with selective elimination of neuronal processes. This process adjusts the size of individual neurons to their anticipated need and is an important component of brain plasticity. This plasticity is an advantage in the developing brain, because neuronal processes targeted for elimination may be saved if they are needed because of damage to other processes, thus preserving functional ability (Blackburn, 1993). Although the infant's genetic background has made a permanent contribution to the infant's development, the environment can be manipulated to support optimal developmental outcome. In this investigation, the central nervous system organization of the preterm infant impacts the stress responses of preterm infants (Blackburn, 2005).

Environment. The Synactive Theory of Development focuses on the environment in the NICU. Environmental events are conditions or episodes that interact with the infant. Based on the immaturity of the central nervous system in preterm infants, there are many stimulations in the NICU that are not good for preterm infants' development and growth (Barb, & Lemons, 1989; Field, 1990; Oehler,1993). Moreover, researchers (Als, 1999; Blanchard, 1991; Heriza & Sweeney, 1990) reported that in addition to too much or too little stimulation, infants in the NICU environment received inappropriate stimulations. Therefore, stimuli should be controlled and matched as closely as possible to the needs and actual level of sensory integration capacities of the preterm infant (Als, 1986, 1998,1999; Blanchard,1991; Yecco, 1993).

Organism-environment transaction. The key feature of the central nervous system, according to Als (1982), is its ability to differentiate and develop by interaction with its environment. Infants communicate developmental needs to the immediate environment that remind the care-giving interventions to satisfy the needs of the infants (Als, 1986, 1990). Infants, according to Als (1986), use five intra-organism subsystems to interact the environmental stimulations and compose to the behaviors. These five subsystems are: (1) autonomatic system (observable by the heart and respiratory rate, skin color changes, visceral signals) (2) motor system (observable in the posture, muscle tone and movement) (3) state organizational system (observable in the range of states movement between states, clarity of state), (4) attention or interaction (the ability to alert, process and respond to stimulation from environment), and (5) self-regulatory (as seem in the ability to integrate all subsystems and return to state of balance and relaxation) (Als, 1986;Young,1996). The functioning of all these systems is reliably observable without technical instrumentation (Als, 1990). Approach behaviors may be interpreted to indicate that the sensory input that is being received by the infant matches their readiness to process and to make sense of the information (Hanlund & Tatarka, 1988).

A high risk infant might not have sufficient subsystem maturity, especially in the autonomic subsystem, to maintain a balance of all subsystems. When infants cannot adapt to stress from the environment, they will show stress behaviors that indicate disorganization. Als (1982) argued that the disorganized infant is unable to process external environmental events without disrupting physiological and behavioral functioning. When infants adapt to stress from environment, they will show the signals of self-regulatory behaviors (Als, 1998, 1999). In this investigation the Synactive Theory of development provides the basis for defining stress physiological responses and stress behavioral responses of preterm infants

Overview of the Preterm Infant

Blackburn and VandenBerg (1993) report that vulnerabilities of preterm infants include the transition to extrauterine life, physiologic limitations, central nervous system immaturity, and the need for intensive care.

Transition to Extrauterine Life

Neonatal transition is the process involved in physiological adaptation of the fetus to extrauterine life. Preterm infants are at higher risk for slower transition to neonatal life due to immaturity of organ systems and lack of body mass (Verklan, 2002). Immediately at delivery, the neonate's respiratory effort, heart rate, color, tone, and reflex irritability should be assessed; all are key components of the APGAR score assigned at 1 and 5 minuets after birth. The APGAR score assigns 0 to 2 points for each of 5 measures of neonatal health, "Appearance", "Pulse", "Grimace", "Activity", and "Respiration". Scores depend on physiologic maturity, maternal perinatal therapy, and fetal cardiorespiratory and neurologic conditions. APGAR scores between 8 and 10 indicate the neonate is making a smooth transition to extrauterine life; scores ≤ 7 at 5 minutes are linked to higher neonatal morbidity and mortality rates. Preterm infants generally do not tolerate labor as well as term infants. This leads to a higher incidence of low APGAR scores and need for resuscitation in the delivery room.

In the first hours of life, preterm infants have significant problems related to thermoregulation. Premature infants are not able to regulate their body temperatures as well as term infants. Factors that contribute to this problem are immaturity of the hypothalamic regulatory center, lack of subcutaneous fat, lack of brown fat and a relatively large body surface area to body mass ratio (Verklan, 2002). This problem in preterm infants will continue over the period of prematurity. Therefore, preterm infants have to stay in an incubator or radiant warmer to keep them warm until they have the ability to maintain their thermoregulation (Gardiner, 2005).

Physiologic and Pathophysiologic Limitations

Preterm infants have many physiologic limitations at birth and cannot survive without life support procedures. Their physiologic limitations are due to immaturity of all major body systems: respiratory, cardiovascular, central nervous system, renal, gastrointestinal, hematologic, metabolic, and immunologic systems. These limitations increase the risk of physiologic and iatrogenic problems and require care in the NICU.

Respiratory system. Preterm infants will have respiratory and cardiovascular problems due to the immaturity of the central nervous system, circulation and respiratory organs (Farrell, et. al., 2003). Respiratory problems are among the most common and important conditions related to prematurity. The immaturity of surfactant systems leads to respiratory distress syndrome (RDS). This problem often necessitates either endotracheal intubations and mechanical ventilation, or continuous positive pressure support to the airways and chest wall in the form of nasal continuous positive airway pressure (CPAP) via nasal prongs (Boxwell, 2000).

Cardiovascular system, The most common cardiovascular problem in premature infants is the persistence of the ductus arteriosus (Boxwell, 2000). This vital inutero communication pathway is programmed to close shortly after birth in term infants.

This normal transition occurs less efficiently in the premature infant and the rate of spontaneous closure is inversely proportional to the degree of prematurity.

Central nervous system. The central nervous system (CNS) is particularly impacted by preterm birth. This is important because the preterm period is a critical time for rapid neurodevelopment of the newborn (Als, 1999). Research has demonstrated that the development of the CNS may be influenced by visual, auditory, cutaneous, tactile somasthetic, kinesthetic, smell, and taste experiences (Als, 1999).

Renal and gastrointestinal function. Renal system immaturity is another physiological limitation in preterm infants. The kidneys cannot create enough urine and preterm infants often have fluid and electrolytic imbalance. The kidneys in preterm infants also cannot create enough erythropoietin, so preterm infants often have physiological anemia (Boxwell, 2000). Preterm infants often have difficulty feeding because they are unable to coordinate suck and swallow before 35 weeks gestation. Because of immaturity in the gastrointestinal system, most preterm infants have poor digestive function which may result in serious infection, placing them at high risk for necrotizing enterocolitis (Farrell, et al., 2003).

Hematologic, immunologic and metabolic function. Preterm infants can easily have problems of anemia, jaundice, and too low or too high levels of minerals or other substances in the blood such as calcium and sugar because preterm infants have immature bone marrow and kidneys (Rondini & Chirico, 1999). Preterm infants are at high risk for infectious diseases because of an immature immune system (Farrell, et al., 2003).

Pathophysiologic problems .Preterm infants not only have physiologic immaturities, they also might experience pathophysiologic problems. These pathophysiologic problems may include apnea, respiratory distress syndrome (RDS), bronchopulmonary dysplasia (BPD), intraventicular hemorrhage (IVH), and necotizing enterocolitis (NEC).

Need for Intensive Care and Impact of the NICU Environment

Because preterm infants often have physiologic limitations due to immaturity and pathophysiologic problems due to immature immune systems, preterm infants have to rely on intensive care to maintain vital functions. However, nursing and medical interventions for preterm infants are often the source of excessive stimulation at a time when the preterm infant's CNS development is in the organization stage. These interventions may alter the CNS organization and disturb the normal growth and development of the preterm infant's brain. According to Field (2003) and Blackburn (1998, 2005), the preterm infant often responds to changes in the environment and to care-giving interventions with behavioral and physiological changes. The sources of stress in the NICU include medical and surgical procedures, pain, pathologic procedures, caregiver interventions, sounds, and light stimuli (Blackburn, 1998). Preterm infants are especially sensitive to sound, light, and caregiver interventions in the NICU. These stresses in the NICU may impact the growth and development of preterm infants. Moreover, they might induce some pathophysiologic problems in preterm infants. In summary, preterm infants are dependent upon intensive care for survival, but are also vulnerable to the effects of the environment. Therefore, clinicians have to provide the appropriate stimuli and modulate the infant's environment according to the physiological and behavioral responses of preterm infants.

Confounding Variables

Confounding variables are extraneous factors that influence variables of interest whose impact needs to be controlled in research. In this investigation, such confounding variables include gestational age, post-conception age, a congenital anomaly, ventilation, medications, photo therapy, sedatives, chronic lung disease, hemorrhagic and ischemic white matter brain injury, and infectious disease. Each of these factors may interfere with accurately assessing physiological and/or behavioral responses to environmental stress in the NICU. Use of a ventilator, photo therapy, or sedatives may adversely influence the reliability and validity of physiological or behavioral measures (Anand, 1998; Perlman, 2006; Schanberg, 1987). Preterm infants with chronic lung disease may have problems breathing, apnea, and low oxygen saturation. Preterm infants with serious brain disease, such as hemorrheagic and ischemic white matter brain injury, not only have immature organs but the pathology of brain disease may influence the stability of physiologic functions (Zahr & Purdy, 2006; Catlet & Holitch-Davis, 1990). Preterm infants who have an infectious disease may have instability in physiologic responses and the infection will also affect their responses to environmental stress (Horowitz, 1990; Johnston, Stremler, Horton, & Friedman, 1999).

Environmental Stress and the Preterm Infant

The term stress is used to describe any physical or psychological challenge that threatens or is perceived to have the potential to threaten the stability of the internal milieu or homeostasis of the organism (Washwa, Culhane, Rauth, Barve, Hogan, & Sandman, et. al., 2001). The effects of the NICU environment on the developing infant have become an area of concern for research and evolve from two perspectives

(Bremmer, Byers, & Kiebl, 2003; Kellman, 2002). First the NICU environment, totally different from the intrauterine environment, is characterized by loud, sharp, and unpredictable sound. Second, the preterm period of the infant is a critical time for development of the nervous system (Lotas, 1992). The NICU exposes infants to bright light, an extremely noisy environment, little diurnal variation, and frequent interventions for technical procedures but little positive handling (Zahr & Balian, 1995). In short, sources of stress in the NICU include medical and surgical procedures, pain, pathologic processes, caregiver interventions, and the physical environment, especially sound and light (Blackburn, 1998).

According to most researchers (Als, 1998; Blackburn, 1998; Young, 1996), light, noise, touch stimulation, handling, and care-giving interventions are the main environmental stressors that are harmful to preterm infants in NICUs. Epstein (2005) pointed out that sources of stress in any modern intensive care unit (e.g. mechanical ventilation, light, noise, and invasive procedures) are similar; however, the difference between ages and populations are not the stressors themselves but rather the individual responses to stress. Because the stress is affecting an as yet undeveloped nervous system in the preterm infant, the preterm infant's stress responses are different and unique. Besides, the possible impact of repeated stress responses on future neurological development, such as the ability to learn, to speak, to movement, does not apply to any other population. Therefore, there is a need to identify the preterm infant's stress responses as different from the stress responses of other populations. In order to improve the quality of neonatal intensive care, neonatal clinicians should become familiar with stress responses in the preterm infant and reduce the NICU's environmental stressors by these stress responses in the preterm infants.

Light

Preterm infants are cared for in NICUs which are typically illuminated 24 hours a day by a mixture which consists of daylight and fluorescent tubes. According to the literature reviews from Kellman (2002), (1) studies describing light levels in NICUs were first reported in the mid-1980s through 1990 and light levels in the NICUs are commonly ranged from 240-1500 lux (approximately 24-150 footcandles, ft-c) with reported means from 47-90 ft-c. (2) In the mid-1990s through the present, the studies showed the NICU average light levels are lower than those studies in the 1980s. However, the reported light levels vary widely, ranging from low levels of less than 1 to 25 ft-c and excessively high levels of up to 235 ft-c. The sources of light illumination in NICUs are heating light (200-300 ft-c); photo therapy light (300-400 ft-c; Blackburn & Patteson,1991; Lotas, 1992), mini-Bili-Lite (Field,1990; Friendly,1993), bed side lamp, inside artificial light, and natural sun light (Oehler,1993). The American Academy of Pediatrics (2002) has recommended that a light illumination level of 60 ft-c is adequate for observation and 100 ft-c is sufficient for treatment procedures in NICUs.

Infants exposed to intensive light illumination may have retinal damage (Lotas, 1992). Other researchers have reported an increase in heart rate, respiratory rate, and intracranial pressure, and a decrease in oxygen saturation when preterm infants are exposed to light stimulation (Hall, et al., 1993). Oehler (1993) noted that intense illumination disturbed the self-regulatory system of preterm infants. All of these effects of light may interrupt the development of the preterm infant and change the outcomes for premature infants. The light dose in neonatal intensive care units is largely governed by environmental or physical factors, including the intensity and spectral characteristics of the light, and the duration of exposure (Fielder & Moseley, 2000).

Researchers exploring the effects of NICU lighting on preterm infant physiologic and behavioral functioning have focused primarily on the effects of light levels and light patterns. Light/dark cycles may influence the development of sleep-wake patterns, infant state stability, and physiologic stability. Studies have reported significant relationships between patterns of increased alertness and improved respiratory stability and reduced environmental lighting levels (Shiroiwa, Kamiya, & Uchiboi, 1986). There were significant relationships between light/dark cycles and decreased heart rates (Blackburn & Patterson, 1991; Lotas, Medoff-Cooper, & Sthl, 1995); decreased respiratory rate (Lotas et al., 1995); and improved sleep patterns and weight gain (Mann, Haddon, Stokes, Goodley, & Rulter, 1986). The sources of peak light exposure for the infant were found to be associated with additional light sources such as heat lamps, phototherapy lamps and most dramatically, extensive direct window exposure supplementing artificial lighting (Blackburn, 1996; Oehler,1993).

Noise

Noise levels in the neonatal intensive care unit are also a major source of environmental stress for premature infants (Oehler, 1993; Sizun & Westrup, 2004).

Researchers have identified the sources of noise in NICUs. The sources of noise include noises from equipment that is running that cause a continually present noise, centrifuge, monitor alarms, telephone's ringing, and conversations. Much of the medical equipment within the NICU comes with some type of noise alert system for caregivers. The incubators themselves increase sound-level problems for the infants inside. Brenig (1982) demonstrated that older model incubators often generated internal noise to 75 decibels (dB). More recent models of incubators are usually engineered to reduce the level of noise to between 59-63 dB (Kellman, 2002). Kellman (2002) pointed out that "the overheat alarm is often vented directly into the enclosed space, generating sounds of up to 85 dB inside, and 100 dB outside, the incubator. While outside ambient sound levels may be dampened for the baby inside the incubator, ventilators noises inside the incubator may be 60 dB or more" (p. 37). In addition, NICUs have constant activities and frequent interactions with preterm infants from healthcare providers that also generate noise. Researchers have reported NICU sounds average between 50 to 90 decibels (Levy, Woolsoton, & Browne, 2003; Oehler, 1993; Young, 1996). Lotas (1992) has reported that NICU noise levels demonstrate little diurnal variation and few fluctuations but when they occurred, they did so in an unpredictable manner. However, this unpredictable noise can disturb preterm infants' rest. The Consensus Committee (2002) has recommended an hourly maximum of 50 dB with an impulse maximum and should not to exceed 75 dB for newborn ICU design (Consensus Committee to Establish Recommended Standards for Newborn ICU Design, 2002).

The effects of nursery sounds have been studied extensively as individual variables that affect the preterm infant in the hospital. In early work, excessive noise levels in the NICU were associated with a pattern of decreased transcutaneous oxygen tension, increased intracranial pressure, and increased heart and respiratory rates (Long, Lucey, & Philip, 1980). Mottling, apnea, and bradycardia in response to sudden sound also have been observed (Gorski, Hole, Leonard, & Martin, 1983; Nair, Gupta, & Jatana, 2003), as well as interrupted infant sleep when the sound levels were similar to that in the NICU (70 and 55 decibels; Kellman;2002; Lotas. & Walden, 1996; Symanski, 2002). Blackburn (1998) pointed out three concerns relating to the effects of the NICU sound environment. Repeated arousal of the infant to sounds in the NICU may (a) deplete the infant's physiologic resources and energy reserves, (b) interfere with sleep, and (c) lead to fatigue and irritability.

Nursing and Physician Interventions

Neonatal nurses and physicians seldom consider infant sleep-wake states and other infant cues when choosing the time for routine interventions. These interventions often combine multiple stimuli that include sound, light, tactile, and pain to preterm infants in the NICU (Bremmer, et. al., 2003; Goldson, 1999; Young, 1996). Infants often respond to changes in the environment and to caregiver interventions with behavioral and physiological changes (Blackburn, 1998). In interventions that require clinicians and nurses to open the plastic sleeve of the incubator, the mean decibel level has been found to be 67-86 dB (Bremmer, et. al., 2003). Nursing and medical interventions sometimes include painful stimuli. These painful interventions may produce a physiological response and induce stress behaviors in preterm infants (Als, 1999; Beacham, 2003; Blackburn, 1998). Werner and Conway (1990) explored the type, frequency and duration of contacts by caregivers by observing 11 extremely premature infants during two 55-minute observation sessions in an NICU. A total of

645 contacts were made over 1,210 minutes of observation. Treatment-oriented procedures accounted for 27.4% of contacts, while 63.7 % were incidental (e.g., sound of incubator doors or accidental disturbance). A total of 4.4% of the contacts were classified as comfortable events (e.g., gentle sound or soothing touch); and 4.5% were activities of daily living (e.g., position change, diaper change, bathing). Holditch-Davis, Blackburn, and VandenBerg (2003) noted that caregiver-infant interactions often have an all-or-nothing quality, ranging from no contact to repeated, frequent, stressful, and often painful interventions. Social interaction with caregivers may be also stressful for the preterm or ill infant. For preterm infants, the critical factor is whether the infant can tolerate the level of sensory input from caregiver interactions, regardless of whether that interaction is positive or is painful (Harrison & Bodin, 1994; Holditch-Davis, et. al., 2003; Peters, 1999).

Stimuli from nursing interventions may induce different responses in preterm infants; some are positive responses but most are negative responses. Touch in the neonatal intensive care unit includes two forms (a) uncomfortable or painful handling during nursing and medical procedures, and (b) touch initiated for the purpose of social interaction (Catlet & Holditch-Davis, 1990; Yecco, 1993). According to a literature review by Young (1996), negative physiological responses by the preterm infant to touch included apnea, significant increase in heart rate, decrease in transcutaneous oxygen tension and transcutaneous oxygen saturation levels, increase in respiratory rate, and increased intracranial pressure. If there are too many incidences of uncomfortable touch, the preterm infants' sleep may be disturbed and this may interfere with development if the preterm infant has to exert a lot of their energy to cope with these stimulations (Catlet & Holditch-Davis, 1990; Peters, 2003).

Two studies reported that routine nursing interventions under excessive continuous lighting may induce low oxygen saturation in preterm infants (Peters, 1999; Shogan & Schumann, 1993).

Stress Responses

The infant often responds to changes in the environment and to interventions with behavioral and physiological changes (Blackburn, 1998). Peters (1999) reported that significant changes related to stress occur in both physiological and behavioral areas. Bernert and others (1997) also reported that the physiological responses were directly related to behavioral responses. According to Blackburn (1998), neonatal stress leads to energy expenditure, which may affect the outcomes of healing, recovery from illness, and growth. According to Sammons and Lewis (1985), the calories and nutrients infants consume are used first to meet physiological demands, then to meet the consequences of both immature function and pathophysiologic events, and finally in response to stressors from environment. Whatever calories or nutrients are left can then be used for growth and development. It is therefore important to simultaneously examine both physiological and behavioral indicators of infant responses.

In this investigation, the preterm infant's response to environmental stress is measured by both physiological signals and behavioral responses. The stress behavioral responses of preterm infant are divided into changes in behavioral states, and stress behavioral cues.

Stress Physiological Signals

Stress physiological indicators and pain are similar and include changes in heart rate (HR), respiratory rate (RR), blood pressure, transcutaneous oxygen levels ($tcPO_2$), transcutaneous carbon dioxide levels ($tcPCO_2$), oxygen saturation (O_2 Sat.), intracranial pressure (ICP), vagal tone, skin blood flow, and palmar sweat (Hall, Ballweg, & Howell, 1996; Franck & Miaskowski, 1997; Oehler, 1993; Shogan, & Schumann; 1993). Stimulations in the NICU environment can cause initial increases in cardiac and respiratory rates in acutely ill infants. Preterm infants experience frequent changes in cardiac and respiratory rates in order to cope with stress from the environment. The infant might also experience an increase in oxygen consumption and caloric requirements (Woodson, Field, & Greenberg, 1983). If the stressful stimulation continues without any intervention, the initial increases in cardiac and respiratory rate ceases and the infant will become apnic and bradycardic (Philibin & Klass, 2000). Sometimes even very brief stimulation can result in apnea and bradycardia in some seriously ill preterm infants. Therefore, the duration of stimulation necessary to bring about this change differs among infants and depends on the intensity of the stimuli (Catlett & Holditch-Davis, 1990). In the NICU, oxygenation always is measured by trascutaneous oxygen monitors ($TcPO_2$) or pulse oximetry, and is another physiological parameter that is affected by the infant's environment. Preterm infants have been found to have a rapid decrease in oxygenation in response to a variety of routine nursing activities and under excessive, continuous lighting (Shogan & Schumann, 1993). Research has also found significant decreases in oxygenation after or during suction, repositioning, and heel sticks (Norris, Campbell, & Brenkert, 1981). Some researchers (Hall, et. al., 1996; Shogan & Schumann, 1993) reported an increase in heart rate, respiratory rate, and intracranial pressure, and a decrease in oxygen saturation when preterm infants were exposed to intensive light illumination. Other researchers also have reported that light and noise in the NICU may disturb the regular sleep-wake state, increase preterm infant fatigue, heart rate, and intracranial pressure, and the infant may experience hypoxic and apnea episodes (Beacham,2003; Lotas, 1992; Oehler, 1993).

Research studies evaluating neonatal responses to stress and painful stimuli have generally included measurement of multiple physiological responses (Franck, & Miaskowski, 1997; Young, 1996). However, physiological responses to stress are difficult to interpret because these responses are influenced by other non noxious stimuli, particularly in ill or premature infants (Frank & Miaskowski, 1997). Heart rate, respiratory rate, and oxygenation levels (O_2 Sat.) can be measured directly from EKG monitoring equipment and are available in the NICU setting. Therefore, in this investigation the physiological responses measured were heart rate, respiratory rate, and oxygenation levels.

Behavioral Assessment and Instruments

Preterm infant's behaviors, behavioral assessment instruments, and behavioral stress responses are described in this section. Hedlund and Tarka (1988) adapted the Synactive Theory of Development and defined infant behaviors as: (a) approach behaviors, (b) self-regulatory behaviors, and (c) stress behaviors. Preterm infants, just like full-term infants, can present positive approach behaviors (Cole & Frappier, 1985). Approach behaviors may be interpreted to indicate that the sensory input that is being received by the infant matches his readiness to process and to make a sense of the information. Self-regulatory behaviors are behaviors of preterm infants to deal with stress in the environment and represent the attempt to maintain the balance between sensory stimulation and processing abilities. Stress behaviors mean the infant cannot deal with stress from the environment. Stress behaviors mean the infant is exhausted by the stress and needs help to relieve the stress. According to Als (1997), "Approach and self-regulatory behaviors may shift and become stress behaviors; when successful in reducing stress, may therewith become self-regulatory strategies" (p.59).

A number of systems for defining and classifying the behavioral states of the human neonate have been developed. Wolff (1966) was the first to suggest an all-inclusive state classification system. He divided the sleep states into regular, irregular, and periodic sleep and divided wake states into alert-in-activity, waking activity and crying states. He also examined the threshold to external and internal stimulation in the various states. The major variables used to distinguish states were motor activity, respiration, and movements for preterm infants. Some states also used skin color and vocalizations.

Brazelton (1984) developed a state scoring system to be used as part of a behavioral evaluation of newborn infants; the Neonatal Behavioral Assessment Scale (NBAS).These six behavioral states are deep sleep, light sleep, drowsy, alert, active wake state, and crying state. Brazelton's state scoring system is easy to learn because the differences between the states are fairly obvious and there are only six states (Holditch-Davis, Blackburn, & VandenBerg, 2003). This state system is very popular in clinical care and also is useful for research.

The Assessment of Preterm Infants' Behavior (APIB) was based on the NBAS and developed by Heidelise Als (1982). The APIB is best administered to infants between 36 and 44 weeks' gestational age (Als, 1986). Als (1986) divided the sleep-wake states of preterm infants into a 13-state system that it is very detailed. These 13 states are very still deep sleep, deep sleep, light sleep, "noise" light sleep, drowsy with more activity, drowsy, awake and quiet, hyper-alert, bright alert, active, considerable activity, crying, lusty and crying. However, a 13-state system is more difficult to learn than a 6-state system, such as Brazelton's NBAS (Holditch-Davis, et. al., 2003). Besides, since the APIB system was developed from Brazelton's NBAS, all the APIB states are similar to the NBAS states.

The Neurobehavioral Assessment of the Preterm Infant (NAPI) was developed by Korner and Thom (1990) at Stanford University. The NAPI is an instrument that primarily measures the differential maturity of medically stable preterm infants with a conceptional age of 32-37 weeks (Koner & Thom, 1990). This test is also used to monitor the developmental progress of preterm infants to identify persistent lags in development, as a research tool to assess the effects of interventions and to study individual differences and basic developmental questions (Constantinou & Korner, 1993).

The Neonatal Intensive Care Network Neurobehavioral Scale (NNNS) was designed for the neurobehavioral assessment of drug-exposed and other high risk infants (Lester, Tronick, & Brazelton, 2004). The NNNS includes 3 parts: (a) the more classical neurologic items that assess active and passive tone and primitive reflexes and items that reflect CNS integrity; (b) behavioral items including state and sensory and interactive responses; and (c) stress/abstinence items particularly appropriate for high-risk infants.

Hedlund and Tatarka (1988), based on the Synactive Theory of Development (Als, 1986), developed an instrument of Infant Behavioral Assessment (IBA). IBA is used to assess the infant's neurobehavioral organization and self-regulatory competence. The IBA evolved from the principles of the Synactive Theory of

Development and divides the behaviors of preterm infants into three categories: (a) approach, (b) self-regulatory, and (c) stress behaviors.

Stress Behavioral Responses

The preterm infant's behavioral responses to stress include self-regulatory behaviors, changes in sleep-wake states, and stress behavior cues. These responses are important to measure because they might be the early indicators of stress.

Self-regulatory behavior. Self-regulatory behaviors are strategies that the infant uses to maintain balance (Heldlund & Tarka, 1988). Self-regulatory behaviors include a series of behaviors, such as sucking, suck search, grasping holding on, tucking, and foot clasping (VandenBerg, Browne, Perez, & Newsterteer, 2003). The self-regulatory behaviors are a way for the preterm infant to concentrate, cope, and console (Heldlund & Tarka, 1988). The concentrate process allows preterm infants to learn from stimuli, such as hand-to-mouth, bracing, and holding in order to calm them. The cope process allows the preterm infant to hold on or contend with a presented stimulus or developmental task. The console process means that the infant may now use self-regulatory strategies to comfort himself and move from an agitated state of fussing or crying to a calm state. If the preterm infant is pushed from environmental stressors beyond the input threshold, the infant may attempt to regain a state of neurophysiological subsystems balance. Self-regulatory behaviors are self-comforting and regulating behaviors that need to be supported by caregivers.

Change in sleep-wake states. State behaviors refer to sleeping and waking cycles. Sleep-wake states include the range of sleep from deep sleep to crying. A preterm infant's state of consciousness influences the degree, duration, and variety of their reactions to a given stimulus and is influenced by their general well-being, including the length of time from the last feeding, the amount of external stimulation sustained, and the state of health (Brazelton, 1984). Generally, most investigators agree that neonates demonstrate two sleep states and describe them with some consistency as having differing parameters of body, eye, and respiratory activity. Behavioral states are judged on the basis of muscle tone, motor activity, respiration, eye-opening, and eye movement (Holditch-Davis &Thoman, 1987). When comparing behavior assessment instruments, the definitions of sleep-wake states are very similar among these scoring systems. It is possible to describe in general the sleeping and waking states displayed by infants. Brazelton, in NBAS, divided the infant's sleep-wake states to six states. However, there are some more complex assessment instruments, such as Aderson's state scoring system and the APIB. These instruments may be more difficult to use than the NBAS because of complexity of these state distinctions (Holditch-Davis, et. al., 2003).

When preterm infants are in self-regulation, they will smoothly transition from one state to another. In other words, a self-regulatory infant will wake up and go from deep to light sleep and become drowsy, then become very alert. After some time, she or he will go slowly and gradually back to sleep (VandenBerg, et. al., 2003). Most preterm infants' sleep-wake states are easily disturbed by environmental stressors causing them to demonstrate disorganized behavioral states. Fussing, crying, hypoalert, hyperalert, gaze averting, upward gaze, staring, and grimace are special disorganized state behaviors preterm infants will demonstrate when they are stressed (Vandenberg, et al., 2003).

Infant responses to the environment will be influenced by factors such as state, basic needs (e.g., hunger, cold), sensory threshold, and parameters of the animate environment (Blackburn, 1998). Holditch-Davis and others (2003) reported that infants are most responsive to the environment when they are in the waking state, especially when alert. This has been confirmed by other research findings (Brandon, Holditch-Davis, & Beylea, 1999;Catlett & Holditch-Davis, 1990; Thoman, 2001). Environmental stimulation is likely to affect active sleep. According to some research (Catlett, & Holditch-Davis, 1990; Hall, et. al., 1996; Holditch-Davis, Brandon, & Schwartz, 2003), approximately 75 percent of the preterm infant's sleep time is spent in active sleep because there are a lot of disturbances from the environment. The amount of quiet sleep is also very sensitive to the environment. Infant stimulation studies have found that quiet sleep is the state most likely to be interrupted by vestibular and kinesthetic interventions (Ingersoll & Thoman, 1994). Therefore, the stimulation provided by routine nursing care results in significantly less quiet sleep as compared with times when the preterm infant is not disturbed (Brandon, Holditch-Davis & Beylea, 1999). Moreover, the development of diurnal rhythm in preterm infants will be disturbed by bright light, extreme noise, and frequent nursing or medical interventions in the NICU (Thoman, 2001).

Respiratory patterns are relatively unstable in active sleep and oxygenation is lower and more variable (Gabriel, Helmen, & Albani, 1980; Holditch-Davis, 1990; Huch & Huch, 1981). The long periods of active sleep seen in young preterm infants may contribute to their respiratory difficulties. Research has shown that brief apneic pauses occurred more frequently in active sleep than quiet sleep (Holditch-Davis, Edwards, & Wingger, 1994; Gabriel, et al., 1980). Over prolonged observation, premature infants exhibited more alertness and non-alert waking activity and less drowsiness than full-term infants (Holditch-Davis & Thoman, 1987). Doussard-Roosevelt , Porges, and McClenny (1996) have found that preterm infants with medical complications showed more active sleep during sleep observations at 33 to 35 weeks than healthier preterm infants. Curzi-Dascalova and others (1993) have also found that the longest sleep cycle of mechanically ventilated preterm infants was shorter than that of non-ventilated infants.

Stress behavioral cues. When premature infants experience stimulation from the external environment, their behavioral subsystems are further supported by the identification of three stages in the premature infant's behavioral organization (Lott, 1989). The first stage is "inturning". This stage is characterized by physiologic organization. External stimulation produces special and obvious physiologic change. The majority of the premature infant's energy is required to maintain stability and minimal energy is available for interaction with the environment. The second stage is "coming out". This stage is beginning responsiveness by the premature infant to the environment. In this stage, there is more ability to resist physiologic changes in response to stimuli. The third stage is "reciprocity". In this stage, the premature infant is going to prepare for interaction with parents and caregivers and can cope with inappropriate stimulation from the environment. This transaction is a continuous process between the preterm infant's brain and environment. Premature infants are born with an immature neurological system which is easily influenced by the environment which in turn may cause abnormal development.

When assessing the stress responses of preterm infants, an assessment must be able to determine the threshold of disorganization indicated in the behaviors of defense and avoidance. Prior to the threshold of disorganization, infants do not struggle or actively attempt to regain an easier or more effective position. The infant is limp and does not react to passive displacements of limbs. When the threshold of disorganization occurs, the infant may struggle as a result of the stress in an effort at modulation. The stress behaviors indicate that the sensory input the infant receives is too intense, too frequent, too long, or too complex (Holditch-Davis, et. al., 2003). Preterm infants are easily overtaxed and show exhausted states very quickly because physiological mechanisms are not mature enough to react to overstimulation from the environment. The preterm infant has a poor balance of flexors and extensors which produces some special behaviors by the infant when they are stressed. These special behaviors are jerking and twitching because preterm infants are often unsuccessful in inhibiting these overshooting responses (Als, 1986).

There are several research reports related to testing the relationship between stress behavioral responses and stress physiological signals. Grunau, Oberlando, Holsti and Whitefield (1998) reported finger splay, facial actions and heart rate all increased following a heel-stick among preterm infants. Graunau, et. al. (2000) found that finger splay, brow raising and leg extension related to low oxygen saturation in preterm infants. Peters (2001) examined the relationship between autonomic and motor systems in a group of preterm infants during bathing. Extension behaviors, such as finger splay, salute, airplane, and sitting-on-air, were more likely to occur either immediately prior to or during a decline in oxygen saturation. Flexion behaviors, such as hand to mouth, hand clasp, foot clasp, grasp and fisting, were more likely to occur during periods of increasing oxygen saturation. Medoff-Cooper (1988) examined physiological and behavioral responses to handling during a neurobehavioral assessment in 23 preterm infants. The most common behavioral responses were facial grimacing, mouthing, and avoidance gazing. Harrison, Roane and Weaver (2004) conducted a secondary analysis and found relationships between stress physiological indicators (HR, low O_2 Sat) and stress behaviors. Stress behavioral cues and motor activity were more often related to low levels of O_2 saturation than to low or high HR. Yawn, tremor, and hiccup were independently associated with high HR and low O_2 Sat. Flexed body trunk, extended legs, hand on face, finger splay, salute, frown, and sitting-on-air were found to be significantly correlated with painful stimulations by one recently research report (Holstin, Grunau, Oberlander, & Whitfield, 2005).

Review of Related Research

This integrative review of the literature includes eight studies undertaken in the last 50 years that were selected for their relevance to inform current practice and future research. Literature searches of MEDLINE, CINAHL, and PyschInfo for all indexed years were searched using the keywords: preterm infant, NICU environmental stressors, physiological stress responses, behavioral response to pain, and stress.

Harrison, Roane, and Weaver (2004) did a secondary analysis to examine the relationship between physiological signals and behavioral stress cues in preterm infants. The research was a descriptive correlational study and research data were collected from a secondary analysis in a quasi-experimental study (Harrison, Williams, Berbaum, Stem, & Leeper, 2000). Only data from the pre-intervention period was used for the secondary analysis. Physiological signals were observed and recorded every five seconds for 10 minutes three times a day. The physiological signals of stress were defined as the percentage of time a high HR (above 200 bpm), low HR (below 100 bpm), and low O_2 Sat. (below 90 mg%) occurred. The behavioral stress cues were observed and recorded at 15 second time intervals during the data collecting period. Behavioral stress cues included startle, yawn, tremor, hiccup, grimace, and clenched fists. Results demonstrated stress cues were more often related to low levels of O_2 Sat. than the other physiological signals. However, the design of the secondary analysis was not well suited to examine the relationship of the indicators. For example, the researchers collected the research data while the preterm infants were not being handled or disturbed, and data on other common stressors in NICUs, such as light and noise, were not collected. Consequently, the relationships between physiological and behavioral indicators of stress in this study may have been attenuated due to the low level of environmental stressors

Thoyre and Carlson (2003) explored preterm infant's behavioral indicators related to oxygen decline while the preterm infants were being bottle fed by their mothers. The research data were collected from a secondary analysis of 20 videotapes of preterm infant bottle feedings which included oxygen saturation data and preterm infant behaviors (Harrison, et. al., 2000). Results showed that eye flutter was present prior to a desaturation event. During the desaturation time period, preterm infants showed significantly relaxed arms/hands, and stopped sucking. A limitation of this study was that the videotapes did not focus on the relationship between stress behaviors and oxygen desaturation. The video recording did not detect any change in skin color of the face of the preterm infants while they were bottle feeding. Literature reviews suggest the most important stress sign is skin color changes (Als, 1998; Norris, et. al. , 1981; VandenBerg, Browne, Perez, & Newstetter, 2003; Brazelton, 1984).

Grunau, and other researchers (2000) examined the relationships between body pain indicators and pain stimulations in extremely low birth weight infants. The research design was exploratory observational repeated measures. A convenience sample of 64 infants with a birth weight less than 1,000 gm were used in this investigation. The clinical interventions were endotracheal suctioning, chest physical therapy, diaper change, and nasogastric feeds. Each clinical intervention was observed about 16 times in this research. Infant's responses were recorded systematically before, during, and after the clinical interventions. Infant's physiological measures included HR, RR, and O_2 Saturation. Behavioral variables were motor (muscle tone fluctuations, movement, postural change); sleep/wake state, and stress behaviors (startle, twitch, finger splay, grimace, squirm). The variables were recorded in two-minute-time blocks. Research results demonstrated that: (a) changes in heart rate and sleep-waking state were related to the procedures, (b) arching, squirming, startles, and twitching were not observed significantly more during procedures than at baseline, (c) finger splay and leg extension were significantly related to ongoing procedures, and (d) facial brow was a function of the number of invasive procedures in the past 24 hours. A limitation of the study is that the researcher did not report how many of the preterm infants received these clinical procedures or if any preterm infant was seriously ill which may affect the results because preterm infants have individual responses to different stressors.

Peters (1998) explored the relationships between physiology, behavior and sponge bathing in preterm infants. The research was a prospective, quasi-experimental repeated measures research design. The independent variable was bathing of preterm infants. The dependent variables were physiological data (HR, oxygen saturation, oxygen delivery, FIO_2 measurements, cardiac oxygen demand) and behavioral responses (behavioral states, activity levels, behavioral motor cues). Research data were continuously recorded by computer and real-time videotape. Behavioral indicators of states were measured using Brazelton's Newborn Assessment Scale. Activity levels were assessed by using the Activity for Premature Infants Scale. The data collection procedure was divided into three periods: 10 minutes before a bath, during a standardized bath, and 10 minutes after the bath. The research sample was 14 ill premature infants. Six infants had umbilical arterial catheters; 11 infants required supplemental oxygen, and 2 of those 11 had chest tubes in place. Research results showed that preterm infants had a significant increase in heart rate, cardiac oxygen demand, and frequency of behavioral motor cues. Significant decreases in oxygen saturation accompanied the bath and a significant association was found between physiological components and the frequency and timing of behavioral motor cues. This research used a number of different instruments to assess the behaviors of preterm infants and also assessed many different physiological variables. This increased the reliability and validity of this research. However, the small research sample is a problem in this study.

Brandon and other researchers (1999) explored the relationship between nursing care and the development of sleep-wake states and related infant behaviors in high-risk preterm infants. The research design was exploratory observational. In this research, nursing interventions were the independent variables and the dependent variables were preterm infants' six sleep-wake states and two behaviors (jitters, and negative facial expressions). Infant sleep-wake states and other behaviors were observed once a week from approximately 7 p.m. to 11 p.m. During the observations, the occurrence of sleep and wake states and infant behaviors were recorded every 10 seconds. Research subjects were 71 preterm infants who weighted less than 1500 grams or required mechanical ventilation. Observation results showed the effects of nursing interventions on sleep-wake states and behaviors in preterm infants. Results showed that nursing care impacted the development of sleep-wake states and behaviors of preterm infants. However, observation time was limited to four hours each day for each infant. There is a need to observe effects over a longer time period to establish effects on the development and growth of preterm infants.

In secondary analysis of data from the Brandon et. al. (1999) study, Holditich-Davis, et. al. (2003) examined the development of eight infant behaviors to determine factors that affect the development of these behaviors in preterm infants. This research was a descriptive correlational study and used observation to collect the research data. Research variables included eight behaviors: yawn, sigh, negative facial expression, startle/ jerk, jitter, large body movement, mouth movement, and hiccup. Behavioral states included non-sleep, active sleep with REM, active sleep without REM and quiet sleep. The research sample was divided into two cohorts. The only difference between the cohorts was that the 37 infants in the first cohorts were recruited and studied prior to the 34 infants in the second cohort. The infants in cohort 1 totally had 132 weekly observations; there were totally 157 weekly observations for cohort 2.Researchers used t-tests for continuous variables and chi-square analysis to test these two cohorts. No differences were found between research samples' demographic data. Research results showed that negative facial expressions increased over the preterm period; whereas sighs, startle, jerks, jitters, and the likelihood of having hiccups decreased. Yawns decreased over time in non-sleeping and active sleep with REM. Sighing; startle/jerks and jitters decreased in all sleep states. The studied behaviors were not typically seen in older infants. The researchers attempted to understand the meaning of these behaviors in preterm infants. Results may indicate the stress meanings of these behaviors in preterm infants; but it is needed advance research.

Chang, Anderson, and Lin (2002) compared the effects of prone and supine positions on behavioral state and stress responses in mechanically ventilated preterm infants. In this study a crossover design was used and 28 preterm infants were randomly assigned to supine/prone or prone/supine position sequence. Infants were placed in each position for 2 hours. Data were collected begin after the infant was in place for 10 minutes. Research results showed that: (a) preterm infants had less crying, less active sleep, and more quiet sleep states when in the prone position; and (b) preterm infants showed fewer stress responses of startle, tremor, and twitch when they were in the prone position. This research used different treatment positions to examine the responses of behavioral states and stress behavioral states. There is a risk of dislocating the endotracheal tube when they change position although the results indicate preterm infants showed less stress in the prone position. In clinical practice, placing preterm infants in the prone position may result in a dislodging of the endotracheal tube and a kink in the umbilical catheter. Therefore, clinicians might be reluctant to use the prone position.

Giganti, Hayes, Akilesh, and Salzarulo (2002) examined the relationship between yawning and behavioral states in preterm infants. The researchers also examined the relationships between yawning and spontaneous alternations in behavioral state in this research. The research design was a descriptive correlational study and used observation to collect research data. Research variables included yawn, behavioral states, and behavioral categories. Behavioral categories included general, eye, facial, hand and arm movements, twitch, startle, and quiescence. Each yawn was coded temporally in the three-minute period in which it occurred. Behavioral categories for coding sleep states were based on the criteria from different literature reviews. A three-minute epoch size was adopted for state determination. A time-lapse video recorder recorded the behaviors of preterm infants from 2400 to 0500 with the infants in the incubator. Infants' movements were recorded electronically using a piezo-eclectric recording pad position under the bottom bed sheet with tape. Nursing interventions were coded in the same fashion as behavioral states. The research results showed the highest prevalence of yawning was in the drowsy state and there was a significantly lower quotient of yawning present in quiet sleep compared to other states. The research subjects were eight preterm infants and research data were collected repeatedly from these subjects. For research goals, small research subjects might be a problem.

Conclusions

The literature review suggests that there is a potential relationship between stress behaviors and stress physiologic signals. Further research is needed to closely examine the relationship of stress behaviors and physiologic responses. Research is needed to test the meanings of most stress behaviors that are assessed on the APIB, and NNNS instruments and to determine whether these behaviors precede or follow indicators of physiological instability. Moreover, further research needs to be done to determine whether the behavioral indicators of stress differ according to factors such as gestational age and post conception age, exposure to the different stressors and exposure time. Neonatal nurses should continue to monitor and study preterm infants' sleep-wake states and stress behavioral cues in response to care interventions and minimize exposure to stimuli that evoke stress responses whenever possible (Harrison, et. al., 2004).

Chapter III

Research Method

Introduction

This chapter describes the methods used in this investigation. Included are descriptions of the research design, setting and participants; the research variables and their operational definitions, reliability and validity; and methods of data analysis.

Method

The purpose of this exploratory descriptive study was to examine relationships between stress physiological signals and stress behaviors in preterm infants during periods of environmental stress.

Research Questions

1. What are the relationships between stress physiological signals (HR, RR, and O_2 Sat level), stress behavioral cues and changes in sleep-wake states in a group of preterm infants under conditions of environmental stressors (light, noise, uncomfortable touch) in the NICU?
2. Is there any priority of response between stress physiological signals and stress behavioral responses to environmental stressors in preterm infants?
3. What is the most common stress physiological signal of the preterm infant to environmental stressors?
4. What is the most common stress behavioral response of the preterm infant to environmental stressors?
5. Are there differences in the relationship between stress physiological signals and stress behavioral responses when preterm infants are in different sleep-wake states?

Research Hypotheses

1. Increases in environmental stressors will result in increases in heart and respiration rate (HR, RR), and decreases in oxygen saturation (O_2 Sat.) level in preterm infants.
2. Increases in environmental stressors will result in specific stress behavioral responses (e.g., finger or toes splay, frown, sit on air, tongue extension, extend arms or legs) in preterm infants.
3. There will be reliable relationships between stress physiological signals and specific stress behavioral responses of preterm infants under conditions of environmental stressors (light, noise and uncomfortable nursing interventions) in NICU.
4. The observed relationships between physiological signals of stress and behavioral responses to environmental stress will be stronger when preterm infants are in a wake state.

Research Design

The study used a repeated-measures design to examine the relationships between environmental stressors, sleep-wake states, and both stress physiological signals and stress behavioral responses in one group of preterm infants. Measurements of these variables for each preterm infant were recorded every two minutes during four 60-minute observation periods (two in the morning and two in the afternoon) conducted over two days (one morning and one afternoon observation each day).

Setting and Subjects

The research settings were two Level III Neonatal Intensive Care Units (NICU) at two teaching hospitals in a city in central Taiwan. For this investigation preterm infants were selected from either the NICU or from an intermediate care unit also called a Sick Baby Room. The research subjects were 37 preterm infants who were born at less than 37 weeks gestational age and were less than 28 days of age at the time of the study. This sample size was selected to help assure adequate statistical power for tests of hypotheses, given that the frequency with which environmental stressors would be observed during data collection for each infant is unknown, and prior research (Peng, 2000; Peng, Mao, Chen, Chang, 2001) indicates considerable variability among preterm infants in their physiological and behavioral stress responses.

All research subjects were in an incubator at the time of the study. The research sample excluded preterm infants who had major health complications (i.e., chronic lung disease, necrotizing enterocolitis, and serious infectious diseases), a congenital anomaly, hemorrhagic/ischemic white matter brain injury above level III, or needed surgery. Preterm infants who were using mechanical ventilation (i.e. intermittent positive pressure ventilation, high-frequency ventilation), phototherapy, and sedative medicines also were excluded from this research.

Research Variables and Operational Definitions

The variables in this investigation were environmental stressors, stress physiological signals and stress behavioral responses. Stress behavioral responses included changes in sleep-wake states (which included regulatory sleep-wake states and stress sleep-wake states), self-regulatory behaviors and stress behavioral cues.

Environmental Stressors

In this research, environmental stressors were defined as increases in the levels of sound or light in the preterm infant's environment, including nursing interventions that increase light and/or noise levels, and handling stimulation. A Likert-type scale was used to measure the degree of uncomfortable stimulation in nursing interventions. In addition, a photometer was used to measure levels of light illumination, and a phonometer was used to measure sound levels in the incubator.

Stress Physiological Signals

Stress physiological signals in the preterm infant for this investigation were heart rate, respiratory rate, and O_2 saturation. Operationally, assessment of the stress physiological signals was measured by a cardiorespiratory monitor to determine heart and respiratory rates, and oxygen saturation. The operational definitions of the stress physiological signals are described and summarized in Table 1. In each case, a stress response means outside of normal limits, or a change (increase of HR and RR, decrease of O_2 Sat.) when measurements were still within normal limits.

Table 3-1

Stress Physiologic Signals and Operational Definitions

Stress Physiological Signals	Operational Definitions
Heart rate	HR<100 bpm or > 160 bpm, or an increase in baseline 5 bpm or more
Respiration rate	Irregular, less than 40 or greater than 60 breaths per minute, or an increase in baseline 7 breaths per minute or more
O_2 Sat	<90mg% or a decrease of 2.5% or more

Operational definitions of stress physiologic signals are adapted from Beacham (2003), Gonsalves and Mercer (1993) and Stevens, Johnston, Pertryshen, and Taddio (1996).

Stress Behavioral Responses

Six regular sleep-wake states were scored by observation of the preterm infants. Operational definitions of regular sleep-wake states were based on the research from Brand and Holditch-Davis (2003), Brazelton's behavioral state scoring system (Brazelton, 1984) and Als' APIB scale (Als, 1986). VandenBerg, et. al. (2003) reported that infant sleep is organized when the infant has stable, predictable sleep with smooth transitions from sleeping to waking. An organized well modulated infant will wake up and go from deep to light sleep and become drowsy, and then become very alert. Then after some time, the infant will go slowly and gradually back to sleep. The infant will smoothly transition from one state to another. The operational definitions of the six sleep-wake states are described in Table 3-2.

Operational definitions of stress sleep-wake states were adapted from Holditch-Davis (1995), VandenBerg, et. al. (2003) and Holditch-Davis, et. al. (2003). Fussing and crying can be stress sleep-wake states in preterm infants. The operational definitions of the stress sleep-wake states in preterm infants are presented in Table 3-3.

Self-regulatory behaviors of preterm infants include hand clasp, hand to mouth, foot clasp, holding on, leg brace, sucking, tuck trunk, and motor tone. Self-regulatory behaviors are described in Table 3-4.

The research operational definitions of stress behavioral cues were based on Als' APIB scale, the Neonatal Intensive Care Network Neurobehavioral Scale (Lester, Tronick, & Brazelton, 2004), VandenBerg, et. al. (2003), and Holditch-Davis (1995). The operational definitions of stress behavioral cues are described in Table 3-5.

Table 3-2

Regular Sleep-Wake States and Operational Definitions

Regular Sleep-Wake States	Operational Definitions
Deep sleep state	Eyes closed, slow regular respiration, no rapid eye movement, relaxed facial expression, no spontaneous movement.
Alert sleep state	Irregular breathing, eyes closed or partially open; rapid eye movements; mild sucking or low level of activity may be observed.
Drowsy state	A transition state. Infant is trying to awaken or sleep. Irregular breathing, eye lids may be closed or open (heavy-lidded), some movement but not purposeful movement
Alert wake	Eyes open, eyes very bright and shining, attentive or scanning, motor activity is always typical or on purpose.
Fussy	Eyes open or closed. Considerable movement and is restless. Infant is not crying, but sounds like about to crying.
Cry	Fundamental frequency, change in mean special energy or latency to cry, duration and total cry

Table 3-3

Stress Sleep-Wake States and Operational Definition

Stress Sleep-Wake States	Operational Definition
Hypoalert	A low level of alertness in which infant's eyes are slightly open looking fatigued, the infant is quiet with little movement.
Hyperalert	A high level of alertness in which the infant is quiet and eyes are wide open, giving the impression of panic or fear. Infant appears to be intensely focusing and may be unable to break the fixation on the stimulus or stop looking.
Gaze Averting	The infant looks away from a face or object. This behavior is viewed as a "time-out" signal.
Upward Gaze	The eyes are looking up over a visual object in front of the infant's face, or the infant moves head back to look up.
Staring	The infant demonstrates glassy-eyed alertness with eye open. Eyes look glazed or fixed and infant appears to be staring.
Grimace	The infant's face retracts and looks distorted. Infant looks uncomfortable.

Table 3-4

Self-Regulatory Behaviors and Operational Definitions

Self-Regulatory Behaviors	Operational Definitions
Grasp	Opening and closing of the hands
Hand clasp	Hands come in contact with each other either holding, pressing against, or interdigitating.
Hand to mouth	Attempted or successful hand/fingers to mouth.
Foot clasp	Sole of foot positioned against other sole or leg. Legs crossed, usually at ankles
Holding on	Infant makes grasping movements with the hand. Curls fingers around bedding, caregiver's fingers or tubing. The infant may holding-on after making contact successfully.
Leg brace	Lower limb extension to the wall of the isolette or a blanket nest
Sucking	Rhythmical opening of mouth in a searching mode
Tuck trunk	Trunk movement into flexion: can include leg flexion
Tone	Balanced: Infant will lie in a softly tucked position well rounded with softly bent arms, legs and trunk. Infant doesn't stiffen or become rigid or limp.
Face	Smile, hand on face, mouthing, suck-search, sucking

Table 3-5

Stress Behavioral Cues and Operational Definitions

Stress Behavioral Cues	Operational Definitions
Airplane	Shoulder abduction
Arch	Trunk and head extension
Diffusion squirm	Small wigging movements of trunk
Finger splay	Fingers extend and abduction
Fisting	Finger flexion into a fist
Gape face	This refers to a drooping open mouth configuration that is the result of decreased lower facial tone. It gives the appearance of exhaustion and facial limpness.
Mouthing	More than one opening and closing of mouth
Salute	Arm extension
Sitting-on-air	Hips flexed and knee extended
Stretch/down	"Labored" trunk extension followed by trunk flexion attempts
Tongue extension	Infant's tongue protrudes in extension beyond lips or extends encased in the lower lip.
Tremor	Trembling or quivering of any apart of the whole body; e.g., leg tremor, chin tremor
Startle	Sudden large amplitude jumping movement of arms or trunk or legs.
Twitch	Small amplitude, brief contractile response of a skeletal muscle, elicited presumably by a single maximal volley of impulses in the neurons supplying it.
Yawning	The infant yawns
Sneezing	The infant sneezes
Hiccough, spit up, vomit	The infant hiccoughs or shows any bringing up of feeding or saliva.

Reliability and Validity of Measurement

The Likert-type scale and rating were used to measure the environmental stressors. Measurements of HR, RR, and O_2 Sat were recorded by the same EKG (cardiorespiatory) monitor. All EKG monitors in NICU were regularly tested for accuracy. Measures of preterm infant sleep-wake states, stress sleep-wake states, self-regulatory behaviors, and stress behavioral cues were coded from videotape. Content validity of the assessment instrument was evaluated by five professionals. To assess the reliability of coding, one of these clinicians was trained by the researcher to use the coding system. Using a sample of video segments, the researcher and clinician independently coded the segment and discussed any disagreements until consensus was achieved. Training continued until a minimum criterion of 80% agreement between the researcher and clinician was obtained. Inter-coder agreement was then estimated by having the clinician independently code a sample of 10% of the study videotapes and comparing these codes with those of the researcher for the same videotapes. A TES-1336 photometer was used to measure light levels in the incubator. The accuracy of the TES-1336 is ±(3%rdg+5dgts). A Rion NL-10A phonometer was used to measure sound levels. The dB-A weight scale was used because it measures sound energy in the range of 500- 10,000 Hz, which is the sound range most sensitive to the human ear (Kellman, 2002). The device used was certified for accuracy at the factory prior to being used in this research.

Instruments

In this investigation, research instruments included recordings of physiological variables, and a checklist of sleep-wake behavioral states, stress behavioral states, self-regulatory behaviors, and stress behavioral cues. Nursing interventions were classified by levels:

Level 1: Interventions that include noise or light stimulation.

Level 2: Interventions that include noise and light stimulation.

Level 3: Interventions that include noise or light and handling stimulation.

Level 4: Interventions that include noise, light and handling stimulation.

Level 5: Any intervention that causes pain.

The sleep-wake behavioral states were observed by the differing parameters of body, eye, and respiratory activity and scored according to the operational definitions provided in Table 3-2. Codes ranged from 1 to 6 as follows: 1= deep sleep, 2= alert sleep, 3= Drowsy, 4= alert wake, 5= fuss, 6=crying. The 6 stress behavioral states, 10 self-regulatory behaviors, and 14 stress behavioral cues were coded as 1/0 (occurred/did not occur). All variables were recorded every two minutes during each of the four 60-minutes observations of each preterm infant. (See Appendix A for the checklist.)

Protection of Human Subjects

Permission to conduct this study was obtained from the Institution Review Boards of the University of Missouri-St. Louis, and hospitals in central Taiwan. Written parental informed consent was obtained. All demographic information, observation protocols, and video recordings were coded and stored in a secure area assessable only by the researcher. Identifying information was destroyed following the completion of the study. Findings were recorded only in the aggregate.

Data Collection Procedures

Parents whose preterm infants matched the criteria for this investigation were invited to give informed consent for their preterm infants to be in the study. Once parental consent was obtained the preterm infants were enrolled in the investigation. Data were collected from each on infant over two consecutive days. On each day, the infant was observed for one hour in the morning and one hour in the afternoon, providing a total of four hours of observation for each infant (two hours in the morning, and two hours in the afternoon). Using this schedule, it was possible to collect complete observation data on two infants during each two-day period, with each individual infant being observed during each of the four one-hour time periods. This observation schedule is illustrated in Table3-6, below.

Table 3-6

Times and Days for Infant Observation Schedule

Times	Day 1	Day 2
Morning 1	Infant 1	Infant 2
Morning 2	Infant 2	Infant 1
Afternoon 1	Infant 1	Infant 2
Afternoon 2	Infant 2	Infant 1

During each observation, the researcher recorded the type (i.e., light, sound, uncomfortable touch) and degree of environmental stressors, and the infant's heart rate, respiration rate, and oxygen saturation during each two-minute interval. To facilitate detailed coding of the behavioral variables, the infants were videotaped during each observation. Two separate digital video recorders were used. Both recorders were placed inside the incubator. One video recorder was placed to capture the infant's facial expressions and hand movements. The second video recorder was placed to capture the baby's trunk and leg movements. The researcher subsequently viewed the video recording on a computer, and coded the behavior states and stress behavior cues shown by the infant during each two-minute interval of observation. The time stamp recorded on the videotapes and displayed by the computer was used to demarcate the two minute behavioral coding intervals and synchronize coding done from the two simultaneous videotape recordings of the infant.

Data Analysis

Descriptive statistics were used to characterize the sample. Generalized estimating equations (GEE) were used to examine the relationships among environmental stress, stress physiological signals, and stress behavioral cues. GEE is a method of estimation used in the analysis of longitudinal data, which consists of repeated measures of an individual or cluster of individuals over time. These repeated measures from any one individual or cluster are correlated with each other and are therefore no longer independent. GEEs use the data to estimate the correlation between a single individual or cluster's response and provide a correct estimate of each effect's variance (Williamson, Lin, & Barbharem, 2003).

Chapter IV

Results

Introduction

This chapter presents the findings of the study. Included is a description of the sample and relationships between stress physiological signals and stress behaviors in preterm infants during periods of environmental stress. The specific findings related to each research question and research hypotheses are described. The chapter concludes with a summary of the findings.

Demographic Characteristics of the Sample

There were 37 preterm infants recruited for this study. Using the observation check list, there were a total of 4164 observations of the preterm infants. Of the 37 preterm infants, four were accepted into the study with a nasal continuous positive airway pressure (nasal CPAP) to protect them from physiological apneas related to an immature CNS system, small lung volume or weakness of the breathing muscular. Even though the infants had nasal CPAP, they were not considered to be in a critical period. Fourteen (37.89%) were recruited from the Taichung Veterans General Hospital (TVGH) and 23 (62.2%) from the China Medical University Hospital (CMUH). Mean gestational age was 32.05 weeks with a range of 27 to 36 weeks. Mean birth weight was 1662.351 grams with a range of 890.00 to 2655.00 grams. The mean APGAR score at one minute was 6.216 with a range from 1 to 9. The mean APGAR score at five minutes was 8.054 with a range from 5 to 10. The mean weight of the preterm infants upon entry into the study was 1673.243 grams with a range from 890 to 2655 grams. There were 10 sets of twins (27%), four sets of triplets

(10.8%), and 23 (62.2%) were single gestation. Table 4-1 summarizes the demographic characteristics.

Table 4-1

Summary of Demographic Variables (N=37)

Variables	Minimum	Maximum	Mean	Std. Deviation
Birth Weight (grams)	950.00	2635.00	1662.351	327.707
Study Initial Weight (grams)	890.00	2635.00	1673.243	300.324
Gestational Age (weeks)	27.00	36.00	32.059	2.208
Initial Study Age (days)	1	27	10.648	8.373
APGAR (1 minute)	1	9	6.216	2.043
APGAR (5 minutes)	5	10	8.0541	1.311

Of the subjects, 18 (48.6%) were female (four from TVGH, 14 from CMUH) and 19 (51.4%) were male (10 from TVGH, nine from CMUH). Table 4-2 summarizes demographic variables by gender. T-tests were conducted and revealed that none of the gender differences were statistically significant.

Missing Coding Times

With 37 subjects, the number of anticipated hours of observation was 148. The observations needed to be interrupted, stopped, or omitted for a variety of reasons resulting in missing coding time. The total missing times for the sample was seven hours and 32 minutes (4%). Reasons for missing data are presented in Table 4-3.

Environmental Stressors

Environmental stressors for the preterm infants included increased noise, light, and nursing interventions occurring in the incubator. In this investigation, nursing interventions were classified into five levels. A baseline measure of light (mean = 0.324 ft-c) and noise (mean = 52.556 dB) were recorded 3822 times when no intervention occurred. Number of observations, means and standard deviations for each of the five levels of nursing interventions are presented in Table 4-4.

Table 4-2

Summary of Demographic Variables by Gender

Variables	Minimum	Maximum	Mean	Std. Deviation
Female (n=18)				
Birth Weight (grams)	1220.00	2655.00	1702.777	350.199
Study Initial Weight (grams)	1410.00	2655.00	1753.888	293.971
Gestational Age (weeks)	28.00	35.00	32.4000	1.874
Initial Study Age (days)	1.00	27.00	11.555	9.954
APGAR (1 minute)	4.00	9.00	6.5556	1.722
APGAR (5 minutes)	6.00	10.00	8.2222	1.262
Male (n=19)				
Birth Weight (grams)	950.00	2174.00	1625.1053	308.917
Study Initial Weight (grams)	890.00	2080.00	1597.894	297.378
Gestational Age (weeks)	27.00	36.00	31.7368	2.490
Initial Study Age (days)	1.00	22.00	9.789	6.713
BBW	950.00	2174.00	1625.1053	308.917
APGAR (1 minute)	1.00	9.00	5.8947	2.306
APGAR (5 minutes)	5.00	10.00	7.8947	1.370

Table 4-3

Missing Data by Subject ID, Amount of Missing Time and Reason

Subject ID	Missing time	Reason
1	6 minutes	Procedure
4	4 minutes	Procedure
10	2 hours	Moved out from incubator to crib
11	1 hour	Moved out from incubator to crib
12	1 hour	Moved out from incubator to crib
15.	1 hour	Moved out from incubator to crib
21	1 hour	Moved out from incubator to crib
25	8 minutes	Procedure
29	8 minutes	Procedure
31	6 minutes	Procedure
35	1 hour	Medical condition (cyanosis)
Total	7 hours 32 minutes	6 hours moved to crib, 32 minutes procedure, one hour medical condition

Stress Physiological Signals

There were 4164 observations of stress physiological signals. Means, standard deviations, ranges and number of measures of the stress physiological signals of heart rate, respiratory rate, and oxygen saturation are presented in Table 4-5.

Table 4-4

Summary of Environmental Stress by Level of Intervention, Light and Noise

Level of Interventions		Light (ft-c)	Noise (dB)
No Intervention	Mean	0.324	52.556
(n= 3822)	Std. Deviation	0.523	4.468
Level 1: Interventions, noise or	Mean	1.174	58.053
light (n= 30)	Std. Deviation	1.0569	8.807
Level 2: Interventions, light or	Mean	0.947	56.129
noise and handling (n= 143)	Std. Deviation	1.25	6.879
Level 3: Interventions, noise or	Mean	1.022	56.34
light and handling (n= 119)	Std. Deviation	0.995	6.374
Level 4: Interventions, noise, light	Mean	1.950	60.576
and handling (n= 38)	Std. Deviation	1.814	8.924
Level 5: Interventions caused with	Mean	2.308	63.625
painful stimulation (n= 12)	Std. Deviation	2.793	6.869
Total (N= 4164)	Mean	0.392	52.931
	Std. Deviation	0.673	4.932

Table 4-5

Stress Physiological Signals Mean, Median, Mode and Standard Deviation (N= 4164)

Stress Physiological Signals	Mean	Median	Mode	SD
Heart Rate (bpm)	148.53	149	150	17.223
Respirator Rate (breaths)	46.33	44	30	14.765
Oxygen Sat. (mg%)	96.97	98	100	3.534

Stress Behavioral Responses

Stress behavioral responses include regular sleep-wake states, stress sleep-wake states, self-regulatory behaviors, and stress behavior cues. Following is a summary of the observations of the preterm infants.

Regular Sleep-Wake States. There are six regular sleep-wake states. The majority of time in this investigation, preterm infants were observed to be in sleep states (deep sleep state, n =1424, 34.2%; alert sleep, n =1509, 36.2%; drowsy state, n = 877, 21.1%). Table 4-6 presents frequency and percent of each of the regular sleep wake states.

Table 4-6

Regular Sleep-Wake States by Frequency and Percent

Regular Sleep-Wake States	Frequency	Percent (%)
Deep sleep state	1424	34.2
Alert sleep state	1509	36.2
Drowsy state	877	21.1
Alert wake	143	3.4
Fussy	144	3.5
Cry	67	1.6
Total	4164	100%

Stress Sleep-Wake States. Six stress sleep-wake states were observed and coded present or not present during periods of nursing interventions. Grimace (n = 103) was the most common stress sleep-wake behavior observed when nursing interventions took place. Table 4-7 exhibits the frequency and percent of stress sleep-awake states present and not present when preterm infants had no nursing intervention and when preterm infants had a nursing intervention.

Table 4-7

Frequency of Stress Sleep-Wake States with No Intervention and with Intervention

	No Intervention		Intervention	
Stress Sleep-Wake States	Present Frequency(%)	Not Present Frequency(%)	Present Frequency(%)	Not Present Frequency(%)
Hypoalert	50 (1.3%)	3772(98.7%)	11(3.25)	331(96.8%)
Hyperalert	55(1.4%)	3767(98.6%)	6(1.8%)	336(98.2%)
Gaze Averting	8(0.2%)	3814(99.8%)	2(0.6%)	340(99.4%)
Upward Gaze	9(0.2%)	3813(99.8%)	3(0.9%)	339(99.1%)
Staring	19(0.5%)	3803(99.5%)	3(0.9%)	339(99.1%)
Grimace	280(7.3%)	3542(92.7%)	103(30.1%)	239(69.9%)

Self-Regulatory Behaviors. Ten self-regulatory behaviors were observed and coded present or not present during periods of nursing interventions. Tuck trunk (n = 176) and balanced muscle tone (n = 233) were the most common self-regulatory behaviors observed when nursing interventions took place. Table 4-8 exhibits the frequency and percent of self-regulatory behaviors present and not present when preterm infants had no nursing intervention and when preterm infants had a nursing intervention.

Table 4-8

Frequency of Self-Regulatory Behaviors with No Intervention and with Intervention

	No Intervention		Intervention	
Self Regulatory Behaviors	Present Frequency(%)	Not Present Frequency(%)	Present Frequency(%)	Not Present Frequency(%)
Grasp	13(0.3%)	3809(99.7%)	3(0.9%)	339(99.1%)
Hand clasp	33(0.9%)	3789(99.1%)	11(3.2%)	331996.8%)
Hand to month	114(3%)	3708(97%)	26(7.6%)	316(92.4%)
Foot clasp	23(0.6%)	3799(99.4%)	6(1.8%)	336(98.2%)
Holding on	31(0.8%)	3791(99.2%)	11(3.2%)	331(96.8%)
Leg brace	329(8.6%)	3493(91.4%)	45(13.2%)	297(86.8%)
Sucking	254(6.6%)	3569(93.4%)	70(20.5%)	272(79.5%)
Tuck trunk	1453(38%)	2369(62%)	176(51.5%)	166(48.5%)
Balanced muscle tone	641(16.8%)	3181(83.2%)	233(68.1%)	109(31.9%)
Face	621(16.2%)	3201(83.8%)	58(17%)	284(83%)

Stress Behavioral Cues. Seventeen stress behavioral cues were observed and coded present or not present during periods of nursing interventions. In this investigation, diffusion squirm (n= 80) was the most common stress behavioral cue observed when nursing interventions took place. Table 4-9 exhibits the frequency and percent of stress behavioral cues present and not present when preterm infants had no nursing intervention and when preterm infants had a nursing intervention.

Table 4-9

Frequency of Stress Behavioral Cues with No Intervention and with Intervention

	No Intervention		Interventions	
Stress Behavioral Cues	Present Frequency(%)	Not Present Frequency(%)	Present Frequency(%)	Not Present Frequency(%)
Airplane	5(0.1%)	3817(99.9%)	2(0.6%)	340(99.4%)
Arch	6(02%)	3816(99.8%)	2(0.6)	340(99.4%)
Diffusion squirm	641(16.8%)	3181(83.2%)	80(23.4%)	262(76.6%)
Finger splay	176(4.6%)	3646(95.4%)	75(21.9%)	267(78.1%)
Fisting	101(2.6%)	3721(97.4%)	18(5.3%)	324(94.7%)
Gape face	30(0.8%)	3792(99.2%)	24(7%)	318(93%)
Mouthing	118(3.1%)	3704(96.9%)	15(4.4%)	327(95.6%)
Salute	140 (3.7%)	3682(96.3%)	49(14.3%)	293(85.7%)
Sitting-on-air	63(1.6%)	3759(98.4%)	27(7.9%)	315(92.1%)
Stretch down	9(0.2%)	3813(99.8%)	1(0.3%)	341(99.7%)
Tongue extension	7(0.2%)	3816(99.8%)	1(0.3%)	341(99.7%)
Tremor	40(1.0%)	3782(99%)	4(1.2%)	338(98.8%)
Startle	139(3.6%)	3683(96.4%)	16(4.7%)	326(95.3%)
Twitch	204(5.3%)	3618(94.7%)	10(2.9%)	332(97.1%)
Yawning	30(0.8%)	3792(99.2%)	15(4.4%)	327(95.6%)
Sneezing	13(0.3%)	3809(99.7%)	1(0.3%)	341(99.7%)
Hiccup, spit out, vomit	87(2.3%)	3735(97.8%)	15(4.4%)	327(95.6%)

Findings related to the Research Questions

Research Question 1. What are the relationships between stress physiological signals (HR, RR, and O_2 Sat level), stress behavioral cues and changes in sleep-wake states in a group of preterm infants under conditions of environmental stressors (light, noise, uncomfortable touch) in the NICU?

A generalized estimating equation (GEE) approach was used to address research question one. It was found that increases in environmental stress resulted in a statistically significant increase in heart and respiratory rates and a decrease in oxygen saturation in the preterm infants. Increased environmental stress was significantly related to a decrease in oxygen saturation in the preterm infants. (See Tables 4-10, 4-11, & 4-12). Increased environmental stress also resulted in a significant increase in some of the preterm infant's stress behavioral responses (See Table 4-11). Finally, there was a significant relationship between stress physiological signals and some stress behavioral responses of preterm infants during periods of environmental stress (Table 4-14, 4-15, & 4-16).

Research Question2. Is there any priority of response between stress physiological signals and stress behavioral responses to environmental stressors in preterm infants?

The research data could not find the priority of response between stress physiological signals and stress behavioral responses to environmental stressors during each 2-minute research coding time. This is because the researcher was unable to distinguish which behavior occurred first during this brief 2-minute period.

Research Question 3. What is the most common stress physiological signal of the preterm infant to environmental stressors?

Increased the heart rate (intervention level 2 to 5) and increased respiratory rate (intervention level 1 to 4) were both significantly related to increase environmental stressors (Tables 4-10 and 4-11).

Research Question 4. What is the most common stress behavioral response of the preterm infant to environmental stressors?

"Grimace" (n = 103, 30.1%) is the most common stress behavioral response of preterm infant to environmental stressors (Table 4-7).

Research Question 5. Are there differences in the relationship between stress physiological signals and stress behavioral responses when preterm infants are in different sleep-wake states?

Because the distribution of the preterm infants sleep-wake states this question could not be answered. The majority of time the infants were in deep, alert, or drowsy sleep states.

Findings Related to the Research Hypotheses

Research Hypothesis 1. Increases in environmental stressors will result in increases in heart and respiratory rate (HR, RR), and decreases in oxygen saturation (O_2 Sat.) level in preterm infants.

A generalized estimating equation (GEE) approach was used to address research hypothesis 1. A p-value < 0.05 was chosen as the critical value. There was a statistically significant relationship between environmental stressors (interventions levels two to five) and an increase in heart rate. Additionally, if the infant was older in birth age, this relationship was enhanced (Table 4-10). There also was a statistically significant relationship between environmental stressors (interventions levels one to four) and an increase in respiratory rate. This relationship was enhanced in female infants (Table 4-11). Finally, there was a statistically significant relationship between environmental stressors (intervention levels two to three) and a decrease in oxygen saturation (Table 4-12).

Table 4-10

GEE Estimates of Relationships Between Environmental Stressors and Heart Rates

Variables	Parameter Estimate	Standard Error	95 % CI	Chi-Square	P Value
Intercept	132.413	2.98	(126.571,138.256)	193.264	0.000
Times	-0.009	0.043	(-0.095, 0.077)	0.041	0.839
Light	0.878	0.596	(-0.290,2.046)	2.170	0.141
Noise	0.067	0.054	(-0.039, 0.173)	1.530	0.216
Intervention Level 5[a]	6.067	1.374	(3.373, 8.761)	19.479	0.000*
Intervention Level 4[a]	7.758	2.519	(2.820, 12.697)	9.480	0.002*
Intervention Level 3[a]	4.922	2.257	(0.498, 9.346)	4.756	0.029*
Intervention Level 2[a]	2.882	1.3047	(0.325, 5.440)	4.881	0.027*
Intervention Level 1[a]	1.259	2.064	(-2.788, 5.306)	0.372	0.542
Gender Female[b]	-1.797	2.381	(-6.465, 2.870)	0.570	0.450
Age	1.097	0.139	(0.823, 1.370)	61.802	0.000*

Dependent Variable: HR/2 min.; Model: (intercept), times, light, noise, interventions, gender, age

a: reference category is intervention (0), b: reference category is male, df=1, p-value < 0.05

Table 4-11

GEE Estimates of Relationships Between Environmental Stressors and Respiratory Rates

Variables	Parameter Estimate	Standard Error	95 % CI	Chi-Square	P Value
Intercept	42.634	2.402	(37.925, 47.344)	314.812	0.000
Times	0.027	0.036	(-0.045, 0.099)	0.538	0.463
Light	-0.578	0.487	(-1.532, 0.377)	1.406	0.236
Noise	0.063	0.033	(-0.003, 0.129)	3.521	0.061
Intervention Level 5 [a]	1.461	5.784	(-9.877, 12.799)	0.064	0.801
Intervention Level 4 [a]	10.681	3.580	(3.663, 17.698)	8.899	0.003*
Intervention Level 3 [a]	4.273	1.924	(0.501, 8.045)	4.931	0.026*
Intervention Level 2 [a]	5.207	1.923	(1.437, 8.978)	7.328	0.007*
Intervention Level 1 [a]	5.606	2.079	(1.531, 9.682)	7.269	0.007*
Gender Female [b]	-5.910	2.235	(-10.292, -1.529)	6.990	0.008*
Age	0.213	0.1247	(-0.032, 0.457)	2.908	0.880

Dependent Variable: RR/2 min.; Model: (intercept), times, light, noise, interventions, gender, age

a: reference category is intervention (0), b: reference category is male; CI: confidence Interval, df=1,

p-value < 0.05

Table 4-12

GEE Estimates of Relationships Between Environmental Stressors and Oxygen Saturation

Variables	Parameter Estimate	Standard Error	95 % CI	Chi-Square	P Value
Intercept	98.127	0.645	(98.862, 99.393)	23095.534	0.000
Light	-.526	0.302	(-1.118, 0.067)	3.025	0.082
Noise	-0.015	0.009	(-0.034, 0.004)	2.324	0.127
Intervention Level 5[a]	-0.601	0.969	(-2.500, 1.299)	0.384	0.535
Intervention Level 4[a]	-1.072	0.649	(-2.345, 0.201)	2.726	0.099
Intervention Level 3[a]	-1.691	0.626	(-1.74, -0.013)	7.283	0.007*
Intervention Level 2[a]	-0.877	0.440	(-0.783, 0.762)	3.961	0.047*
Intervention Level 1[a]	-0.011	0.394	(-0.783, 0.762)	0.001	0.979

Dependent Variable: O_2 Sat..; Model: (intercept), times, light, noise, interventions, a.: reference category is intervention (0), df=1, p value < 0.05

Research Hypothesis 2. Increases in environmental stressors will result in specific stress behavioral responses (e.g., finger or toes splay, frown, sit on air, tongue extension, extend arms or legs) in preterm infants.

A GEE approach also was used to examine hypothesis 2. Analysis with GEE generates an odds ratio (OR) for categorical variables (with some continuous variables transformed to categorical) that can be interpreted to indicate the probability of showing behaviors or not showing behaviors of preterm infants while preterm infants have the interventions. An OR >1 is associated positively with showing behaviors and an OR <1 is associated negatively. A p value <0.05 was chosen as the critical value. There was a statistically significant relationship between measured stress sleep-wake state, self-regulatory behavior, and stress behavioral cues and increases in environmental stress (Table 4-13). With the exception of one stress behavioral response (self-regulatory behavior - muscle tone, OR = 0.231) (Table 4-13), all of these behaviors increased with greater environmental stress.

Table 4-13

GEE Estimates of Relationships Between Environmental Stress and Stress Behavioral Responses

Variables names	Estimate	Stand Error	P value	Odds Ratio
Stress Sleep-wake State				
Grimace	1.743	0.799	0.029	5.711
Self-Regulatory Behavior				
Hand to mouth	2.399	0.583	0.000*	11.014
Holding on	2.759	1.004	0.006*	15.777
Sucking	1.298	0.359	0.000*	3.662
Tone	-1.463	0.397	0.000*	0.231
Stress Behavioral Cues				
Finger splay	2.813	0.352	0.000*	16.659
Salute	1.527	0.577	0.008*	4.605
Sitting-on-air	3.050	1.096	0.005*	21.116
Yawning	1.902	0.848	0.025*	6.699

P value < 0.05, OR < 1 is a negative relationship; OR > 1 is a positive relationship

Research Hypothesis 3. There will be reliable relationships between stress physiological signals and specific stress behavioral responses of preterm infants under conditions of environmental stressors (light, noise and uncomfortable nursing interventions) in NICU.

A GEE approach was used to address research hypothesis 3. A p value <0.05 was chosen as the critical value. There was a statistically significant relationship between nine stress behavioral responses (one stress sleep- wake behaviors, two self-regulatory behaviors and six stress behavioral cues) and change in heart rate. The one stress sleep-wake behavior and the six stress behavioral cues were associated with an increase in heart rate in response to environmental stressors and a decrease in heart rate for the two self-regulatory behaviors (Table 4-14).

There was a statistically significant relationship between nine stress behavioral responses (two stress sleep- wake states, two self-regulatory behaviors and five stress behavioral cues) and change in respiratory rate. Grasp, tone, and tongue extension were associated with a decrease in respiratory rate in response to environmental stressors while all of the other behavioral responses were associated with an increase in respiratory rate (Table 4-15).

There was a statistically significant relationship between 11 stress behavioral responses (one stress sleep wake state; four self-regulatory behaviors, and six stress behavioral cues) and changes in oxygen saturation. Hand to mouth, hold on, and face were associated with an increase in oxygen saturation in response to environmental stressors, while all of the other behavioral responses were associated with a decrease in oxygen saturation (Table 4-16). Note that in order to code correctly for GEE, hiccough or spit up was separated into three stress behavioral cues: hiccough, spit up and vomit.

Table 4-14

GEE Estimates of Relationships Between Heart rate and Stress Behavioral Responses

Variables names	Estimate	SE	CI	Chi-Square	P value
Stress Sleep-Wake States					
Grimace	7.990	2.523	(3.044, 12.935)	10.026	0.002*
Self-Regulatory Behavior					
Grasp	-19.811	0.981	(-21.735, -17.887)	407.112	0.000*
Tone	-7.272	2.863	(-12.885, -1.659)	6.449	0.011*
Stress Behavioral Cues					
Airplane	9.037	1.290	(6.509, 11.565)	49.079	0.000*
Arch	21.462	0.870	(19.756, 23.169)	607.628	0.000*
Salute	5.718	2.873	(0.086, 11.351)	3.959	0.047*
Stretch down	17.048	1.284	(14.530, 19.565)	176.161	0.000*
Tongue extension	10.332	2.380	(5.666, 14.998)	18.832	0.000*
Sneezing	7.456	0.461	(60551, 8.360)	260.930	0.000*

Dependent variable: HR, Model: (intercept), times, light, noise, (behaviors), environmental stressor: interventions >0; p value < 0.05

Table 4-15

Correlations Between Respiratory Rate and Stress Behavioral Responses

Variables names	Estimate	SE	CI	Chi-Square	P value
Stress Sleep-Wake State					
Hypoalert	10.515	3.078	(4.480, 16.549)	11.664	0.001*
Grimace	5.879	2.085	(1.791, 9.966)	7.946	0.005*
Self-Regulatory Behaviors					
Grasp	-10.978	1.018	(-12.975, -8.981)	116.105	0.000*
Tone	-3.953	1.892	(-7.662, -0.245)	4.365	0.037*
Stress Behavioral Cues					
Airplane	46.897	1.509	(43.939, 49.855)	965.698	0.000*
Diffusion Squirm	5.020	2.510	(0.100, 9.940	4.000	0.046*
Stretch Down	23.987	1.749	(20.559, 27.415)	188.066	0.000*
Tongue Extension	-21.029	1.910	(-24.773, -17.285)	121.190	0.000*
Sneezing	43.226	0.343	(42.552,43.899)	15829.300	0.000*

Dependent variable: RR, Model: (intercept), times, light, noise, (behaviors), environmental stressor: intervention >0; p value < 0.05

Table 4-16

Correlation between Oxygen Saturation and Stress Behavioral Responses

Variables names	Estimate	SE	CI	Chi-Square	P value
Stress Sleep-Wake States					
Eye upward	-0.936	0.300	(-1.524, -0.348)	9.738	0.002*
Self-Regulatory Behavior					
Grasp	-2.104	0.314	(-2.721, -1.487)	44.656	0.000*
Hand to mouth	2.121	0.763	(0.624, 3.618)	7.710	0.005*
Hold on	2.342	0.583	(1.198, 3.486)	16.092	0.000*
Face	2.204	0.877	(0.485, 3.923)	6.315	0.012*
Stress Behavioral Cues					
Airplane	-4.675	0.614	(-5.879, -3.471)	57.909	0.000*
Fisting	-2.179	1.002	(-4.143, -0.214)	4.726	0.030*
Stretch Down	-5.505	0.376	(-6.244, -4.767)	213.479	0.000*
Tongue extension	-3.219	1.186	(-5.544, -0.893)	7.358	0.007*
Sneezing	2.634	0.536	(1.583, 3.685)	24.128	0.000*
Vomit	-9.251	1.352	(-11.903, -6.600)	46.770	0.000*

Dependent variable: Oxygen Sat., Model: (intercept), times, light, noise, (behaviors), environmental stressor: intervention >0; p value < 0.05

Research Hypothesis 4. The observed relationships between physiological signals of stress and behavioral responses to environmental stress will be stronger when preterm infants are in a wake state.

Because the preterm infants were in deep sleep, alert sleep, or drowsy sleep states the majority of the time (n = 3810) and awake states (state 4-6, n=354) were relatively rarely observed, this hypothesis could not be tested.

Summary

This chapter presented the findings of the investigation. There were 4164 observations of the 37 preterm infants. Increases in environmental stressors (noise, light, and nursing interventions) resulted in statistically significant increases in heart rate and respiratory rates and a decrease in oxygen saturation.

There were significant relationships between nine stress behavioral responses and environmental stress. There also were significant associations between nine stress behavioral responses and changes in heart rate; nine stress behavioral responses and changes in respiratory rates; and 11 stress behavior responses and changes in oxygen saturation for the preterm infants under environmental stress. There was insufficient data to analyze research question 5 and hypothesis 4. Levels of nursing interventions were found to be important environmental stressors for preterm infants.

Chapter V

Conclusion and Recommendations

In this chapter, the summary of the problems and the purpose are presented, along with discussing results for the research questions, and hypotheses. The implications for theories, nursing science and nursing practice, and recommends for future research are presented.

Summary of the Problem

Preterm infants have many physiologic limitations because of immaturity of all major body systems, especially the cardiorespiratory system and central nervous system. In order to survive, preterm infants need to rely on sophisticated medical technologies and intensive nursing interventions for survival before they reach developmental maturity (Farrell, et. al., 2003). The NICU is the place that provides these treatments for maintaining vital functions in preterm infants. Considerable research has demonstrated that the NICU is a stressful environment for preterm and high risk infants (Als, 1986, 1996, 1998; Blackburn, 1998; Hall, et. al., 1996; Lotas, 1992; Robinoson & Fielder, 1992; Shogan & Schumann, 1993).

Behaviors are the only way infants can communicate their needs and responses to their environment (Holditch-Davis, et. al., 2003). It is important for nurse clinicians and researchers to identify specific behaviors that indicate the preterm infant's response to stressful stimulation in the NICU. The problems are the behavioral signs of stress in preterm infants and relationships between infant behaviors and environmental stress have not been clearly identified and it has not been established whether and how preterm infant behaviors are related to physiological responses to environmental stress (Morison, Grunau, Oberlander, & Whitfield, 2001).

Summary of Purpose

The purpose of this investigate was to explore the relationships between stress physiological signals and stress behaviors in preterm infants during periods of environmental stress. This researcher identified environmental stressors and the preterm infants stress physiological signals and stress behavioral responses. This is important because little research validating the suspected relationships between infant behaviors and environmental stress, and few studies have reported relationships between behavioral and physiological responses during the infant stress situation (Morison, et. al., 2001).

Discussion of Results

The general model for this investigation (Figure 1) describes the environmental stressors in the NICU and their impact on the preterm infant. Using the model, a discussion of the results related to environmental stressors, and their relationship to stress physiological signals and stress behaviors results follows.

Environmental Stressors

Noise. In this study, the mean noise level for preterm infants in the incubators was 52.55 dB. The mean level was calculated when there were no nursing interventions and each incubator was covered with a blanket. This dB level is lower than reports by other researchers. Saunders (1995) reported an average mean noise level of 57.9 dB inside covered incubators. Johnson (2001) reported and average mean noise level of 58.5 dB inside covered incubators. In utero, Floyd (2005) reported that fetuses were exposed to a mean noise level of 50 dB. The mean level in this study was a little bit higher.

Light. In this investigation, the mean light level was 0.324 ft-c (3.24 lux). The mean level was calculated when there were no nursing interventions. In both research settings, a blanket was used to cover each incubator to protect preterm infants from bright light. This may account for the low light levels in this investigation. There are other studies where light levels were also low. This finding is similar to a previous study by Slevin, Farrigton, Duffy, Daly, and Muphy (2000) who reported a mean light level of 3.0 lux during a quiet period when the protocol included darkening the NICU and no interventions.

Nursing Interventions. Nursing interventions were classified by levels: Level 1: Interventions that include noise or light stimulation, Level 2: Interventions that include noise and light stimulation, Level 3: Interventions that include noise or light and handling stimulation, Level 4: Interventions that include noise, light and handling stimulation, Level 5: No other study classified nursing interventions in this way combining the multiple stimulations of light, noise, handling interventions and painful stimulations.

Stress Physiological Signals

This section addresses the relationship between stress behavioral response and the stress physiological signals of heart rate, respiratory rate and oxygen saturation. Also the relationship between environmental stressors and stress physiological signals is discussed.

Heart Rate

Behavioral Responses. In this study, there was a relationship between nine stress behavioral responses and a change in heart rate (seven increase, two decrease) in the preterm infants. Other researches reported fewer stress behavioral responses and changes in heart rate. Grunau, et al., (1998) reported two stress behavioral responses (finger splay, grimace) and an increase in heart rate. Harrison et al., (2004) reported three stress behavioral responses (yawn, tremor, hiccough) associated with a higher heart rate but also a low oxygen saturation. In this investigation, the only stress behavior found that was similar to previous research reports was grimace. Hiccough, yawn, finger splay, and tremor were not significant in this study.

Environmental Stressors. In this investigation, there was a relationship between four environmental stressors (nursing interventions levels 2,3,4,5) and an increase in heart rate in the preterm infants. This finding is similar to another study that demonstrated that changes in heart rate was the most common stress physiological signal of preterm infant in response to environmental stressors (Medoff-Cooper, 1998). Other researchers also found the NICU stressful environment can cause initial increases in heart rates in acutely ill infants (Hall, et. al., 1996; Oehler, 1993; Woodson, et. al., 1983).

Respiratory Rate

Behavioral Responses. In this study, there was a relationship between nine stress behavioral responses and a change in respiratory rate in the preterm infants. Although it is routine in the NICU to observe and record respiratory rates, no studies were found that examined the relationship between respiratory rate and preterm infant's stress behavioral responses to environmental stressors of noise, light and nursing interventions.

Environmental Stressors. In this study, there was a relationship between four environmental stressors (nursing interventions levels 1,2,3,4) and increases in respiratory rate. Other researchers also found the NICU stressful environment can cause initial increases in respiratory rates in acutely ill infants (Hall, et. al., 1996; Oehler, 1993; Woodson, et. al., 1983).

Oxygen Saturation

Behavioral Responses. In this study, there was a relationship between 11 stress behavioral responses and a change in oxygen saturation in the preterm infants. Seven of the behavioral changes were associated with a decrease in oxygen saturation and four were related to an increase in oxygen saturation. Other researches reported fewer stress behavioral responses and changes in oxygen saturation. For example, Peters (2001) reported eight behavioral responses and changes in oxygen saturation in preterm infants. Four (finger splay, salute, airplane, sitting on air) were associated with in a decrease in oxygen saturations while four (fisting, hand to mouth, hand or foot clasp, grasp) were associated with and increase in oxygen saturation. Harrison (2004) reported three behavioral responses (yawn, tremor, hiccough) and a decrease in oxygen saturation. Grunau and other researchers (2000) reported three stress behavioral responses (finger splay, brow raising, leg extension) associated with a decrease in oxygen saturation. In this investigation, only four of 11 stress behavioral responses were similar to other studies. It is important to note that grasp, hand to mouth, and fisting were related to an increase in oxygen saturation and airplane was associated with a decrease in oxygen saturation in both this study and Peter's study. Finger splay was associated with a decrease in oxygen saturation in two studies (Peters and Grunau) but was not found to be significant in this investigation.

Environmental Stressors. In this study, there was a relationship between two environmental stressors (nursing interventions levels 2, 3) and decreases in oxygen saturation. This result is similar to other studies that found a significant decrease in oxygen saturation as due to the environmental stressor painful stimulations in the NICU (Gruanu, et. al., 2000; Gonsalves, & Mercer, 1993; Johnston, & Stevens, 1996). In this study a Level 5 nursing intervention, an intervention that causes pain, was not associated with a decrease in oxygen saturation. Although a decrease in oxygen saturation occurred least often in this investigation, this is still an important stress physiological signal. A decrease in preterm infant's oxygen saturation appears to happen most often when the infant experiences an environmental stressor that causes pain.

In this study it is also important to note that some of the stress behavioral responses were associated with a combination of changes in heart rate, respiratory rate and oxygen saturation. For example, four stress behavioral responses (airplane, stretch down, tongue extension, sneezing) were associated with both an increase in heart rate and an increase in respiratory rate. Two stress behavioral responses (stretch down, sneezing) were associated with an increase in heart rate and an increase respiratory rate as well as decrease oxygen saturation. Three behavioral responses (grasp, airplane, tongue extension) were associated with a decrease in oxygen saturation.

Environmental Stressors and Stress Behavioral Responses

In this study, the environmental stressors of noise, light and nursing interventions were analyzed together to determine the relationship with the preterm infant's stress behavioral responses. When combined, there was a relationship (eight positive, one negative) between environmental stressors and nine behavior responses. The results in this investigation are similar to other researchers who found four behavioral responses (finger splay, salute, sitting on air, yawning) associated with an increase in environmental stress (Grunau, et. al., 1998; Harrison, et. al., 2004; Helsti, Grunau, Oberlander, Whitfield, & Weinberg, 2005). In this study tone was found a decrease in relationship to environmental stressors. Other studies found a similar decrease in tone related to environmental stressors in the NICU (Lester, et. al., 2004; VandenBerg, et. al., 2003; Holditch-Davis, 1995).

Implications for Conceptual Framework

The conceptual model was developed based on Epstein's Model of Stress, Levine's Conservation Model, and the Synactive Theory of Development. An important strength of combining these theorists was an extensive list of 33 stress behavioral responses (self-regulatory behaviors, stress sleep-wake states, stress behavioral cues) which included a list of six regular sleep-wake states. The six regular sleep-wake states were used in this investigation to identify the preterm infant's usual sleeping pattern. Since behaviors are the only way preterm infants can communicate there needs (Holditch-Davis, et. al., 2003), the other 27 behaviors were observed important because they signaled and association between environmental stressors and stress physiological signals. Although other researchers identified a variety of stress behavioral responses, (Grunau, et. al., 1998, 2000; Peters, 2001, Harrison, et. al., 2004; Helsti, et. al., 2005), no investigator combined self-regulatory behaviors, stress sleep-wake states, and stress behavioral cues to study the preterm infant's responses to environmental stressors. Therefore, this conceptual model may be more useful to nurse clinicians and researchers to help identify specific behaviors that indicate preterm infant's responses to environmental stressors in the NICU.

Implications for Nursing Science and Practice

Nursing Science

There are differing opinions among nurse scientists. Some argue that the preterm infant's environment must be controlled to protect the preterm infant (Bremmer, et. al., 2003; Kellman, 2002; Lotas, 1992), while others argue that decreasing environmental stimulations deprive the infants of enough stimulation necessary for growth and development (Als, 1999; Cole, & Frappier, 1985; Holditch-Davis, et. al., 2003). Important to nursing science is the need to decrease environmental stressors in a way that does not interfere with growth and development. It is also important to identify the stress behaviors and the stress physiological signals of preterm infants to protect the infant from over stimulation. The investigation has contributed to nursing science by offering a conceptual model that provides a number of stress behavioral responses. Awareness and identification of responses of infants may provide early intervention in the NICU environment.

Nursing Practice

Following are recommendations for nursing practice in the NICU. Nurses in the NICU should:

1. Assess self-regulatory behaviors, sleep-wake states, stress behavioral cues, physiological signals before, during, and after nursing interventions.
2. Learn about the function of self-regulatory behaviors.
3. Learn how to help preterm infants use self-regulatory behaviors to relieve stress. For example, have them "holding on", "sucking", "grasp", "hand to mouth", or providing positioning to facilitate infant's muscle tone.

4. Help families learn how to help preterm infants use self-regulatory behaviors to relieve stress. For example, have them "holding on", "sucking", "grasp", "hand to mouth", or providing positioning to facilitate infant's muscle tone.

Recommendations for Future Research

The following are recommendations for future research include:

1. Include a comparison group of other preterm infants.
2. Replicate the study with a larger sample of preterm infants.
3. Collect data at less than 2 minutes intervals because some preterm infants showed stress behavioral responses to environmental stressors prior to a change in stress physiological signals.
4. In order to understand the pattern of sleep-wake states, it is important to observe the state in preterm infants for more than one hour. The reason is when preterm infants' sleep-wake states are interrupted it may be difficult for the preterm infant to return to a regular sleep-wake cycle.
5. Use a high quality video recorder so that changes of facial expressions and fine movements may be recorded.

Conclusions

The conceptual framework was useful to guide this research. Findings of this investigation demonstrated the relationships among environmental stressors, stress physiological signals, and stress behavioral responses may be observed by caregivers.

Environmental stressors do cause changes in the stress physiological signals of preterm infants. The most common response is a rise in heart rate and respiratory rate. This rise in heart rate and respiratory rate occurs most often as a result of nursing interventions. Oxygen saturation does not change as often for preterm infants in response to most environmental stressors.

Environmental stressors also cause changes in stress behavioral responses of preterm infants. The most frequently occurring stress behavioral responses are grimace, muscle tone. Interestingly even though some stress behavioral response occurred less often, they were significant. These include hand to mouth, sucking, and finger splay.

These study findings are useful to nursing practice. The importance of recognizing preterm infant's behavioral responses and stress physiological signals to environmental stressors allow for early interventions to reduce the possibility of a more serious physiological or pathological change in the status of the preterm infant.

The conceptual model in this study may be useful to future nurse researchers to study the relationship between environmental stressors, stress physiological signals, and the stress behavioral response. This will help gain evidence for care of preterm infants. For example nurse scientist could use the model for further research to determine stress behavioral responses of preterm infants with infant message or music therapy.

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Appendix A

Research Instrument

ID Number ________

Observation Checklist of Preterm Infant's Responses to Stress

Sex_______, GA.___________, age_______weeks _______days, birth weight_____, body weight _______, APGAR 1'________, 5' _______;

Respiratory function: Endo tracheal CPAP_____ days, IPPB ________ days, IMV __________days, High frequency ventilator_______ days, Nasal CPAP____ days, O_2 Cannula _____ days, O_2 hood ______, No Aid_____

Medicines: ______________________________ Infant Complications: ____

Environmental Stressors

time / items																													
light																													
noise																													
Nursing interventions																													

Light and noise will be rated according to the level of no, slight, or strong. Nursing interventions will be check in 1-5. 1: not uncomfortable, 2: a little uncomfortable, 3: moderate uncomfortable, 4: uncomfortable, 5: very uncomfortable

Stress Responses in Preterm Infant

(1) Stress Physiological signals

time / items																													
HR																													
RR																													
O_2 Sat.																													

ID Number ________

(2) Sleep-Wake States

time / items																													
Behavioral States																													

1= deep sleep, 2= alert sleep, 3= Drowsy, 4= alert wake, 5= fuss, 6=crying

(3) stress sleep-Wake States

time / items																													
Hypoalert																													
Hyperalert																													
Gaze averting																													
Upward gaze																													
Staring																													
Grimace																													

The 6 stress behavioral states will be coded as 1/0 (occurred/did not occur).

ID Number ________

(4) Self-regulatory Behaviors

time / items																													
Grasp																													
Hand clasp																													
Hand to mouth																													
Foot clasp																													
Holding on																													
Leg brace																													
Sucking																													
Tuck trunk																													
Tone																													
Face																													

The 10 self-regulatory behaviors will be coded as 1/0 (occurred/did not occur).

ID Number ________

(5) Stress Behavioral cues

time / items																													
Airplane																													
Arch																													
Diffusion squirm																													
Finger splay																													
Fisting																													
Gape face																													
Mouthing																													
Salute																													
Sitting-on-air																													
Stretch/ down																													
Tongue extension																													
tremor																													
startle																													
twitch																													
yawing																													
sneezing																													
Hiccough/ spit up																													

The 17 stress behavioral cues will be coded as 1/0 (occurred/did not occur).

Appendix B

Informed Consent for Participation in Research

台中榮民總醫院人體試驗計畫受試者同意書

☐ 本自願書由受試者本人簽署

☐ 本自願書由法定代理人簽署

計畫名稱： 探討早產兒在環境壓力下之壓力生理指標與壓力行為的關係

計畫執行單位：台中榮民總醫院兒童醫學部新生兒科

計畫主持人：陳昭惠　　職稱：新生兒科主任電話：0919747978

緊急聯絡人：陳昭惠　　職稱：研究醫師　24小時緊急電話：0919747978

受試者姓名：　　性別：　　年齡：　　病歷號碼：

通訊地址：　　電話：

法定代理人姓名：　　性別：　　年齡：

通訊地址：　　電話：

（醫療法第七十九條規定：受試者為無行為能力或限制行為能力人，應得其法定代理人之同意）

敬啟者：

為增進醫學新知及提高醫療技術，進而服務社會，承蒙您自願接受(法定代理人同意)為本試驗計畫之主要受試對象，為能使您完全瞭解本計畫施行人體試驗部分主要內容及方法，敬請詳閱以下各項資料。倘若您對本試驗進行的方法及步驟仍有疑問，本計畫有關人員願意提供進一步解釋，以期您能充分瞭解。

本自願書以下列方式敘述理由：□ 口述　□ 筆述〈同時使用〉

一、試驗目的及方法：

目的：

探討早產兒,在新生兒加護病房內的環境壓力下，特殊壓力行為及其生理壓力指標之間的關係。

研究方法:

當您的嬰兒接受的此研究，他將接受以下研究步驟:

整個研究過程將持續兩天，在研究當天早晨，您的嬰兒將接受觀察記錄一小時及在下午時，您的嬰兒將再接受觀察記錄一小時。整個觀察時間持續4小時。在研究觀察期間，將以兩個攝影機分別在保溫箱內攝影您的嬰兒的壓力行為反應，其中一個攝影機將擺置於近早產兒的頭部，第二個攝影機則擺置及攝影早產兒的軀幹及肢體的活動。EKG 監視器將被應用於研究中，以收集早產兒的心跳、呼吸速率及血氧飽和度。研究過程中也將以照光度儀器來監測光線照度，噪音測量器以監測音量。

所有擺置於保溫箱內的研究設備儀器將依據醫院新生兒加護病房內的感染控制措施來維護清潔。整個研究收案過程也將收集35個早產兒，您的嬰兒將會跟其他接受研究的早產兒一樣的接受同等研究措施。
二、預期試驗效果： 研究結果將確認臨床上有意義的早產兒壓力指標以協助臨床醫護人員提供更合適於早產兒的醫護措施。
三、可能產生之併發症、副作用、危險及其處理方法： 此研究沒有具體的傷害或副作用。然而為了維護早產兒及其家屬的隱私權，在完成整體研究後，所有有關個人隱私的文件及攝影記錄將予以銷毀。
四、試驗可能造成的不適： 沒有。
五、其他可能之治療方法及說明： 不參加此試驗
六、試驗經費來源及所有參與試驗之機構： 研究生自費，本研究將與美國密蘇蘇里州州立大學-聖路易分校護理學院博士班研究生彭孃慧及Jean Bachman 博士共合作進行。
七、受試者之禁忌、限制與應配合之事項： 沒有具體的是項需要注意

八、本試驗受試者之權益將受到下列保護：

(一)醫院將盡力維護貴受試者在試驗施行期間之權益，並善盡醫療上必要之注意。

(二)如依本研究所訂試驗計畫，足以證明因本案處置而使您的健康受到任何傷害，本醫院願依法負損害賠償責任。

(三)本試驗已經得到醫院人體試驗委員會審查通過，該委員會的審查重點即是對受試者是否有適當的保護。

(四)試驗所獲得資料之使用或發表，醫院將對受試者之隱私（例如：姓名、得以辨識受試者身分之照片等資料）絕對保密。

(五)貴受試者於試驗施行期間中，可隨時無條件撤回同意，退出試驗。

(六)受試者退出試驗，將不影響醫病關係或任何醫療上的正當權益。

九、若您對於參與本臨床試驗的相關權益有所疑問，您可與本院人體試驗委員會之承辦人聯絡，聯絡電話：04-23592525轉4006，傳真：04-23592705，E-mail：irb@vghtc.gov.tw

十、經本試驗計畫主持人或其代理人向本人說明上列事項後，本人已明瞭其內容；有關本試驗之疑問，亦得到詳細解答，本人係在完全自主，未被詐欺、脅迫或利誘之情形下，同意參加本試驗，並知悉在試驗期間本人有權隨時無條件退出試驗。試驗內容如有變更，將先取得本人同意。

受試者簽名： 日期：

受試者法定代理人簽名： 日期：

計畫主持人簽名： 日期：

說明人簽名： 日期：

Department

8001 Natural Bridge Road
St. Louis, Missouri 63121-4499
Telephone: 314-516-xxxx
Fax: 314-516-xxxx
E-mail: xxxxx@umsl.edu

Informed Consent for Participation in Research Activities

An exploration of the relationship of stress physiological signals and stress behaviors in preterm infants during periods of environmental stress in the neonatal intensive care unit

Participant ______________________________ HSC Approval Number ______________

Principal Investigator __Niang-Huei Peng__________________ PI's Phone Number ______________

Why am I being asked to allow my infant to participate?

You are invited to give permission for your infant to participate in a research study about how your infant responds to noise, light, and care procedures in the neonatal intensive care unit (NICU). This study examines the relationships between noise, light and care procedures and your infant's sleep and wake states, behaviors, and heart rate, breathing rate, and oxygen saturation. This study is being conducted by Niang-Huei Peng, a doctoral student at the University of Missouri St. Louis. You have been asked to give permission for your infant participate in the research because they are in a NICU and may be eligible to participate. We ask that you read this form and ask any questions you may have before agreeing to allow your infant to participate in the research. Your infant's participation in this research is voluntary. Your decision whether to allow your infant to participate will not affect your current or future relations with the hospital. If you decide to allow your infant to participate, you are free to withdraw your infant at any time without affecting that relationship.

What is the purpose of this research?

The purpose of this research is to examine relationships between noise, light, and care procedures in the neonatal intensive care unit and your infant's sleep and wake states, behaviors, and heart rate, breathing rate, and oxygen saturation.

What procedures are involved?

If you allow your infant to participate in this research, you can expect the following:

On each day, your infant will be observed for one hour in the morning (either between 9am and 10am, or between 11am and 12pm) and one hour in the afternoon (either between 1pm and 2pm, or between 2:15 pm and 3:15pm), providing a total of four hours of observation for your infant (two hours in the morning, and two hours in the afternoon). Two separate digital video recorders will be used. Both recorders will be placed inside the incubator. One video recorder will be placed to capture your infant's facial expressions and hand movements. The second video recorder will be placed to capture your infant's trunk and leg movements. Your infant's heart rate, breathing rate, and oxygen saturation will be measured by an EKG monitor. In addition, a photometer will be used to measure levels of light, and a phonometer will be used to measure sound levels in the incubator.

Approximately 35 to 50 infants may be involved in this research. The research equipment will be cleaned prior to placing it in your infant's incubator following infection control procedures in the NICU.

What are the potential risks and discomforts?

There are no risks and discomforts that may be associated with this research. If your infant should need any special treatment we will stop the research.

Are there benefits to taking part in the research?

Benefits as a result of this research are learning more about how infants respond to light, noise, and care procedures in the NICU. This will help caregivers learn to recognize and respond to the preterm infant's behavior cues and provide better care for infants in the NICU.

Will I be told about new information that may affect my decision to allow my infant to participate?

During the course of the study, you will be informed of any significant new findings (either good or bad), such as changes in the risks or benefits resulting from your infant's participation in the research, or new alternatives to participation, that might cause you to change your mind about allowing your infant to continuing in the study. If new information is provided, your consent to allow your infant to continue to participate in this study will be re-obtained.

What about privacy and confidentiality?

The only people who will know that your infant is a research subject are members of the research team. No information about your infant, or provided by you during the research, will be disclosed to others without your written permission, except:

- if necessary to protect your rights or welfare (for example, if your infant needs emergency care or when the University of Missouri-St Louis Institutional Review Board monitors the research or consent process); or
- if required by law.

When the results of the research arc published or discussed in conferences, no information will be included that would reveal your infants identity. Only the research team will view the videos. Videos recordings of your infant will be erased upon completion of the research. Any information that is obtained in connection with this study, and that can be identified with your infant, will remain confidential and will be disclosed only with your permission or as required by law.

All demographic information, observation protocols, and video recordings will be coded and stored in a secure area assessable only by the researcher. Identifying information will be destroyed following the completion of the study. No individual findings about your infant will be recorded.

The research team will use and share your information until all of the completion of the research. At that point, the investigator will remove the identifiers from your information, making it impossible to link your infant to the study.

Will I be paid for allowing my infant to participate in this research?
There is no payment to allow your infant to participate in this study.

Can I withdraw my infant or my infant be removed from the study?

You can choose whether to be in this study. If you allow your infant to be in this study, you may withdraw your infant at any time without consequences of any kind. The investigator may withdraw your infant from this research if circumstances arise which warrant doing so. For example your infant needs special treatment. If you decide to end your infant's participation in the study, please complete the withdrawal letter found at http://www.umsl.edu/services/ora/IRB.html, or you may request that the Investigator send you a copy of the letter.

Who should I contact if I have questions?

The researcher conducting this study is Niang-Huei Peng. You may ask any questions you have now. If you have questions later, you may contact the researcher at parent's interview time.

What are my rights as a parent of a research subject?

If you have any questions about your rights as a parent of a research subject, you may call Dr. Chao-Huei Chan at 06-23592525 Extension 8056. A secondary contact in the United States is the Chairperson of the Institutional Review Board at the University of Missouri – St. Louis at (314) 516-5897 or ora@umsl.edu.

Remember: Your permission to allow your infant to participate in this research is voluntary. Your decision whether to allow your infant to participate will not affect your current or future relations with the hospital. If you decide to allow your infant to participate, you are free to withdraw them at any time without affecting that relationship.

You will be given a copy of this form for your information and to keep for your records.

I have read the above statement and have been able to express my concerns, to which the investigator has responded satisfactorily. I believe I understand the purpose of the study, as well as the potential benefits and risks that are involved. I give my permission to participate in the research described above.

All signature dates must match.

______________________________ Date ______________________________
Parent or Guardian's Signature Date Parent or Guardian's Printed Name

______________________________ Date
Researcher's Signature Date

Appendix C

Institutional Review Board Approval

OFFICE OF RESEARCH ADMINISTRATION

Interdepartmental Correspondence

The UM-St. Louis Human Subjects Committee reviewed the following protocol:

Name: Niang-Huei Peng

Title: An exploration of the relationship of stress physiological signals and stress behaviors in preterm infants during periods of environmental stress in the neonatal intensive care unit

This proposal was approved by the Human Subjects Committee for a period of one year starting from the date listed below. The Human Subjects Committee must be notified in writing prior to major changes in the approved protocol. Examples of major changes are the addition of research sites or research instruments.

An annual report must be filed with the committee. This report should indicate the starting date of the project and the number of subjects since the start of project, or since last annual report.

Any consent or assent forms must be signed in duplicate and a copy provided to the subject. The principal investigator is required to retain the other copy of the signed consent form for at least three years following the completion of the research activity and the forms must be available for inspection if there is an official review of the UM-St. Louis human subjects research proceedings by the U.S. Department of Health and Human Services Office for Protection from Research Risks.

This action is officially recorded in the minutes of the committee.

Protocol Number	Date	Signature - Chair
070705P	7/20/07	[signature]

台中榮民總醫院人體試驗委員會

The Institutional Review Board of Taichung Veterans General Hospital

40705 台中市西屯區台中港路三段 160 號

Taichung Veterans General Hospital, Taichung, Taiwan 40705, ROC

TEL:886-4-23592525-4006 FAX:886-4-23592705

E-mail: irbtc@vghtc.gov.tw

人體試驗研究計畫許可書

中華民國 96 年 9 月 24 日

計畫名稱：探討早產兒在新生兒加護病房的環境壓力下，生理壓力指標及壓力行為反應之關係

(計畫書版本: Version 1, 20070822, 受試者同意書版本: Version 1, 20070822; 本會編號:C07098)

計畫主持人：兒童醫學部新生兒科陳昭惠科主任

協同主持人：密蘇里大學護理學院彭孃慧研究生

上述計畫已於中華民國 96 年 9 月 10 日經本院人體試驗委員會第 77 次會議審查通過，本證明有效期限至 97 年 9 月 9 日止。

(每屆滿一年人體試驗委員會必須進行審查，請於有效期限到期二個月前繳交期中報告)

人體試驗委員會主任委員

副院長　陳穎從

陳穎從

Clinical Trial Authorization

Date: 24 September 2007

The project entitled, " An Exploration of the Relationship of Stress Physiological Signals and Stress Behaviors in Preterm Infants During Periods of Environmental Stress in Neonatal Intensive Care Unit " (Protocol: Version 1, 20070822 , ICF: Version 1, 20070822; IRB TCVGH No: C07098) submitted by the investigator Chao-Huei Chen, and the sub- investigator Niang-Huei Peng, has been approved by the Institutional Review Board of Taichung Veterans General Hospital at the 77th full committee meeting on 10 Septembe 2007. This permission is valid to 9 Septembe 2008.

Ying-Tsung Chen

Ying-Tsung Chen, M.D.

Chairman, Institutional Review Board, TCVGH

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TEL:(04)22052121

The Institutional Review Board
China Medical University Hospital, Taichung, Taiwan

Tel: 886-4-22052121 ext: 4132   Fax: 886-4-2207-1478

Expedited Approval

Date：Nov. 21, 2007

To：Hung-Chih Lin, Associate Director of Department of Pediatrics,
China Medical University Hospital

From：Martin M-T Fuh MD, DMSci.
Chairman, Institutional Review Board

Subject：An Exploration of the Relationship of Stress Physiological Signals and Stress Behaviors in Preterm Infants During Periods of Environmental Stress in the Neonatal Intensive Care Unit.

The Institutional Review Board has recommended the approval of the Protocol Number: DMR96-IRB-166 date Nov. 21, 2007; Informed Consent Form Version Date: Nov. 16, 2007, for the protocol identified above, for a period of 12 months, and has determined that human subjects will be at risk.

Approval of your research project is, therefore, granted until Nov. 20, 2008. You are reminded that a change in protocol in this project requires its resubmission to the Board. By the end of this period you may be asked to inform the Board on the status of your project. If this has not been completed, you may request renewed approval at that time.

Also, the principal investigator must report to the Chairman of the Institutional Review Board promptly, and in writing, any unanticipated problems involving risks to the subjects of others, such as adverse reactions to biological drugs, radio-isotopes or to medical devices.

CHINA MEDICAL UNIVERSITY HOSPITAL
The Institutional Review Board
NO.2, YUH-DER ROAD, TAICHUNG, TAIWAN, R.O.C.

Martin M-T Fuh MD,DMSci.
Chairman, Institutional Review Board
China Medical University Hospital