

THE ROLE OF SPECIAL CHILD SERVICES IN EXTREMELY PRETERM CHILDREN'S
NEURODEVELOPMENT AND BEHAVIOR

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DEDICATION

For my husband, Luis Javier, your unshakable confidence in me and your sacrifices have been the foundation of my success. For my daughter, Kassandra Louise, your pure excitement, and fascination have inspired me to reach new heights and be everything I can be. With all my heart, I dedicate this work to both of you.

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ABSTRACT

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The current study investigated the potential moderating effect of special child services, such as early childhood intervention, speech therapy, occupational therapy, and physical therapy on the neurodevelopmental and behavioral skills of extremely preterm children. While survival rates of preterm infants have increased due to advancements in neonatal intensive care and perinatal technology, the risk of moderate to severe neurodevelopmental impairments, behavioral problems, and complex medical issues has also increased (Bell et al., 2022; Niklasson et al., 2003). Early detection and intervention for neurodevelopmental delays and behavioral difficulties are crucial, but community resources may be lacking after discharge from the neonatal intensive care unit (Fefferman et al., 2017; Forsythe & Willis, 2008). The study aimed to identify the contribution of special child services in improving the neurodevelopmental and behavioral outcomes of extremely preterm children and to encourage early detection and intervention.

The present study found that early intervention programs did not serve as a moderator in the association between cognitive skills and internalizing or externalizing problem behaviors. Additionally, speech therapy did not serve as a moderator in the association between communication skills and problem behaviors. However, occupational and/or physical therapy served as a moderator in the association between motor skills and externalizing problem behaviors, but not internalizing problem behaviors.

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CHAPTER I

INTRODUCTION

The survivability of preterm infants has been improving for the past decade due to the advancement of neonatal intensive care and perinatal technology (Niklasson et al., 2003). In fact, the mortality rate of infants born extremely preterm has immensely decreased between 2008 to 2012 and from 2013 to 2018 (Bell et al., 2022; Stoll et al., 2015). However, as more extremely premature children are surviving after birth, the risk for moderate to severe neurodevelopmental impairments (NDI) and complex medical issues has also increased (Adams-Chapman et al., 2018; Seaton et al., 2019). Furthermore, extremely premature children may also develop intellectual and behavioral difficulties (Taylor et al., 2011).

Early detection and intervention for neurodevelopmental delays and behavioral difficulties have become crucial in mitigating delays or disabilities related to extreme prematurity as more preterm infants survive (Fefferman et al., 2017). Although social support and family education are essential for better patient outcomes, resources within the community may be lacking after a neonatal intensive care unit (NICU) discharge (Forsythe & Willis, 2008). Despite the ongoing efforts of researchers worldwide to investigate the impact of NICU hospitalization on parental mental health, family financial status, and parent-child relationships, there is still also a significant need for further research on child intervention services and follow-up healthcare programs designed to improve child health outcomes.

Currently, there is limited research regarding the moderating effects of special child services on the association of neurodevelopmental skills of extremely preterm children and their behaviors. Special child services refer to early intervention programs (EIPs), speech therapy (ST), occupational therapy (OT), and physical therapy (PT). The current study aimed to provide

a further understanding of how special child services may potentially improve the neurodevelopmental and behavioral skills of extremely preterm children. Therefore, this study may aid in the customization of specialized care services to meet the distinctive needs of extremely preterm children.

Therapies such as EIPs, ST, OT, and PT are also important in improving the neurodevelopmental outcomes of preterm children (Nwabara et al., 2017). Detecting a delay may also identify any emotional or behavioral challenges a preterm child may be experiencing (Lowe et al., 2019). In many cases, these emotional and behavioral difficulties may stem from frustration arising from medical complications and existing neurodevelopmental delays. Early identification of such issues allows therapists to create personalized interventions that address the challenges faced by preterm children. Early intervention therapies also incorporate activities that promote positive social interaction and problem-solving skills. Through these activities, preterm children may acquire positive behaviors such as emotion regulation, independence, and social competence.

Early childhood intervention (ECI) services, such as EIPs, were designed to be family-centered programs, where primary caregivers play a vital role in planning and implementing therapies to support their preterm child's growth and development (Texas Health & Human Services, n.d.a). Caring for a preterm child may be stressful and challenging for parents, and as such, ECI is also essential in supporting their mental health. Through education, ECI empowers parents by providing them with the knowledge to understand their preterm child's abilities and needs. Individualized family service plans are developed to identify goals for the child's development, including assistance in transitioning to publicly funded preschool programs (Texas Health & Human Services, n.d.a).

Despite the extensive research conducted on medical factors associated with premature birth and their impact on neurodevelopmental and behavioral outcomes (Chung et al. 2020; Peralta-Carcelen et al., 2018), there is limited published evidence concerning the role of special child services in moderating these outcomes in extremely preterm children. Examining the potential moderating effect of these services will allow researchers to identify the contribution of early intervention practices in improving the neurodevelopmental and behavioral skills of extremely preterm children. Early detection of neurodevelopmental risk factors may lead to earlier intervention, which may prevent potential internalizing and externalizing behaviors in extremely preterm children. Therefore, the purpose of this study was to investigate the association between neurodevelopmental skills (as measured by Bayley Scales of Infant and Toddler Development, Third Edition [BSID-III]) and problem behaviors (as measured by Child Behavior Checklist 1.5-5 [CBCL/1.5-5]) of extremely preterm children when moderated by special child services (as reported by primary caregivers).

Purpose of the Current Study

As preterm births grow in number and degree of prematurity, it is imperative to explore the protective factors that mitigate the impact of prematurity. Past research has determined that prematurity increases the risk for both poor neurodevelopmental and behavioral outcomes during early childhood years (Chung et al., 2020). Often, the challenges preterm children encounter become increasingly evident as they advance through various developmental stages. Once these children enter school age, educational problems can be traced back to their early childhood years. Therefore, it is crucial to initiate specialized services that promote early intervention for preterm children who have neurodevelopmental delays and behavioral difficulties.

The present study seeks to investigate the moderating effects of special child services on the association of neurodevelopmental skills of extremely preterm children and their problem behaviors while controlling for sociodemographic characteristics and maternal medical history.

The study will allow the researcher to answer the following research questions:

1. What are the effects of Early Intervention Programs in the association between cognitive skills and behaviors characterized by either internalizing or externalizing problems?
2. What are the effects of Speech Therapy on the association between communication skills and behaviors characterized by either internalizing or externalizing problems?
3. What are the effects of Occupational Therapy and/or Physical Therapy in the association between motor skills and behaviors characterized by either internalizing or externalizing problems?

The following hypotheses will examine the role of special child services on the association between the neurodevelopmental skills of extremely preterm children and their behaviors characterized by either internalizing or externalizing problems using hierarchical multiple regressions using SPSS:

1. Early intervention programs will significantly moderate the relationship between cognitive skills and behaviors characterized by either internalizing or externalizing problems.
2. Speech Therapy will significantly moderate the relationship between communication skills and behaviors characterized by either internalizing or externalizing problems.

3. Occupational and/or Physical Therapy will significantly moderate the relationship between motor skills and behaviors characterized by either internalizing or externalizing problems.

Definition of Terms

Alcohol

The National Cancer Institute (2019a) defines alcohol as a chemical compound found in drinks such as beer, wine, and liquor.

Anxiety

The American Psychological Association (n.d.a) defines anxiety as a form of emotion that includes both physical signs of tension and mental fear. It occurs when a person anticipates a future risk, tragedy, or misfortune.

Attention-Deficit/Hyperactivity Disorder

The American Psychological Association (n.d.b) defines attention-deficit/hyperactivity disorder as a behavioral disorder that involves the persistent presence of six or more symptoms linked to either (a) inattentiveness or (b) impulsivity/hyperactivity.

Bayley Scales of Infant and Toddler Development, Third Edition

The BSID-III is a comprehensive assessment tool used to detect developmental issues in children ages 1 to 42 months (Bayley, 2006).

Behavior

The American Psychological Association (n.d.c) defines behavior as an organism's reaction to both internal and exterior stimuli. It is comprised of both externally visible behaviors and those that can only be recognized via introspection and processes that are not consciously perceived.

Birth Defect

The Centers for Disease Control and Prevention (n.d.b) defines birth defects as structural changes that are present at birth and can damage numerous sections of the body, such as the heart, brain, or foot. These changes may affect the physical appearance, functioning, or both of the body's functions.

Bronchopulmonary Dysplasia

The National Heart, Lung, and Blood Institute (n.d.) defines bronchopulmonary dysplasia (BPD) as a serious respiratory condition that affects newborns. Infants with BPD are typically delivered more than 10 weeks before their expected due date, weigh below 2 pounds at delivery, and have respiratory issues.

Cerebral Palsy

The American Psychological Association (n.d.d) defines cerebral palsy as a group of non-progressive mobility and postural abnormalities caused by brain injuries during pregnancy, at delivery, or shortly after birth.

Child Behavior Checklist 1.5-5

The CBCL/1.5-5 is a standardized interview assessment tool designed to examine behavioral issues and abilities in children aged 1.5 to 5 years (American Psychological Association, n.d.e).

Chlamydia

The CDC (n.d.c) defines chlamydia as a prevalent sexually transmitted illness that may infect both men and women. It can permanently harm a woman's reproductive system.

Cognition

The American Psychological Association (n.d.f) defines cognition as modes of awareness and knowing, including perception, conception, memory, analysis, evaluation, judgment, imagination, and problem-solving.

Comorbidity

The American Psychological Association (n.d.g) defines comorbidity as the simultaneous occurrence of several illnesses, diseases, or disorders in an individual.

Depression

The American Psychological Association (n.d.h) defines depression as an emotional condition that interferes with daily living and can range from dissatisfaction and discontent to a severe sense of despair, pessimism, and despondency.

Diabetes

The World Health Organization (WHO, n.d.a) defines diabetes as a long-term metabolic condition marked by high blood glucose levels that, over time, seriously harms the heart, blood vessels, eyes, kidneys, and nerves.

Early Childhood Intervention

The CDC (2022) defines early intervention as services and support offered to families with children from birth to age 3 who have developmental delays and impairments.

Expressive Communication

Expressive communication refers to how people communicate their basic needs, goals, and emotions (Frazier, 2011). It includes the use of spoken, written, and bodily language, including facial expressions and sign language.

Externalizing Behavior

Externalizing behavior refers to a wide range of behaviors that go against social standards and/or hurt other people (Kauten & Barry, 2020). These behaviors range from those that may be viewed as victimless, such as substance use, to those that are directed at another individual.

Fine Motor

The American Psychological Association (n.d.i) defines fine motor as skills necessary for the coordination of small muscles such as the hands.

Gestational Age

Gestational age refers to the period of pregnancy just before birth, as determined by historical data, fetal ultrasound, or neonatal evaluation (Mizrahi & Kellaway, 2001). It is typically measured in weeks and describes the duration of gestation from the time of the last menstrual period to the time of delivery.

Gonorrhea

The CDC (n.d.d) refers to gonorrhea as a sexually transmitted disease that is common, especially among those between the ages of 15 and 24, and can affect the vaginal, rectal, and pharyngeal areas.

Gross Motor

The American Psychological Association (n.d.j) defines gross motor as skills that need the use of strong muscles to move the limbs or torso and to control body posture to maintain balance.

Hyperactivity

The American Psychological Association (n.d.k) defines hyperactivity as an atypical amount of uncontrollable, vigorous bodily motions or agitation for the person's age.

Impairment

The National Cancer Institute (2019b) defines impairment as a condition in which a physical or cognitive function such as eyesight, movement, or learning capacity, is partially or completely absent.

Impulsivity

The American Psychological Association (n.d.l) defines impulsivity as engaging in risky actions, especially, behavior that is characterized by a lack of careful planning, reflection, or evaluation of potential risks.

Inattention

The American Psychological Association (n.d.m) defines inattention as a condition when an individual has difficulty staying focused or attentive and may have a propensity for their attention to waver or change.

Internalizing Behavior

Internalizing behavior is a term used to describe behaviors that are inwardly directed or excessively regulated and are associated with different types of depression and anxiety disorders (Hansen & Jordan, 2020). Withdrawal, concern, physical problems, and fearfulness are examples of these behaviors.

Intrauterine Growth Restriction

Intrauterine growth restriction (IUGR) refers to the condition where the fetus and/or its organs achieve much less than expected growth during pregnancy (Gao et al., 2020), resulting in weight, length, and/or head circumference that is less than 10% for gestational age at birth.

Intraventricular Hemorrhage

Intraventricular hemorrhage (IVH) refers to bleeding that takes place within or the surrounding ventricles (Daou et al., 2017).

Large for Gestational Age

Large for gestational age (LGA) is defined as having a birth weight that is higher than the 90th percentile for the gestational age (Brown & Chang 2018).

Late-Onset Sepsis

Late-onset sepsis (LOS) is an infection involving the bloodstream in newborns less than 28 days where the illness first manifests 72 hours after birth (Singh et al., 2022).

Low Birth Weight

The WHO (n.d.b) defines low birth weight as less than 2,500 grams or 5.5 pounds at birth.

Necrotizing Enterocolitis

The Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD, n.d.b) defines necrotizing enterocolitis (NEC) as an inflammatory intestinal disease that primarily affects young infants and causes the lining of the gut to die and slough.

Neonatal Intensive Care Unit

The NICU is a specialized nursery in a hospital that provides care to preterm or unwell infants (March of Dimes, n.d.a). To guarantee the greatest outcomes for newborns, the unit is staffed by medical personnel who are qualified and equipped to offer specialized care.

Neurodevelopment

The American Psychological Association (2013) defines neurodevelopment as the process of growth and maturation within the nervous system, influenced by factors such as genetics, environment, and nutrition.

Neurological Assessment

Neurological assessment refers to an evaluation of the nervous system of an individual that may be performed in the healthcare provider's clinic (Johns Hopkins Medicine, n.d.a).

Nicotine

The National Cancer Institute (2019c) defines nicotine as a hazardous, addictive substance that tobacco contains.

Obesity

The WHO (n.d.c) defines obesity as an abnormal or excessive accumulation of fat that poses a danger to health. An individual with a body mass index (BMI) of greater than 30 is considered obese.

Occupational Therapy

The American Psychological Association (n.d.n) defines occupational therapy as a form of fine motor rehabilitation that makes use of tasks and activities to improve functioning, encourage independence, and enhance overall life quality.

Patent Ductus Arteriosus

Patent ductus arteriosus (PDA) is a cardiac defect that can arise shortly after birth due to the failure of this fetal structure to close naturally, which can adversely impact cardiopulmonary dynamics (Johns Hopkins Medicine, n.d.b).

Perinatal

Perinatal refers to the period from before birth to the seventh completed day following birth. The day of birth is denoted as a day of life zero (WHO, 2023).

Periventricular Leukomalacia

Periventricular leukomalacia (PVL) is characterized by the softening of brain tissue as a result of inadequate blood supply or oxygenation to the periventricular region (National Institute of Neurological Disorders and Stroke, 2023).

Physical Therapy

Physical therapy treats pain, injuries, and diseases using mechanical or physical methods including exercise, heat, water, massage, or electric current. It usually focuses on gross motor skills (American Psychological Association, n.d.o).

Preeclampsia

Preeclampsia is a severe pregnancy condition that can develop after the 20th week of pregnancy or after delivery (March of Dimes, n.d.c). It causes high blood pressure and impairs the operation of many organs, including the kidneys and the liver.

Prematurity

Prematurity, also known as preterm birth, occurs when a baby is delivered before the 37 completed weeks of gestation (CDC, n.d.a).

Receptive Communication

Expressive communication, as opposed to expressive communication, refers to what an individual understands and processes (American Psychological Association, n.d.p).

Retinopathy of Prematurity

Retinopathy of prematurity (ROP) is an eye disorder that can arise in preterm newborns or those weighing less than 3 pounds at birth. It is distinguished by the formation of abnormal blood vessels in the retina, the portion of the eye responsible for light detection (National Eye Institute, 2022).

Social Development

Social development refers to the process of acquiring certain skills, attitudes, relationships, and behaviors that enable a person to interact with others and actively participate in society (American Psychological Association, n.d.q).

Sociodemographic

The Merriam-Webster dictionary (2023a) defines sociodemographic as concerning, relating to, or containing a combination of factors related to both societal and population characteristics.

Socioeconomic

The Merriam-Webster dictionary (2023b) defines socioeconomic as referring to, relating to, or comprising a variety of societal and economic conditions.

Special Child Services

In this retrospective study, special child services refer to a variety of services that a preterm child may receive such as speech therapy, occupational therapy, physical therapy, infant stimulation, neurodevelopmental follow-up, or NICU follow-up.

Specialized Skills Training

Specialized skills training (SST) is a type of EIP treatment that promotes the growth of a child's abilities in several developmental domains, including cognitive functioning and social

interaction (Parent to Parent of Texas, n.d.). The Neonatal Research Network (NRN) refers to specialized skills training as an EIP.

Speech Therapy

Speech therapy uses interventions and techniques to improve communication with the use of speech and language (American Psychological Association, n.d.r).

Syphilis

Syphilis is a chronic bacterial and curable sexually transmitted disease that can potentially infect a growing baby when a woman is pregnant (CDC, n.d.e).

Ultrasound

Ultrasound refers to a medical imaging technique that uses high-frequency sound waves to examine internal organs and tissues (National Cancer Institute, 2019d).

Summary

Preterm children are more likely to experience adverse neurodevelopmental and behavioral consequences (Lowe et al., 2019). Early interventions such as EIPs, ST, OT, and PT have the potential to enhance these outcomes. However, there is limited research on the impact of special child services on these outcomes, particularly in extremely preterm children. The purpose of this study is to investigate how special child services moderate the neurodevelopment and behavior of extremely preterm children.

CHAPTER II

REVIEW OF THE LITERATURE

Existing literature has extensively examined the medical and sociodemographic factors that contribute to the risk of preterm birth (Adhikari et al., 2020; Hidalgo-Lopezosa et al., 2019; Jiang et al., 2018; Tedesco et al., 2020). Both types of risk factors have been found to increase the chances of preterm birth. Based on the NRN findings, 74% of extremely preterm infants survive after NICU discharge (Patel, 2016). However, several studies have demonstrated that extremely preterm infants who survive birth are more susceptible to health, neurodevelopmental, and behavioral comorbidities (Adams-Chapman, 2018; Rogers & Hintz, 2016). As a result, neurodevelopmental and behavioral outcomes of preterm children may vary greatly depending on these risk factors. Though preterm children often receive specialized services to enhance their neurodevelopmental outcomes, limited research exists on how these interventions may affect the relationship between neurodevelopmental and behavioral outcomes in this population.

This literature review begins with a definition of preterm birth and proceeds onto an examination of various risk factors related to prematurity. Next, the review examines the health, neurodevelopmental, and behavioral outcomes of preterm children. Additionally, this literature review examines the specialized early childhood services that are frequently recommended to support the developmental needs of preterm children. Lastly, Arnold Sameroff's transactional model of development is applied to understand and study the role of special child services in preterm children's neurodevelopment and behavior.

Definition of Preterm Birth

Nearly 10% of children born in the United States are premature, a term used to describe live births that occur before 37 weeks of gestational age or completed weeks of pregnancy

(March of Dimes, n.d.b; WHO, 2022). The CDC have reported that in 2021, the rate of preterm birth and low birth weight (less than 2,500 grams) in the United States increased by 4% and 3%, respectively (Osterman et al., 2022). According to the NICHD (n.d.a), preterm birth is a major cause of infant mortality and long-term disability. Previously, an infant's birth weight was utilized as an indicator of prematurity. Wolke (2011) described the characterization for birth weight as follows: extremely low birthweight (less than 1,000 grams), very low birth weight (less than 1,500 grams), and low birth weight (less than 2,500 grams). However, this approach was flawed as it failed to identify some infants born prematurely and did not account for issues such as IUGR or LGA.

With advances in technology, gestational age assessment through ultrasound has become the gold standard for determining prematurity (Blencowe et al., 2013). While ultrasound is generally an established tool for measuring gestational age, its use can be limited due to a number of challenges and limitations. Abinader and Warsof (2019) emphasized that ultrasound may not be able to accurately estimate fetal weight and noted the potential for overdiagnosis and overtreatment associated with its use. They also highlighted the importance of operator skill and experience when interpreting ultrasound images. Through the use of ultrasound, the WHO (2022) categorizes preterm births into three groups based on gestational age: extremely preterm (less than 28 weeks), very preterm (28 to 32 weeks), and moderate to late preterm (32 to 36 weeks). Consequently, gestational age and birth weight are now used in conjunction with each other in current literature to classify an infant as premature.

The use of standardized definitions for prematurity based on gestational age and birth weight, as established by the WHO, allows researchers to study prematurity consistently across diverse populations and contexts, guaranteeing consistency in identifying risk factors and health

outcomes across different groups. However, it is not without its limitations. Relying solely on gestational age and birthweight as defining criteria for prematurity may not fully capture the complex nature of the condition. Other factors such as medical co-morbidities and sociodemographic risk factors play a significant role in determining the probability of preterm birth as well as the health, neurodevelopmental, and behavioral outcomes of premature infants. Furthermore, there is a significant need for further research to explore how preterm births may be prevented and to assess the effectiveness of interventions in improving outcomes for preterm infants and children. This area of investigation remains an important gap in the current literature.

Maternal Medical Risk Factors Related to Preterm Birth

Complications during pregnancy, maternal medical conditions, and previous history of premature birth are associated with an increased risk of preterm births (Jiang et al., 2018). Among maternal medical conditions, diabetes, obesity, and pre-eclampsia have been found to increase the likelihood of preterm births (Berger et al., 2020). Type one and type two diabetes are associated with an increased likelihood of infants being born LGA (Kong et al., 2019). Additionally, the risk of preterm birth is further heightened when maternal obesity coexists with diabetes (Aubry et al., 2019). Preeclampsia, another cause of premature birth, may necessitate medical induction of labor before term in order to reduce the risk of neonatal death and other medical complications for both the mother and infant (Davies et al., 2016).

Maternal infection is also a significant risk factor for preterm birth. In one study from the Brazilian Multicentre Study, 65.9% of participants who had at least one maternal infection during pregnancy had preterm births (Tedesco et al., 2020). Some maternal sexually transmitted infections such as gonorrhea, chlamydia, and syphilis, have been found to result not only in preterm birth but also in birth defects (Baer et al., 2019). Multiple gestations often result in

preterm birth: the majority are delivered between 34 to 36 weeks of gestation due to the unique challenges associated with carrying multiples (Lee et al., 2006). In certain situations, Murray et al. (2018) reported that 10% of twin pregnancies are delivered at less than or equal to 32 weeks.

The analysis of maternal medical risk factors is imperative in understanding how the health conditions of pregnant women may increase the risk of preterm births. The existing literature on maternal medical risk factors has provided insights that may be applied to similar populations as large samples in the studies have been employed. However, few studies have examined the interactions between various medical risk factors, which could limit the understanding of how the comorbidity of such health issues contributes to preterm births. Additionally, there is a lack of consistency in how medical risk factors are measured, making it difficult to compare results across studies. Therefore, further research is necessary to establish the relationships between medical risk factors and to ensure greater consistency in measuring them.

Sociodemographic Risk Factors Related to Preterm Birth

Various sociodemographic risk factors increase the likelihood of premature labor and birth. Research indicates that maternal age that is less than 19 years and more than 35 years old is associated with low birth weight in infants (Ratnasiri et al., 2018). Ferrero et al. (2016) also found that the incidence of preterm delivery has an odds ratio of 1.4 for women over the age of 35 based on a sample size of 4.1 million births from five countries including the United States. The effect of maternal age is further compounded by other medical complications such as diabetes, obesity, and hypertension (Fuchs et al., 2018). Despite controlling for socioeconomic status, Johnson et al. (2020) concluded that racial disparities in the incidence of prematurity still exist. For example, it has been determined that Black mothers account for 13.3% of preterm

deliveries, a greater incidence than other racial groupings in the United States (Purisch et al., 2017).

Marital or cohabitation status may also be a determinant of preterm births, as it affects the financial stability of the parental household in the state of Texas (Sullivan et al., 2012).

Similarly, in the state of Wisconsin, research showed that single mothers who did not identify a father on their infant's birth certificate had a higher likelihood of having preterm delivery than those who had established paternity through the court or birth certificate (Ngui et al., 2009).

These higher incidence rates of preterm delivery in single mothers may be due to inadequate social support and resources. Finally, the neurodevelopment and behavior outcomes of preterm children may also be affected by the higher risk for psychological symptoms, including anxiety, depression, parenting stress, and posttraumatic stress, experienced by single mothers (Gondwe et al., 2017).

Expectant mothers' economic and community circumstances may elevate the risk of preterm labor (Adhikari et al., 2020). Stylianou-Riga et al. (2018) implicated maternal nutrition, stress, education level, and drug consumption in these circumstances. Hajianfar et al. (2018) also found a significant positive association between heavy consumption of processed foods during pregnancy and delivering a low-birth-weight infant. Exposure to stress during pregnancy may also increase the likelihood of having a preterm delivery. In one research study, 54% of the women who reported anxiety, depression, fear for their unborn child as well as work-related stress during their pregnancy had a preterm delivery (Lilliecreutz et al., 2016). Pregnant women may turn to alcohol, nicotine, and other recreational drugs during pregnancy due to stress, which increases the risk of late and moderate preterm births (Smith et al., 2015). Medicaid-managed care is also linked to poor neonatal outcomes, as well as inequalities in the NICU discharge

procedures based on insurance type (Brandon et al., 2009). Furthermore, the study by Moster et al. (2008) found a statistically significant relationship between maternal education and preterm birth, with a higher likelihood of preterm birth among mothers who did not complete high school compared to those who did.

Many of these studies investigating the association between sociodemographic risk factors and preterm birth utilized longitudinal study designs, which provided a valuable understanding of the relationship between social factors and preterm births over time. Additionally, certain studies had the benefit of utilizing a large sample size. However, it is important to note that selection bias may have affected the results of some studies, as they may have focused on a specific population. Furthermore, other sociodemographic factors that could have influenced the findings may not have been fully accounted for. To address these limitations, future research should prioritize intersectionality and attempt to include underrepresented groups in their study sample.

Medical Health Outcomes of Preterm Children

Prematurity in infants has been associated with several neonatal morbidities, including but not limited to BPD, PVL, IVH, LOS, PDA, NEC, and ROP, all of which may have long-term impacts on their medical and neurodevelopmental outcomes. BPD, which continues to be the most common diagnosis associated with prematurity, is a form of chronic lung disease that increases the risk for adverse neurodevelopmental outcomes (Natarajan et al., 2012; Thekkevedu et al., 2017). The incidence rates of BPD in premature infants have shown significant variability across different research networks. For example, the Vermont Oxford Network (VON) has reported rates ranging from 26.2% to 30.4%, while the average incidence in the NRN was 68% (Jensen & Schmidt, 2014).

PVL is a medical term used to denote white matter injury in the brains of premature infants (Reddy et al., 2022). On the other hand, IVH is a condition in which bleeding occurs within the ventricles of the brain (Daou et al., 2017). Irrespective of the timing of detection via cranial imaging, PVL is linked to NDI and is often associated with moderate to severe cerebral palsy (CP), a motor disorder frequently observed in premature infants (Peaceman et al., 2022; Sarkar et al., 2018). Likewise, the neurodevelopmental outcomes of children who are diagnosed with Grade 4 IVH are more adverse on average than those diagnosed with Grades 1 to 3 IVH (Merhar et al., 2012). However, it is important to note that when analyzing the association between IVH and PVL, not every case of Grade 4 IVH (the most severe form of IVH) results in the emergence of PVL. Furthermore, it is critical to understand that PVL might emerge without the presence of IVH in some circumstances.

LOS is another frequent complication following premature birth, which may be attributed to the extended duration of stay in the NICU (Downey et al., 2010). Infants who are diagnosed with LOS are 1.5 times more likely to have NDI compared to those who were not according to a study conducted by the NRN (Stoll et al., 2004). PDA, also a common cardiac condition seen in premature infants, is a failure of blood vessel closure between the pulmonary artery and the aorta (Eilers et al., 2021). A small PDA may not require treatment, but a large PDA that is left untreated for an extended period may result in other severe complications such as NEC and ROP (Parkerson et al., 2021). NEC, a gastrointestinal complication often seen in premature infants, increases the likelihood of experiencing adverse neurodevelopmental consequences, especially if it requires surgical intervention (Adams-Chapman, 2018). Finally, the improved survival rates of very low birth weight infants have led to a significant increase in the incidence of ROP, a retinal

condition that may result in blindness or severe visual impairment for premature babies (Kumar et al., 2011).

In sum, extensive research has been conducted on the medical health outcomes of preterm infants, revealing that they are more susceptible to various healthcare complications than their full-term counterparts, and consequently, at a greater risk of experiencing neurodevelopmental delays and behavioral issues. Research networks such as NRN and VON have compiled large amounts of data and have completed rigorous research leading to more robust findings. However, discrepancies in diagnoses across networks may create challenges when comparing results. Additionally, most follow-up studies have focused on the period between 22 to 26 months of corrected age, with only a few exploring the longer-term impacts of premature birth. Therefore, further research is needed to more fully comprehend the school age and later impact of these medical health outcomes on preterm infants.

Neurodevelopmental Outcomes of Preterm Children

Numerous studies have investigated the neurodevelopmental outcomes of preterm children. Typically, the BSID are utilized to measure the cognitive, communication, and motor skills of preterm children in the United States (Stephens & Vohr, 2009). The NRN currently uses specific cutoffs for composite scores to define the different levels of neurodevelopmental impairment. For cognitive composite scores, 70 to 84 (between 1 and 2 *SD* below the mean) is classified as moderate impairment, 55 to 69 (between -2 and -3 *SD*) as severe, and less than 55 as profound (Vohr, 2014). The NRN adopted a similar classification system for composite motor scores. Using this classification, studies have shown a significant risk of severe disability among extremely premature infants born between 22 and 25 weeks from 1996 to 2005 (Rogers & Hintz, 2016).

Vohr (2014) reported that cognitive impairment is the most prevalent and severe form of developmental impairment among extremely preterm infants at 18 to 22 months corrected age. Additionally, a systematic review of the communication outcomes of preterm children found that term children scored significantly higher than preterm children and had significantly less difficulty in complex language function as they grew older compared to preterm children (Van Noort-van der Spek et al., 2012). In terms of motor impairment, Burns et al. (2009) discovered that infants with extremely low birth weight experience difficulties with motor coordination. Moreover, Williams et al. (2010) reported that preterm children are at a heightened risk of developing CP and other motor skill impairments, including developmental coordination disorder (DCD).

Several studies have established and validated the neurodevelopmental outcomes of preterm children, often by comparing them with those born at full term. However, several variables that could influence the results, such as socioeconomic status, maternal education, and racial inequalities, are sometimes overlooked. Likewise, the current definition of NDI may change as future research studies transition from BSID-III to BSID-4, a newer edition of the developmental assessment frequently used in investigating the neurodevelopmental outcomes of preterm children. Additionally, a limited number of ongoing studies in the United States are exploring the long-term outcomes of preterm children. Therefore, further research is necessary to investigate the long-term neurodevelopmental outcomes of preterm children that extend beyond early childhood.

Behavioral Outcomes of Preterm Children

Studies have found that prematurity is associated with increased behavioral and emotional difficulties in children. The CBCL/1.5-5, a commonly used tool to measure these

outcomes in preterm children, assesses internalizing and externalizing problem behaviors as well as total problem behaviors (sum of the scores of all the problem items). Potijk et al. (2012) have found that preterm births, especially for girls, are associated with increased internalizing, externalizing, and total problems when compared to term birth children using the CBCL/1.5-5. Moreover, Wolf et al. (2002) found that very low birth weight preterm infants exhibited more problems in self-regulation during infancy, specifically at 6 months of age. Lower cognitive and language neurodevelopmental scores were also found to be associated with higher behavioral problem scores in anxiety and oppositional defiant disorder (Lowe et al., 2019). Moreover, Scott et al. (2012) found that extremely preterm children showed higher rates of social functioning difficulties, with 25% of them showing impairment in this domain. Finally, Cosentino-Rocha et al. (2014) reported that preterm children displayed significantly higher negative affectivity and surgency scores, as well as lower effortful control scores when investigating temperament.

Internalizing and externalizing behaviors such as anxiety, attention deficit hyperactivity disorder (ADHD), and depression have been associated with prematurity. According to Moore et al. (2021), parents and teachers have reported higher levels of anxiety and depression symptoms in premature adolescents among extremely low gestational age newborns (ELGAN). When compared to full-term children, Montagna et al. (2020) also found that very preterm children exhibit higher than expected prevalence of ADHD symptoms and signs, including inattention, hyperactivity or impulsivity, and a combination of both. Researchers continue to investigate internalizing and externalizing behaviors that may manifest as behavioral disorders in preterm children, making it a significant area of interest in the study of prematurity.

There is an increasing body of research on the behavioral outcomes of preterm children using the CBCL/1.5-5 and other validated tools. It has become apparent from recent research that

behavioral difficulties experienced by preterm children may extend beyond early childhood. However, there is still a scarcity of research on the behavioral outcomes of preterm children. As many studies focus primarily on individual characteristics, such as the health of extremely preterm infants, there is a need for more research that incorporates contextual, such as social determinants, that may impact the behavioral outcomes of preterm children.

Specialized Services for Preterm Children

NICU and neurodevelopmental follow-up clinics are available for preterm infants after discharge. In addition, preterm infants are often referred to intervention therapies such as EIPs, ST, OT, and PT. These services intend to improve various outcomes related to the development, behavior, social and psychological functioning, and cognitive abilities of preterm children (Kalstabakken et al., 2021; Nwabara et al., 2017).

A distinctive benefit of a NICU follow-up clinic is the availability of a multidisciplinary team of experts who may address the specific issues preterm infants may face after NICU discharge (Andrews et al., 2014). Effective communication between primary caregivers and healthcare providers is essential for active monitoring of a preterm child's progress, and it is crucial that primary caregivers feel satisfied with the care their child is receiving. Unfortunately, many healthcare providers fail to accommodate the emotional needs of primary caregivers and focus solely on the medical care of the preterm infant (Adama et al., 2022). This may lead to confusion and lack of collaboration between providers and parents and hinder the development of trust between the primary caregiver and healthcare provider. However, in a NICU follow-up program, coordination of care and support for the primary caregiver of the preterm infant is often provided, which may help reduce these barriers (Bockli et al., 2014).

Neurodevelopmental-only appointments are also available for preterm infants who receive care from traditional pediatric clinics. These appointments typically involve a routine neurological examination and a developmental assessment to monitor the neurodevelopmental progress of premature children. The continuous examinations and assessments minimize the delay in identifying developmental disabilities and improve the probability of receiving appropriate therapies required by the preterm child (Kalstabakken et al., 2021).

To address neurodevelopmental impairments commonly seen in preterm children, early intervention using EIPs, ST, OT, and PT is often utilized and referred by NICU and neurodevelopmental follow-up clinics. Various EIPs have been developed to promote the overall development of children as well as equip primary caregivers with skills that strengthen parent-child interactions. Programs such as Kangaroo Care (KC), Mother-Infant Transaction Program (MITP), Modified Mother-Infant Transaction Program (M-MITP), Infant Health and Development Program (IHDP), and Creating Opportunities for Parent Empowerment (COPE) were among the most effective EIPs across parent-child outcomes for parents and their preterm child (Puthussery et al., 2018). The state of Texas provides SST, a type of EIP, that caters to children aged up to 36 months (Texas Health & Human Services, n.d.a). This unique developmental therapy concentrates on improving the cognitive, behavioral, and social development of children with delays (The Warren Center, n.d.). Nordhov et al. (2010) found that there were significant differences in the cognitive outcomes of children who were in the control group compared to the intervention group.

ST is also critical in improving not just the communication but also the feeding skills of preterm children, addressing common oral motor and eating difficulties in these infants, and lowering the likelihood of speech impairments (Adams-Chapman et al., 2013). These

abilities are critical because they affect a child's capacity to suck, swallow, chew, and make speech and language sounds. Research has shown that 58% of preterm school-age children have voice anomalies, which are most likely caused by extended intubation during their NICU stay, whereas oral feeding issues, such as dysphagia, are caused by prolonged intubation or tracheostomy (Hseu et al., 2018; Kamity et al., 2021). Language development and nutrition can both be improved with ST, resulting in better long-term communication, and feeding outcomes for preterm children.

A recent systematic review by Novak et al. (2020) identified that preterm children with CP may benefit from OT and PT interventions such as bimanual training, constraint-induced movement therapy (CIMT), and mobility training, all of which are critical in improving fine and gross motor impairments. Furthermore, it has been determined that hand-arm bimanual intensive training (HABIT) improved hand function at the 6-month follow-up, whereas CIMT has shown efficacy in improving arm function, particularly for those receiving home-based therapy (Brandão et al., 2018; Chen et al., 2014). Mobility training has also been recognized as an effective intervention for improving children with CP's walking abilities and functional gait (Booth et al., 2018). As a result, combining OT and PT may considerably improve the motor outcomes of preterm children, thereby enhancing their quality of life.

Implementing early intervention practices is vital to reducing the negative consequences of neurodevelopmental delays and promoting optimal progress in preterm children. EIPs and therapies may improve the neurodevelopmental outcomes of children. However, there is a lack of standardization in the types and intensity of therapies offered to extremely preterm children, making it challenging to determine the effectiveness of specific interventions. Furthermore, the availability of some services may be limited based on the community and socioeconomic status

of the preterm children, and insurance coverage, leading to disparities in access to care. Further research is necessary to explore ways of addressing these disparities regarding accessing services for preterm children, and how early intervention services may be smoothly transitioned to school-aged services.

Theoretical Framework

Sameroff's *The Transactional Model of Development: How Children and Contexts Shape Each Other* (2009) is useful in understanding the complexities of prematurity. The transactional model of development is useful in explaining how a preterm child's development and behavior are influenced by the continuous and reciprocal interaction between the child and their experiences in their environment. This model provides a comprehensive understanding of the impact of prematurity on the development and well-being of children and their families.

Arnold Sameroff's Transactional Model of Development

Sameroff (2009) explains that the transactional model of development emphasizes the bi-directional and interdependent effects of children and their environment. For preterm children, these environments may include their families, as well as the healthcare, therapy, and community services they receive. Sameroff and Chandler (1975) were specifically researching medical issues such as preterm birth and how some preterm children did not develop any cognitive or emotional difficulties. They theorized that a child is an active participant in their environment and may compensate through resources such as support from their caregivers or community resources. Continuous adaptation is vital in overcoming the complexities that come with prematurity. In the cases of preterm children, environmental opportunities such as special child services may lead to better developmental outcomes.

While epigenotypes and parent-child interactions are important in determining developmental outcomes, Sameroff (2009) explained that the envirotypes of children also play a significant role in their cognitive and socio-emotional development. Epigenotype refers to the biological sequence that regulates the physical development of a child, whereas envirotype refers to the unique experiences and contexts present in a child's environment. Although parents do influence their children's individual differences through their values and beliefs, socialization and cultural practices may also impact a child's experiences. Sameroff (2009) explained that a child's behavior is the product of the transactional relationship between the epigenotype and envirotype.

It is obvious that both the preterm child and their parents engage in many ecological settings such as their NICU follow-up healthcare programs, therapies, and primary caregiver's workplace. The transactional model may be utilized to explain how these ecological settings may interact with the child's individual characteristics to determine how various special child services may improve not only the developmental outcomes but also the behavioral outcomes of preterm children. Typically, the parent-child interaction is predominantly the primary influence in a term infant's life (Sameroff, 2009). However, for preterm infants, healthcare providers especially in NICU follow-up clinics also have a large influence on their lives. As the preterm child develops, other early special child services become more involved in other settings. As a result, the child's interaction with these special child services may be as important as the parent-child relationship.

In a transactional model, the environment is also impacted by the child's individual differences (Sameroff, 2009). The medical history of a preterm child may change the child's interaction with individuals around them or their environment. For example, extremely premature children who are likely to have severe neurodevelopmental impairment are less likely

to seek out new experiences since they are limited by their motor skills, whereas term children are more likely to manipulate objects around them due to mobility. Preterm children, who have difficulty with social interaction due to their delayed language skills, may elicit a negative response from their caregiver compared to a child who is more able to meaningfully convey their frustration. Thus, the caregiver's response to the child's behavior will shape their subsequent interactions and experiences.

Over time, these transactions may shift as individual and environmental circumstances change (Sameroff, 2009). For example, a family's sociodemographic status or the child's medical status may improve or deteriorate. Examining the dyadic interaction between these circumstances and the child's neurodevelopment may shed light on how tailored special services may improve the behavioral outcomes of preterm children in early childhood. Therefore, a preterm child's neurodevelopmental outcomes, medical history, and the sociodemographic status of their primary caregiver may mutually influence the child's environment. By considering not only the child's epigenotypes and envirotypes but also their dynamic interplay, the transactional model provides an opportunity to develop interventions that promote the overall health of preterm children.

Summary

Neurodevelopmental and behavioral outcomes in extremely preterm children are influenced by various risk factors associated with preterm births, including maternal medical conditions, socioeconomic and racial disparities, and the extremely preterm children's medical health outcomes. The impact of these factors on neurodevelopmental and behavioral outcomes may be explained by using Sameroff's transactional model of development (2009). Special child services such as EIPs, ST, OT, and PT can potentially lessen the association between the

neurodevelopmental and behavioral outcomes of extremely preterm children. To explore this further, the current study sought to address the following research questions:

1. What are the effects of Early Intervention Programs in the association between cognitive skills and behaviors characterized by either internalizing or externalizing problems?
2. What are the effects of Speech Therapy on the association between communication skills and behaviors characterized by either internalizing or externalizing problems?
3. What are the effects of Occupational Therapy and/or Physical Therapy in the association between motor skills and behaviors characterized by either internalizing or externalizing problems?

CHAPTER III

METHODOLOGY

A retrospective study was conducted at the THRIVE clinic located at Children's Medical Center in Dallas, Texas. The primary aim of this study was to examine the moderating role of special child services on the neurodevelopment and behavior of extremely preterm children. The purpose of this chapter was to comprehensively describe the research methods utilized in the current study, the characteristics of the sample of research participants, the variables analyzed, and the data collection tools used in the current study. Furthermore, this chapter presented a detailed outline of the data analysis plan.

Method

This retrospective study employed secondary data obtained from the NRN, a multi-site research group initiated by the NICHD. At that time, the NRN had 15 operating sites and three site collaborators across the United States and ongoing research studies (NICHD & NRN, n.d.b). Since its establishment in 1986, the network had gathered data for both randomized controlled trials and observational studies that had enabled researchers to enhance the treatment of very low birth weight infants (Watterberg et al., 2022). As of February 2022, the NRN Centers had enrolled more than 91,000 infants who satisfied the inclusion criteria (Watterberg et al., 2022). By utilizing both multi-method and multi-informant data collection, the NRN was able to gather detailed information on the participants. Therefore, the data set allowed researchers to comprehensively examine the moderating effects of special child services in the association of neurodevelopmental skills and behavior of extremely preterm children, without being constrained by a small sample size. The current study made use of a subset of the NRN data

collected from both the general (GDB) and follow-up databases from one of the 17 sites, namely the site based in Dallas, Texas. This data was utilized to investigate the proposed hypotheses.

The primary method utilized for data collection in the GDB phase was a sequence of chart reviews using the mother's medical records and the participant's chart from the NICU (NICHD & NRN, 2007/2019a). For the follow-up phase, data were collected using direct child assessment and examination as well as face-to-face primary caregiver interviews at a primary care follow-up clinic in Dallas, Texas. To mitigate reliability and validity concerns, the developmental examiners from each site were certified yearly by gold-standard examiners from the NRN. This involved a submission of a videotaped BSID-III assessment along with documentation of the scoring process and a self-critique of the examination (NICHD & NRN, 2007/2013). During the certification process, examiners were provided with feedback to minimize discrepancies in executing the assessment. The research staff who conducted the CBCL/1.5-5 interviews were also trained in administering and scoring the interview. Furthermore, to ensure that the data collection process was standardized and carried out in a consistent manner, a specialized assessment battery was developed and followed by all sites (NICHD & NRN, 2007/2013).

To prevent some ethical concerns concerning participant autonomy and discomfort during the assessment of the interview, the examiner stopped the assessment or interview if the participant or their parents appeared uncomfortable, and the examiner used their professional judgment to determine whether to continue or discontinue the process. The participants and their families were also given adequate breaks during the visit if needed. If the assessment results indicated a need for treatment, the research team recommended an appropriate program, regardless of the patient and family's background. It is worth noting that all participants had the

option to withdraw from the study at any point in time, and they did not face any negative consequences for doing so.

The protocol for obtaining informed consent, safeguarding the rights of the participants, and obtaining approval for the research was carried out for every individual according to the practices followed at UT Southwestern Medical Center and Children's Health, prior to their study enrollment from the NICU and follow-up visits (NICHD & NRN, 2007/2013). The information collected from each center was securely stored in locked filing cabinets at each site, while the NRN database was protected with a password (NICHD & NRN, 2007/2013). The NRN database, which did not contain any personally identifiable information, such as names, addresses, or phone numbers, was managed by Research Triangle Institute (RTI) International (NICHD & NRN, 2007/2013). The link between the unique study number identifiers and the patient's personal information was housed at each site and was under the control of the study's principal investigator and study coordinator (NICHD & NRN, 2007/2013). This retrospective study obtained approval from the Institutional Review Board (IRB) of the University of Texas Southwestern Medical Center, Children's Medical Center, and Texas Woman's University, in addition to the data user agreement approval from the NRN.

Sample

The secondary data obtained from NRN for this study included all infants born and cared for in the NICU at Parkland Memorial Hospital (PMH) in Dallas, Texas, one of the leading hospitals for birth deliveries in the United States (Parkland Health, 2019). In addition, the participants were seen for a 22- to 26-month follow-up visit in the THRIVE clinic at Children's Medical Center in Dallas, Texas between April 1, 2014, and May 20, 2022. The enrolled patients

included diverse socioeconomic statuses, races, and ethnicities. The following standard NRN inclusion criteria for the enrolled patients were utilized (NICHD & NRN, 2007/2013):

- Observational study:
 - Gestational age at birth less than 27 weeks and/or
 - Birth weight of fewer than 1,000 grams
- And/or enrolled in one or more NRN randomized controlled trials, each of which had its study-specific inclusion criteria, and which required a formal neurodevelopmental follow-up assessment at 22 to 26 months of corrected age

To initiate the enrollment, the NICU staff was required to inform the neonatal research coordinator each time they admitted an eligible newborn based on the established inclusion criteria. The research coordinator approached the participant's family in the NICU to obtain consent to participate in the NRN GDB and/or a randomized or observational NRN study that required monitoring of the participant's health status and follow-up on their development (NICHD & NRN, 2007/2013). Once the parent or legal guardian of the participant agreed to take part in any given randomized controlled study (RCT), the participant's parent or legal guardian signed a consent form that allowed the follow-up research coordinator to track the participant and keep contact with the family until the time of the follow-up visit (NICHD & NRN, 2007/2013). Consent for infants who were not part of an RCT but who qualified for the ongoing observational study was obtained at the time of the first visit to THRIVE clinic. A unique study number identifier was also assigned to each participant. The identifier was applied to the diverse forms that were used for collecting information related to the participant (NICHD & NRN, 2007/2019a).

During the NICU hospitalization, a series of clinical outcome forms were completed using extracted data from the mother's medical records and the participant's chart (NICHD & NRN, 2007/2019a). These forms were intended to provide a summary of the clinical progress of each infant. These data were then entered into the GDB (NICHD & NRN, 2007/2019a). For the Dallas site, a referral to a specialized follow-up clinic was also arranged for the prospective participant upon NICU discharge.

Once the participants approached the follow-up window, the primary caregiver was contacted to re-consent for the follow-up study if a revision in the original consent form had been made (NICHD & NRN, 2019b). The targeted study window for the follow-up visit was between the participant's corrected ages of 22 to 26 months (NICHD & NRN, 2019b). However, if outside the window, a follow-up study appointment was scheduled up to the patient's corrected age of fewer than 42 months. The research coordinator was responsible for arranging a follow-up visit that included a comprehensive assessment battery consisting of the following components (NICHD & NRN, 2019b):

- Demographic and medical history interview
- Neurological examination
- BSID-III
- CBCL/1.5-5

Both the examiner and interviewer were proficient in conducting the assessment and interviews in both English and Spanish. In the event that it was required, an interpreter was also accessible for other languages.

Upon completion of the follow-up visit, another set of outcome forms was completed, and data was subsequently entered into the follow-up database (NICHD & NRN, 2019b). This

allowed for the most up-to-date information to be accurately recorded and tracked for each participant. Lastly, the families were compensated with a gift card, and the amount depended on the type of studies the patients were enrolled in as the NRN typically had several ongoing studies that used the same follow-up visits (NICHD & NRN, 2019b). Lastly, the participants received a developmental toy and a book at the end of the visit.

The present study adhered to the inclusion criteria specified for the NRN follow-up database (NICHD & NRN, 2019b). However, the dataset for this study only included participants who received BSID-III assessments at the Dallas site in the THRIVE clinic between June 1, 2014, and June 30, 2022. With this additional inclusion criterion, the sample for the study was narrowed down to 314 participants.

Measures

Neurodevelopmental Composite Scores

The BSID-III, originally published in 2005, was used to measure the neurodevelopmental outcomes of the participants. This norm-referenced test is recognized as the gold standard in measuring cognitive, receptive communication, expressive communication, fine motor, and gross motor developmental skills in children aged 0 to 42 months (Albers & Grieve, 2007; Del Rosario et al., 2021). According to Ackerman and Brown (2006), the assessment had great test-retest reliability of 0.80 or higher across multiple age groups. Additionally, Bayley (2006) reported that the internal consistency of each area ranged from 0.86 to 0.93. On average, the assessment takes about 90 to 120 minutes to complete. The neurodevelopmental composite scores for cognitive, language, and motor skills were used as the independent variables in the analysis.

Behavioral Syndrome T Scores

The CBCL/1.5-5, originally published in 1991, was used to measure the behavioral outcomes of the participants. The behavioral syndrome T scores were designated with the following syndrome domains: emotionally reactive, anxious, or depressed, somatic complaints, withdrawal, attention problems, aggressive behavior, and sleep problems (Achenbach, 1991). These domains were grouped into three scales: internalizing, externalizing, and total problems. For the present study, the total problems scale was not utilized. The internalizing problem scale was composed of scores from the anxious/depressed, withdrawn-depressed, and somatic complaints domains, while the externalizing problem scale was composed of scores from the attention and aggressive behavior domains.

The CBCL/1.5-5 is widely recognized for its good reliability and validity. Achenbach (1991) reported that the test-retest reliability of the assessment ranged from 0.68 to 0.92 while the inter-rater reliability of the assessment was reported to range from 0.48 to 0.67. On average, it usually took about 10 to 20 minutes to complete the interview. The internalizing and externalizing problem T scores were used as the dependent variables in the analysis.

Special Child Services

The special child services section of the NRN SES follow-up form was used to collect information about the special child services that each participant received or was currently receiving at the time of the assessment. Interventions such as EIPs, ST, OT, and PT are therapy services that are often recommended for preterm infants and children (Nwabara et al., 2017). Responses from the form were coded as follows: 0 as *not receiving*, 1 as *recommended but not receiving*, 2 as *received in the past but discontinued*, 3 as *receiving*, or 999 as *unknown*. These

responses were re-coded as follows: 0 as *did not receive*, 1 as *received or receiving*, or 999 as *unknown*. The special child services were used as moderators in the analysis.

Primary Caretaker's Sociodemographic Status

The education and occupation section of the SES follow-up form was used to collect information about the primary caretaker's education level, employment status, type of insurance, and marital status. Various research studies have shown that sociodemographic status has a significant impact on the likelihood of preterm births (Behrman & Butler, 2007; Frey & Klebanoff, 2016; Hidalgo-Lopezosa et al., 2019). These variables were analyzed to determine if any could be used as control variables for the various analysis conducted.

Education Level

Lower education level has been linked to an increased risk of preterm births (Stylianou-Riga et al., 2018). For the current study, the responses for the education level were coded as follows: 1 as *less than 7th grade was completed*, 2 as *7th to 9th grade was completed*, 3 as *10th to 12th grade was completed but did not graduate high school*, 4 as *high school degree was obtained*, 5 as *partial college or an associate degree was obtained*, 6 as *bachelor's degree was obtained*, 7 as *graduate degree was obtained*, or 999 as *unknown*. These responses were re-coded as follows: 1 as *less than high school graduate*, 2 as *high school graduate*, 3 as *partial college or trade*, 4 as *more than or equal to college graduate*, or 999 as *unknown*. Lastly, these variables were transformed into dummy variables, resulting in the creation of the following variables: less than high school education (0 for *no*, 1 for *yes*), high school graduate (0 for *no*, 1 for *yes*), partial college or trade (0 for *no*, 1 for *yes*), and more than or equal to college graduate (0 for *no*, 1 for *yes*).

Employment Status

Financial status has been associated with an increased risk of preterm births (Adhikari et al., 2020). For the current study, the responses for the employment level were coded as follows: 0 as *not working* or 1 as *working*, or 999 as *unknown*.

Insurance Type

Medicaid-managed care patients are susceptible to experiencing negative health outcomes (Brandon et al., 2009). Responses were coded as follows: 1 as *uninsured*, 2 as *public*, 3 as *private*, 4 as *both public and private*, or 999 as *missing*. These variables were transformed into dummy variables, resulting in the creation of the following variables: uninsured (0 for *no*, 1 for *yes*), public (0 for *no*, 1 for *yes*), private (0 for *no*, 1 for *yes*), and both public and private (0 for *no*, 1 for *yes*).

Marital Status

Single mothers are at a higher risk for less mother-infant interaction which ultimately impacts the neurodevelopment and behavior outcomes of preterm children (Gondwe et al., 2017). Responses were coded as follows: 1 as *single*, 2 as *widowed*, 3 as *divorced*, 4 as *married*, and 999 as *unknown*. These responses were re-coded as the following: 0 as *not married*, 1 as *married*, or 999 as *unknown*.

Child's Medical History

The participant's medical history, including diagnoses of BPD, Grades 3 to 4 IVH and PVL, LOS, NEC, ROP, and PDA, were collected during the participant's stay in the NICU. Several research studies have demonstrated the significant impact of these conditions on neurodevelopmental and behavioral outcomes (Agarwal et al., 2021; Natarajan et al., 2012;

Merhar et al., 2012; Sarkar et al., 2018). These variables were analyzed to determine if any can be used as control variables for the various analysis conducted.

BPD

The status section of the respiratory support form was used to collect information about the final BPD diagnosis received during the NICU hospitalization. The diagnosis and classification of BPD are determined by evaluating the respiratory support status of the participant at 36 weeks postmenstrual age (NICHD & NRN, 2023). The Jensen BPD criteria were utilized to establish a standardized definition of BPD. If the participant was still receiving any respiratory support by 36 weeks postmenstrual age, the patient is diagnosed with BPD. Responses were dichotomized as follows: 0 as *no BPD*, 1 as *diagnosed with BPD*, or 999 as *unknown*.

Grades 3 to IVH/PVL

The neurology section of the GDB clinical outcome form was used to collect information about the Grades 3 to 4 IVH/PVL diagnosis received during the NICU hospitalization. If there was evidence that the ventricular size was enlarged with concurrent or prior blood in the ventricles, the participant was diagnosed with Grade 3 IVH (NICHD & NRN, 2023). Alternatively, if there was evidence that blood or echodensity was present in the parenchyma, the participant was diagnosed with Grade 4 IVH. Lastly, PVL is diagnosed when white matter injury is present in the brain. Responses were coded as follows: 0 as *no grade 3 or 4 IVH or PVL*, 1 as *diagnosed with grade 3 or 4 IVH or PVL*, or 999 as *unknown*.

LOS

The infection section of the GDB clinical outcome form was used to collect information about the LOS diagnosis received during the NICU hospitalization. If the blood culture was

positive for septicemia or bacteremia after 72 hours of delivery, the participant was diagnosed with LOS (NICHD & NRN, 2023). Responses were coded as follows: 0 as *no late-onset sepsis*, 1 as *diagnosed with late-onset sepsis*, or 999 as *unknown*.

NEC

The gastrointestinal section of the GDB clinical outcome form was used to collect information about the NEC diagnosis received during the NICU hospitalization. If necrotizing enterocolitis was absent or only suspected, the patient was not diagnosed with necrotizing enterocolitis (NICHD & NRN, 2023). However, if it was proven with or without surgery or autopsy, the participant was diagnosed with necrotizing enterocolitis. Responses were coded as follows: 0 as *no necrotizing enterocolitis*, 1 as *diagnosed with necrotizing enterocolitis*, or 999 as *unknown*.

ROP

The ophthalmology section of the GDB clinical outcome form was used to collect information about the ROP diagnosis received during the NICU hospitalization. The presence of retinopathy in either eye was used to diagnose the participant with this condition (NICHD & NRN, 2023). Responses were coded as follows: 0 as *no retinopathy*, 1 as *diagnosed with retinopathy in one eye*, 2 as *diagnosed with retinopathy in both eyes*, or 999 as *unknown*. These responses were re-coded as follows: 0 as *no retinopathy*, 1 as *diagnosed with retinopathy*, or 999 as *unknown*.

PDA

The cardiovascular section of the GDB clinical outcome form was used to collect information about the PDA diagnosis received during the NICU hospitalization. The diagnosis of patent ductus arteriosus was made if there was evidence of its presence in the participant

(NICHD & NRN, 2023). Responses were coded as follows: 0 as *No patent ductus arteriosus*, 1 as *Diagnosed with patent ductus arteriosus*, or 999 as *unknown*.

Analysis

Six separate hierarchical multiple regressions were conducted to evaluate the moderation effects of special child services (EIPs, ST, and OT/PT) on the neurodevelopment-behavior relationship. Preparation of the data and analysis were performed using SPSS version 28 (IBM, Inc., Armonk, NY). SPSS was used to summarize the descriptive statistics for the demographic data by analyzing categorical variables with frequencies and percentages, continuous variables with means and standard deviations, and estimating bivariate correlations. This will ensure that the data follows a normal distribution with acceptable ranges of skewness (± 3) and kurtosis (± 7), as well as account for missingness (Field, 2013).

Little's MCAR test was also utilized to assess missingness and ensure that it is random. A power analysis was conducted to determine sufficient statistical power. The predictor variables and interactions term between each predictor and moderator were centered. This is done to decrease multicollinearity (Cohen et al., 2013; Field, 2013). It is unnecessary to center the moderator and control variables as they are dichotomous. In addition, bivariate correlation tests were conducted to test the associations between the moderator variables (ST or OT/PT), predictor variables (cognitive, communication, or motor composite score), outcome (internalizing or external problems), and control variables (primary caretaker's sociodemographic status and child's medical history; Cohen et al., 2013; Field, 2013). If the results of the bivariate correlations are significant, the control variable was included in the main analyses. However, the control variables that do not have any statistically significant associations with the predictor and outcome variables were excluded.

For the main analyses, the researcher utilized six hierarchical multiple regressions using SPSS to answer the research questions. Assumptions of multiple regression were checked for homoscedasticity, normality, linearity, multicollinearity, independence of residuals, and variance (Field, 2013). The variance inflator factor (VIF) and tolerance values were assessed to ensure that the values are less than 3 and more than .3, respectively for normality and variance (Field, 2013). A residual scatterplot between the predictor and outcome variables will also be utilized to assess homoscedasticity and linearity (Field, 2013). Additionally, multicollinearity was assessed using correlations analysis to ensure that any statistically significant correlations between the predictor, outcome, moderator, and control variables are less than .80. Finally, a Durbin-Watson test was utilized to test for the assumption of independent residuals (Field, 2013).

The use of hierarchical multiple regressions and interaction terms (predictor variable x moderator) allowed the researcher to examine the moderating role of special child services on the association between the neurodevelopmental skills of preterm children and their internalizing and externalizing behaviors while controlling for sociodemographic status and medical history. The moderator was evaluated using this model, which established if the presence of the interaction in each equation explains a significantly greater amount of variance than the predictor and moderating variables alone (Field, 2013). The appropriate controls, predictor z-scores, and moderators were entered in the first block, while the interaction variable was entered in the second block in each hierarchical multiple regression analysis.

Summary

This chapter presented the methodology for a retrospective study to better understand the moderating role of special child services on the neurodevelopment and behavior of extremely preterm children. The researcher received approval from the IRB of Texas Woman's University

and UT Southwestern Medical Center in addition to a data user agreement with NRN. The study was conducted using neurodevelopmental composite scores, as measured by the BSID-III, and behavior T-scores, as measured by the CBCL/1.5-5, to assess the neurodevelopmental and behavioral outcomes of extremely preterm children when moderated by special child services (as reported by primary caregivers). The data collecting method was strictly followed, including all regulations and protocols provided by Texas Woman's University, UT Southwestern Medical Center, and NRN.

CHAPTER IV

RESULTS

Preliminary Analysis

Initially, all variables were assessed for departures from normality and for missingness. All variables were found to have appropriate normal distributions; skewness and kurtosis coefficients were within acceptable limits (Field, 2013). The observed data met the criteria outlined by Field (2013) for normal distributions, where the absolute values of skewness and kurtosis were less than three and 10, respectively (see Table 1). The current study included all participants ($n = 314$) who met the inclusion criteria and have received both BSID-III evaluations, and CBCL/1.5-5 interviews. The missingness was completely random based on Little's MCAR test ($\chi^2(5) = 5.45, p = .36$). Furthermore, G*Power 3.1 (Faul et al., 2009) was utilized to determine the proper sample size for the current study. Based on a power analysis conducted, a sample size of 172 was necessary to detect a statistically significant effect size of 0.05 based on the variables being utilized in the current study which suggests that the sample size of the current study was determined to be sufficient.

Table 1*Descriptive Statistics for Study Variables*

Variable	<i>M</i>	<i>SD</i>	Range	Skewness	Kurtosis
Cognitive	81.00	11.96	55-100	-0.25	0.06
Communication	74.29	13.86	47-115	0.21	-0.02
Motor	86.16	13.97	46-118	-0.95	1.12
Internalizing	50.25	10.24	29-84	0.18	0.03
Externalizing	49.58	10.66	28-97	0.47	1.04
Marital Status	0.49	0.50	0-1	0.03	-2.01
BPD	0.25	0.43	0-1	1.15	-0.68
PDA	0.49	0.50	0-1	0.06	-2.01
ROP	0.69	0.46	0-1	-0.84	-1.30
Early Intervention	0.45	0.50	0-1	0.21	-1.97
ST	0.58	0.49	0-1	-0.31	-1.92
OT/PT	0.51	0.50	0-1	-0.05	-2.01

Descriptive Information

Descriptive statistics were used to summarize the data, with categorical variables analyzed through frequencies and percentages, and continuous variables through means and standard deviations (see Table 2). Certain sociodemographic variables such as the primary caretakers' education level and child's insurance type, as well as medical history variables such as Grade 3–4 IVH/PVL, LOS, and NEC were excluded. This decision was made a priori due to their non-statistically significant associations with the predictor, outcome variables, and/or

moderators. Ultimately, the sociodemographic variable marital status, and medical history variables such as BPD, PDA, and ROP were included as controls. Table 3 provided information on means, standard deviations, bivariate correlations, and significance of all variables used in the hierarchical regression models.

Table 2

Participant Characteristics of Preterm Children at 22 to 26 Months Corrected Age (N = 314).

Characteristics	Participants
Primary Caretaker Education Level	
< High School	118 (37.6) ^a
High School Graduate	99 (31.5)
Partial College or Trade	57 (18.2)
≥ College degree	40 (12.7)
Corrected Age (months)	22.99 ± 2.17 ^b
Primary Caretaker Marital Status	
Married	155 (49.4)
Not Married	159 (50.6)
Primary caretaker work status	
Employed	161 (51.3)
Unemployed	151 (48.1)
Sex	
Male	158 (50.3)
Female	156 (49.7)
BSID-III Language	

Characteristics	Participants
Spanish	164 (52.2)
Other	7 (2.2)
Insurance Type	
Public	282 (89.8)
Private	20 (6.4)
Uninsured	12 (3.8)
Bronchopulmonary Dysplasia	77 (24.5)
Grade 3-4 IVH/PVL	65 (20.7)
Late Onset Sepsis	78 (24.8)
Necrotizing Enterocolitis	27 (8.6)
Patent Ductus Arteriosus	149 (47.5)
Retinopathy	212 (67.5)

^a Values are the number and percent of the total in each column.

^b Values are mean $\pm$ *SD*.

Table 3*Means, Standard Deviations, and Correlations of All Variables Used in the Hierarchical Regression Models*

Variable	<i>M</i>	<i>SD</i>	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Cognitive	81.00	11.96	-											
2. Communication	74.29	13.86	.62**	-										
3. Motor	86.16	13.97	.71**	.60**	-									
4. Internalizing	50.25	10.24	.00	-.13*	-.03	-								
5. Externalizing	49.58	10.66	.17**	.01	.17**	.67**	-							
6. Marital Status	.49	.50	-.02	.02	-.04	-.12*	-.15**	-						
7. BPD	.25	.44	-.18**	-.14*	-.23**	-.07	-.04	.05	-					
8. PDA	.49	.50	-.12*	.01	-.06	-.14*	-.19**	.10	.25**	-				
9. ROP	.69	.46	-.13*	-.09	-.15**	-.03	-.05	.04	.25**	.23**	-			
10. Early Intervention	.45	.50	-.08	-.05	-.21**	.04	-.10	.01	.10	-.05	.06	-		
11. ST	.51	.50	-.15**	-.15**	-.22**	.17**	.06	-.02	.07	-.02	.13*	.50**	-	
12. OT/PT	.58	.50	-.18**	-.11	-.28**	.15**	-.02	.01	.19**	.07	.14*	.57**	.56**	-

* $p < .05$. ** $p < .01$.

Cognitive composite scores were positively associated with the communication composite scores ($r = .62, p < .01$), motor composite scores ($r = .71, p < .01$), and externalizing problem behaviors ($r = .17, p < .01$). On the other hand, cognitive composite scores were negatively associated with BPD ($r = -.18, p < .01$), PDA ($r = -.12, p < .01$), ROP ($r = -.13, p < .01$), ST ($r = -.15, p < .01$), and OT/PT ($r = -.18, p < .01$). These results indicate that as composite scores increase, communication, motor skills, and externalizing problem behaviors also increase. However, higher cognitive composite scores are associated with a decreased likelihood of being diagnosed with BPD and PDA, as well as receiving ST and OT/PT.

Communication composite scores were negatively associated with internalizing problem behaviors ($r = -.13, p < .05$), BPD ($r = -.14, p < .05$), and ST ($r = -.15, p < .01$). As communication composite scores increase, there is a decreased likelihood of exhibiting internalizing problem behaviors, being diagnosed with BPD. In addition, as communication composite scores increase, there is a decreased likelihood of receiving ST.

Motor composite scores were positively associated with externalizing behavior ($r = .17, p < .05$). Conversely, motor composite scores were negatively associated with BPD ($r = -.23, p < .01$), ROP ($r = -.15, p < .01$), EIP ($r = -.21, p < .01$), ST ($r = -.22, p < .01$), and OT/PT ($r = -.28, p < .01$). These findings suggest that increasing motor scores correspond to increases in externalizing problem behaviors. In contrast, higher motor composite scores are associated with a decreased likelihood of being diagnosed with BPD and ROP, as well as receiving early EIP, ST, and OT/PT.

In addition, internalizing problem T-scores were positively associated with externalizing behavior ($r = .67, p < .01$), ST ($r = .17, p < .01$), and OT/PT ($r = .15, p < .01$). On the other hand, internalizing problem behaviors were negatively associated with marital status ($r = -.12, p < .05$),

and PDA ($r = -.14, p < .05$). These results indicate that as internalizing problems increase, externalizing problem behaviors, along with receiving speech therapy and occupational therapy/physical therapy, also increase. In contrast, increased levels of internalizing problems are associated with a decreased likelihood of the primary caretaker being married and the child being diagnosed with PDA.

Externalizing problem behaviors were negatively associated with marital status ($r = -.15, p < .01$) and PDA ($r = -.19, p < .01$). As externalizing behavior increases, there is a decreased likelihood of the primary caregiver being married and being diagnosed with PDA. Also, as externalizing behavior increases, there is a decreased likelihood of being diagnosed with PDA.

Lastly, ST was positively associated with ROP ($r = .13, p < .05$) and EIP ($r = .50, p < .01$) whereas OT/PT was positively associated with BPD ($r = .19, p < .01$), ROP ($r = .14, p < .05$), EIP ($r = .57, p < .01$), and ST ($r = .56, p < .01$). These findings suggest that receiving ST is associated with a diagnosis of ROP and the receipt of EIP. Additionally, receiving OT/PT is associated with a diagnosis of BPD, and ROP, as well as the receipt of EIP and ST.

Hierarchical Regression Models

Six separate hierarchical regression analyses were conducted to test the moderating effects of special child services (EIP, ST, and OT/PT) on the association of neurodevelopmental skills (cognitive, communication, and motor) of extremely preterm children and their behaviors (internalizing and externalizing problems). The scatterplots of the residuals proved that the homoscedasticity requirement was satisfied. The assumption for independent residual was also met based on the Durbin-Watson test for hierarchical regression analysis since the values are more than one and fewer than three. The predictor variables and interaction terms between each

predictor and moderator were mean-centered to minimize significant multicollinearity (Cohen et al., 2013).

Regression models were created using the moderation processes specified by Cohen et al. (2013). The procedure included the following steps: the outcome variable (internalizing or external problems), predictor variable (cognitive, communication, or motor composite score), moderator (EIP, ST, or OT/PT), and control variables (marital status, BPD, PDA, and ROP), were all included in the first step of each regression analysis. Following that, an interaction term between the predictor variable and the moderator was introduced in the second stage. For example, the internalizing problem T-scores were included in the dependent box. The first block included the following variables: cognitive composite score, EIP, marital status, BPD, PDA, and ROP. The interaction term, cognitive composite scores X EIP was included in the second block. The statistical significance of the interaction term was used to establish the presence of moderation. The existence of moderation was indicated if the interaction term was determined to be statistically significant.

Moderation Effects of Early Intervention Programs

Cognitive and Internalizing Problem Behaviors

The first hierarchical regression analyzed how the interaction between cognitive and early intervention programs moderates the relationship between cognitive composite scores and internalizing problem behaviors (see Table 4). The first step included the following variables: cognitive, marital status, BPD, PDA, ROP, and EIP. These variables did not account for a statistically significant amount of variance in internalizing problem behaviors, $R^2 = .03$, $F(6, 298) = 1.75$, $p = .11$. The second step included the interaction term between cognitive and EIP being added to the regression model, which also did not account for a statistically significant

amount of variance in internalizing problem behaviors, $\Delta R^2 = .03$, $F(1, 297) = .10$, $b = .18$, $p = .75$. Ultimately, EIP was not a statistically significant moderator in the model. Figure 1 shows the non-statistically significant moderating effects of EIP for internalizing problem behaviors.

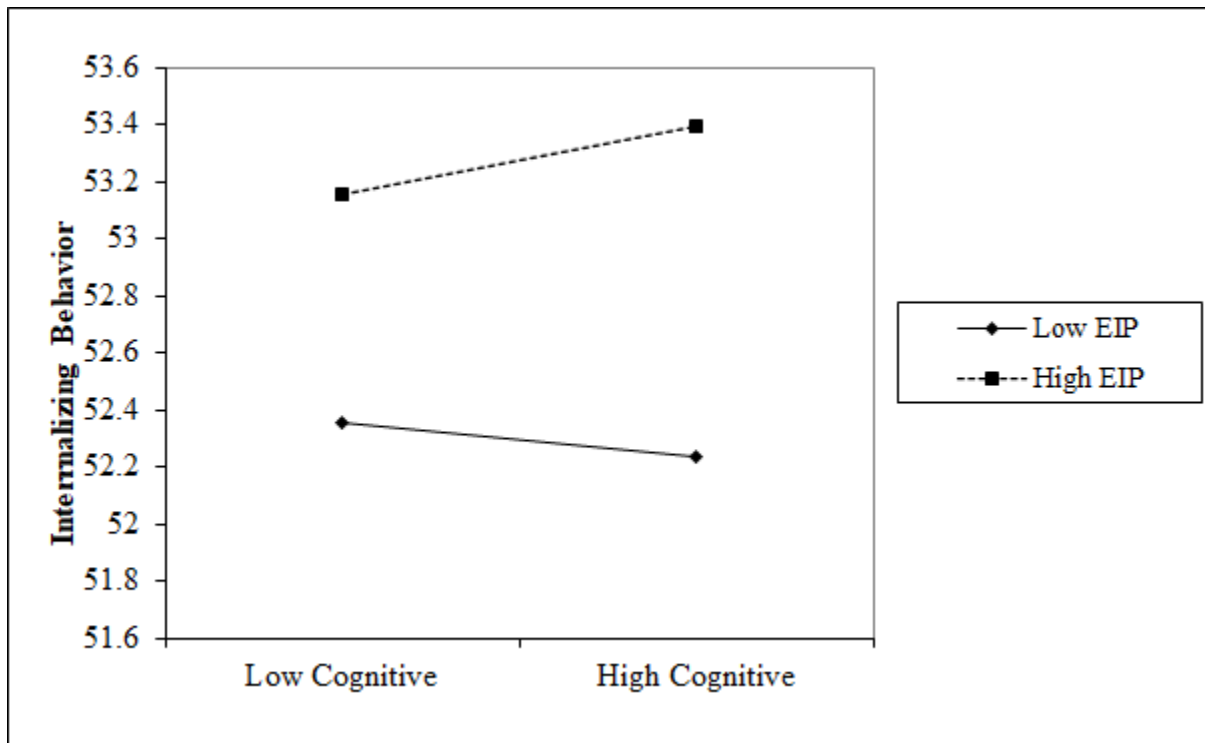
Table 4*Moderation Hierarchical Regression Model: Cognitive and Internalizing Problem Behaviors*

Variable	Internalizing problem behavior			
	R^2	b	SE	β
Step 1	.03			
Cognitive		-0.03	0.60	0.00
Marital Status		-2.33	1.17	-0.11
BPD		-0.72	1.45	-0.03
PDA		-2.42	1.24	-0.12
ROP		0.28	1.33	0.01
EIP		0.98	1.19	0.05
Step 2	.03			
Cognitive		-0.05	0.60	0.00
Marital Status		-2.37	1.18	-0.12
BPD		-0.74	1.45	-0.03
PDA		-2.40	1.24	-0.12
ROP		0.26	1.34	0.01
EIP		0.99	1.19	0.05
Cognitive X EIP		0.18	0.59	0.02

* $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 1

EIP Moderation Effects on Cognitive and Internalizing Behavior



Note. Low EIP = did not receive EIP; High EIP = received or receiving EIP

Cognitive Composite Scores and Externalizing Problem Behaviors

The second hierarchical regression analyzed how the interaction between cognitive composite scores and early intervention programs moderates the relationship between cognitive composite scores and externalizing problem behaviors (see Table 5). The first step included the following variables: cognitive, marital status, BPD, PDA, ROP, and EIP. These variables accounted for a statistically significant amount of variance in externalizing problem behaviors, $R^2 = .08$, $F(6, 298) = 4.49$, $p < .001$. Upon examining the individual variables, it was determined that cognitive ($b = 1.55$, $p < .05$, $\beta = .15$), marital status ($b = -.13$, $p < .05$, $\beta = -.13$), and PDA ($b = -3.63$, $p < .01$, $\beta = -0.17$) were statistically significant on the first step. This

indicates that as cognitive composite scores increased by 1 *SD*, externalizing problem behaviors increased by .15 *SD*. Also, as marital status increased by 1 *SD*, externalizing problem behaviors decreased by .13 *SD*. Finally, as PDA increased by 1 *SD*, externalizing problem behaviors decreased by .17 *SD*.

The second step included the interaction term between cognitive and EIP being added to the regression model, which did not account for a statistically significant amount of variance in externalizing problem behaviors, $\Delta R^2 = .01$, $F(1, 297) = 1.55$, $b = .74$, $p = .22$. However, EIP was not a statistically significant moderator in the model, but both cognitive ($b = 1.49$, $p < .05$, $\beta = .14$) and PDA ($b = -3.56$, $p < .05$, $\beta = -.17$) were statistically significantly associated with externalizing problem behaviors. This indicates that as cognitive composite scores increased by 1 *SD*, externalizing problem behaviors increased by .14 *SD*. Also, as marital status increased by 1 *SD*, externalizing problem behaviors decreased by .17 *SD*. Figure 2 shows the non-statistically significant moderating effects of EIP for externalizing problem behaviors.

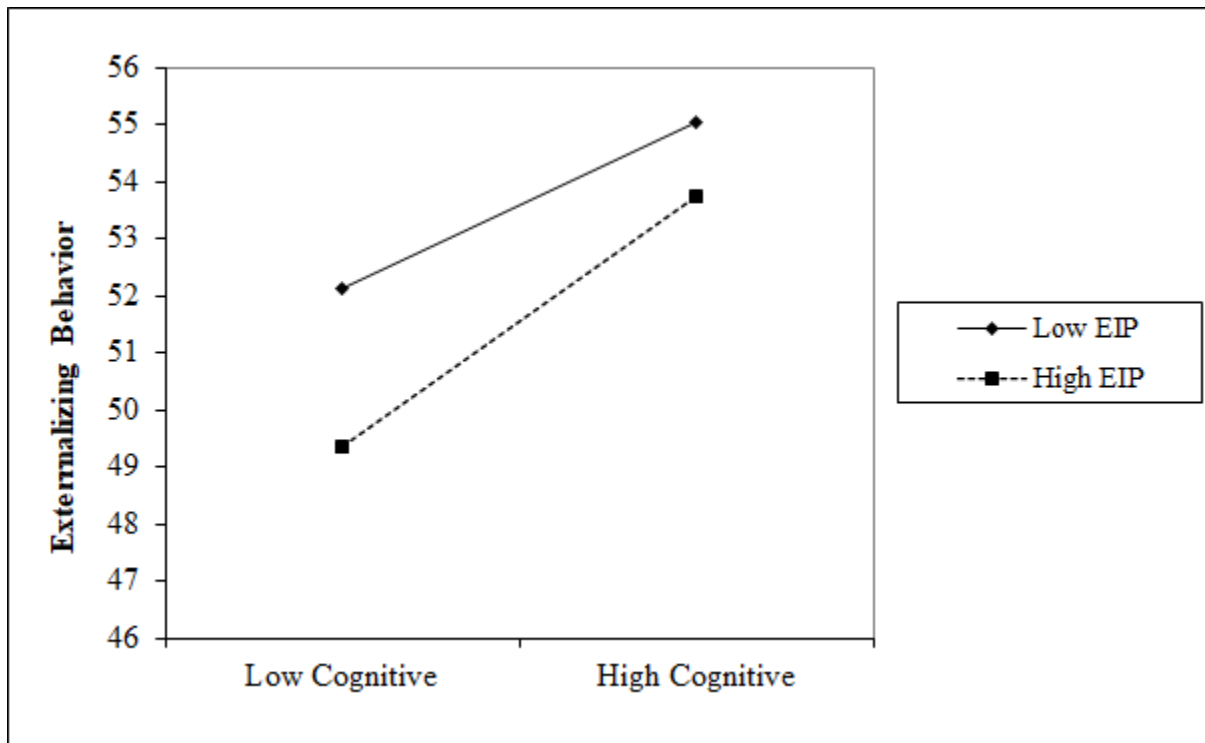
Table 5*Moderation Hierarchical Regression Model: Cognitive and Externalizing Problem Behaviors*

Variable	Externalizing problem behavior			
	R^2	b	SE	β
Step 1	.08***			
Cognitive		1.55	0.60	0.15*
Marital Status		-2.79	1.18	-0.13*
BPD		1.03	1.46	0.04
PDA		-3.63	1.25	-0.17**
ROP		0.36	1.34	0.02
EIP		-2.08	1.20	-0.10
Step 2	.09			
Cognitive		1.49	0.60	0.14*
Marital Status		-2.92	1.19	-0.14
BPD		0.94	1.46	0.04
PDA		-3.56	1.25	-0.17*
ROP		0.28	1.34	0.01
EIP		-2.04	1.20	-0.10
Cognitive X EIP		0.74	0.59	0.07

* $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 2

EIP Moderation Effects on Cognitive and Externalizing Behavior



Note. Low EIP = did not receive EIP; High EIP = received or receiving EIP

Moderation Effects of Speech Therapy

Communication Composite Scores and Internalizing Problem Behaviors

The third hierarchical regression analyzed how speech therapy moderates the relationship between communication composite scores and internalizing problem behaviors (see Table 6).

The first step included the following variables: communication, marital status, BPD, PDA, ROP, and ST. These variables accounted for a statistically significant amount of variance in internalizing problem behaviors, $R^2 = .07$, $F(6, 298) = 3.74$, $p < .01$. Upon examining the individual variables, it was determined that ST ($b = 3.27$, $p < .05$, $\beta = .16$) was statistically

significant. This indicated that as ST increased by 1 *SD* internalizing problem behaviors increased by .16 *SD*.

The second step included the interaction term between communication and ST being added to the regression model, which did not account for a statistically significant amount of variance in internalizing problem behaviors, $\Delta R^2 = .00$, $F(1, 297) = .73$, $b = .51$, $p = .39$, but both marital status ($b = -2.37$, $p < .05$, $\beta = -.12$) and ST ($b = 3.27$, $p < .05$, $\beta = .16$) were statistically significantly associated with internalizing problem behaviors. This indicated that as marital status increased by 1 *SD* internalizing problem behaviors decreased by .12 *SD*. Also, as ST increased by 1 *SD*, externalizing problem behaviors increased by .16 *SD*. Ultimately, ST was not a statistically significant moderator in the model. Figure 3 shows the non-statistically significant moderating effects of ST on internalizing problem behaviors.

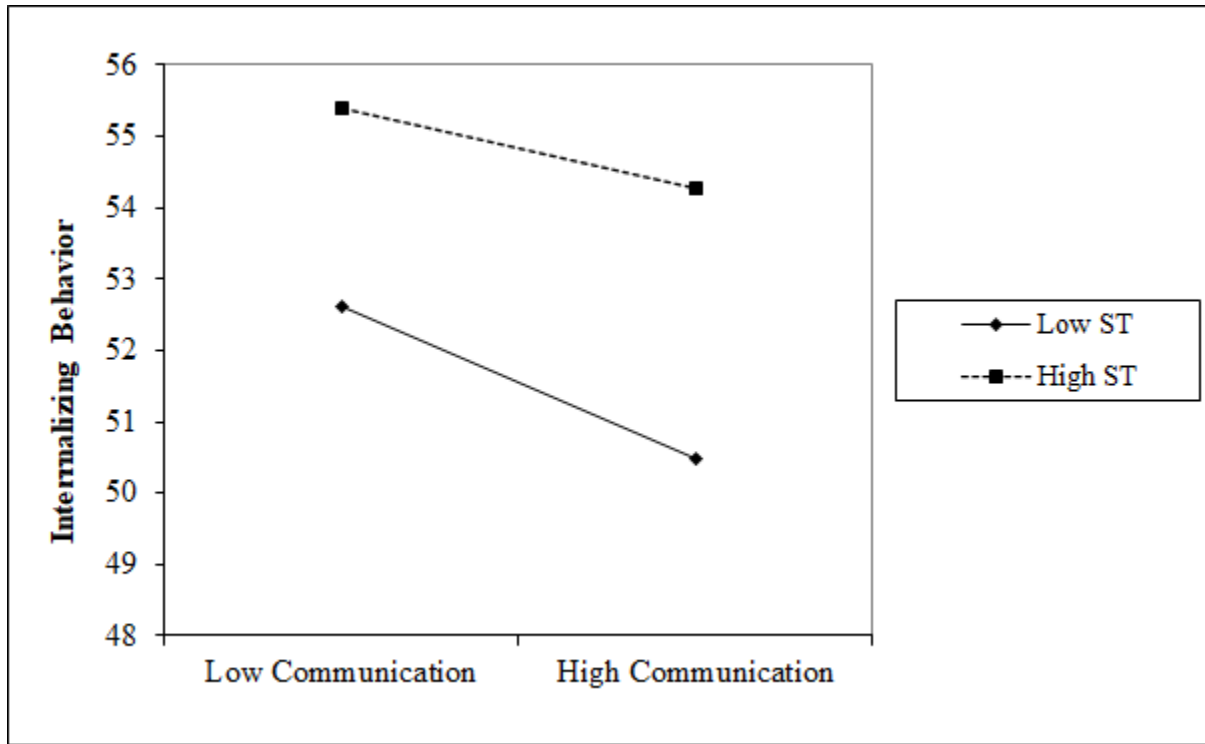
Table 6*Moderation Hierarchical Regression Model: Communication and Internalizing Problem**Behaviors*

Variable	Internalizing problem behavior			
	R^2	b	SE	β
Step 1	.07**			
Communication		-1.03	0.59	-0.10
Marital Status		-2.29	1.15	-0.11
BPD		-1.17	1.41	-0.05
PDA		-2.19	1.21	-0.11
ROP		-0.26	1.32	-0.01
ST		3.27	1.17	0.16*
Step 2	.07			
Communication		-1.08	0.59	-0.10
Marital Status		-2.37	1.16	-0.12*
BPD		-1.27	1.42	-0.05
PDA		-2.05	1.22	-0.10
ROP		-0.30	1.32	-0.01
ST		3.27	1.17	0.16*
Communication X ST		0.51	0.59	0.05

* $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 3

ST Moderation Effects on Communication and Internalizing Behavior



Note. Low ST = did not receive ST; High ST = received or receiving ST

Communication Composite Scores and Externalizing Problem Behaviors

The fourth hierarchical regression analyzed how speech therapy moderates the relationship between communication composite scores and externalizing problem behaviors (see Table 7). The first step included the following variables: communication, marital status, BPD, PDA, ROP, and ST. These variables accounted for a statistically significant amount of variance in externalizing problem behaviors, $R^2 = .06$, $F(6, 298) = 2.97$, $p < .01$. Upon examining the individual variables, it was determined that marital status ($b = -2.82$, $p < .05$, $\beta = -.13$) and PDA ($b = -3.59$, $p < .05$, $\beta = -.17$) were statistically significant. This indicated that as marital status

increased by 1 *SD*, externalizing problem behaviors decreased by .13 *SD*. Also, as PDA increased by 1 *SD*, externalizing problem behaviors decreased by .17 *SD*.

The second step included the interaction term between communication and ST being added to the regression model, which did not account for a significant amount of variance in externalizing problem behaviors, $\Delta R^2 = .01$, $F(1, 297) = 1.74$, $b = .81$, $p = .19$, but both marital status ($b = -2.94$, $p < .05$, $\beta = -.14$) and PDA ($b = -3.37$, $p < .05$, $\beta = -.16$) were significantly associated with externalizing problem behaviors. This indicated that as marital status increased by 1 *SD* externalizing problem behaviors decreased by .14 *SD*. Also, as PDA increased by 1 *SD*, externalizing problem behaviors decreased by .16 *SD*. Ultimately, ST was not a significant moderator in the model. Figure 4 shows the non-significant moderating effects of ST for externalizing problem behaviors.

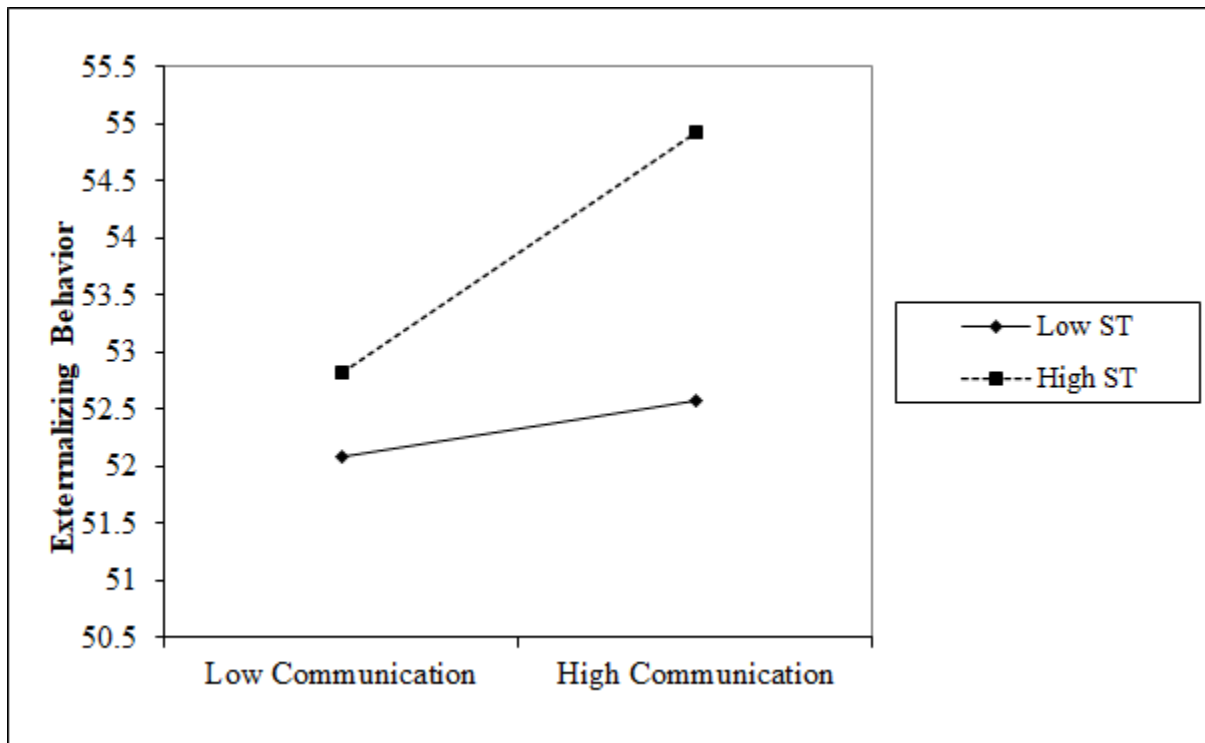
Table 7*Moderation Hierarchical Regression Model: Communication and Externalizing Problem**Behaviors*

Variable	Externalizing problem behavior			
	R^2	b	SE	β
Step 1	.06**			
Communication		0.30	0.61	0.03
Marital Status		-2.82	1.20	-0.13*
BPD		0.23	1.47	0.01
PDA		-3.59	1.26	-0.17*
ROP		-0.19	1.37	-0.01
ST		1.54	1.22	0.07
Step 2	.06			
Communication		0.23	0.61	0.02
Marital Status		-2.94	1.20	-0.14*
BPD		0.08	1.48	0.00
PDA		-3.37	1.27	-0.16*
ROP		-0.26	1.37	-0.01
ST		1.55	1.22	0.07
Communication X ST		0.81	0.62	0.08

* $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 4

ST Moderation Effects on Communication and Externalizing Behavior



Note. Low ST = did not receive ST; High ST = received or receiving ST

Moderation Effects of Occupational /Physical Therapy

Motor Composite Scores and Internalizing Problem Behaviors

The fifth hierarchical regression analyzed how occupational/physical therapy moderates the relationship between motor composite scores and internalizing behavior problems (see Table 8). The first step included the following variables: motor, marital status, BPD, PDA, ROP, and OT/PT. These variables accounted for a significant amount of variance in internalizing behavior problems, $R^2 = .06$, $F(6, 298) = 3.31$, $p < .01$. Upon examining the individual variables, it was determined that marital status ($b = -2.35$, $p < .05$, $\beta = -.11$), PDA ($b = -2.51$, $p < .05$, $\beta = -.12$), and OT/PT ($b = 3.73$, $p < .05$, $\beta = .18$) were statistically significant. This indicated that as marital

status increased by 1 *SD*, internalizing problem behaviors decreased by .11 *SD*. Also, as PDA increased by 1 *SD*, internalizing problem behaviors decreased by .12 *SD*. Finally, as PDA increased by 1 *SD*, internalizing problem behaviors increased by .18 *SD*.

The second step included the interaction term between motor and OT/PT is added to the regression model, which did not account for a significant amount of variance in internalizing behavior problems, $\Delta R^2 = .00$, $F(1, 297) = 1.74$, $b = .52$, $p = .47$, but both marital status ($b = -2.37$, $p < .05$, $\beta = -.12$) and OT/PT ($b = 3.53$, $p < .05$, $\beta = .17$) were significantly associated with internalizing problem behaviors. This indicated that as marital status increased by 1 *SD* internalizing problem behaviors decreased by .12 *SD*. Also, as OT/PT increased by 1 *SD*, internalizing problem behaviors increased by .17 *SD*. Ultimately, OT/PT was not a significant moderator in the model. Figure 5 shows the non-significant moderating effects of OT/PT for internalizing problem behaviors.

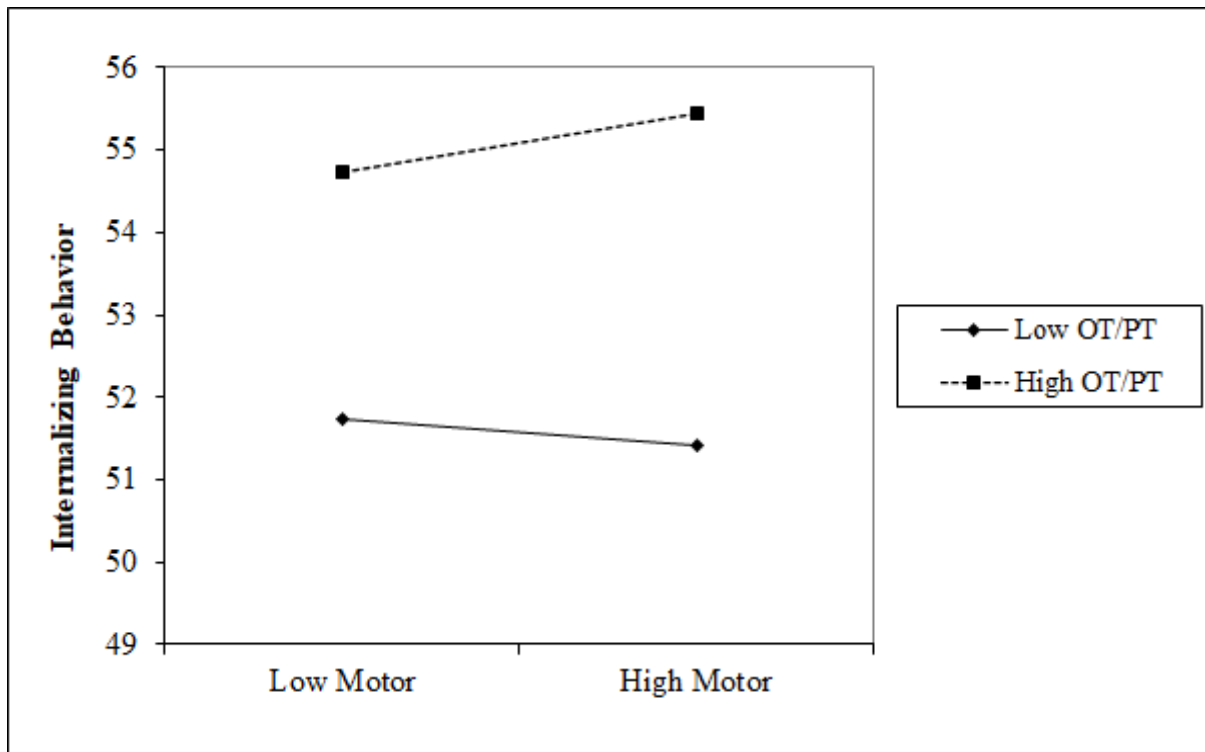
Table 8*Moderation Hierarchical Regression Model: Motor and Internalizing Problem Behaviors*

Variable	Internalizing problem behavior			
	R^2	b	SE	β
Step 1	.06**			
Motor		0.01	0.61	0.00
Marital Status		-2.35	1.16	-0.11*
BPD		-1.30	1.44	-0.05
PDA		-2.51	1.21	-0.12*
ROP		-0.03	1.32	0.00
OT/PT		3.73	1.23	0.18*
Step 2	.06			
Motor		-0.20	0.67	-0.02
Marital Status		-2.37	1.16	-0.12*
BPD		-1.33	1.44	-0.06
PDA		-2.43	1.22	-0.12
ROP		-0.12	1.33	-0.01
OT/PT		3.53	1.26	0.17*
Motor X OT/PT		0.52	0.71	0.05

* $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 5

OT/PT Moderation Effects on Motor and Internalizing Behavior



Note. Low OT/PT = did not receive OT/PT; High OT/PT = received or receiving OT/PT

Motor Composite Scores and Externalizing Problem Behaviors

The sixth hierarchical regression analyzed how occupational/physical therapy moderates the relationship between motor composite scores and externalizing behavior problems (see Table 9). The first step included the following variables: motor, marital status, BPD, PDA, ROP, and OT/PT. These variables accounted for a significant amount of variance in externalizing behavior problems, $R^2 = .08$, $F(6, 298) = 4.11$, $p < .001$. Upon examining the individual variables, it was determined that motor ($b = 1.78$, $p < .01$, $\beta = .17$), marital status ($b = -2.71$, $p < .05$, $\beta = -.13$), and PDA ($b = -3.71$, $p < .01$, $\beta = -.17$) were statistically significant. This indicated that as motor increased by 1 *SD*, externalizing problem behaviors increased by .17 *SD*. Also, as marital status

increased by 1 *SD*, externalizing problem behaviors decreased by .13 *SD*. Finally, as PDA increased by 1 *SD*, externalizing problem behaviors decreased by .17 *SD*.

The second step included the interaction term between motor and OT/PT being added to the regression model, which accounted for a significant amount of variance in externalizing behavior problems, $\Delta R^2 = .02$, $F(1, 297) = 1.74$, $b = 1.58$, $p < .05$, and both marital status ($b = -2.80$, $p < .05$, $\beta = -.13$) and PDA ($b = -3.47$, $p < .05$, $\beta = -.16$) were significantly associated with externalizing problem behaviors. The interaction between motor and OT/PT ($b = 1.58$, $p < .05$, $\beta = .14$) were also significantly associated with externalizing problem behavior. This indicated that as marital status increased by 1 *SD* externalizing problem behaviors decreased by .13 *SD*. Also, as PDA increased by 1 *SD*, externalizing problem behaviors decreased by .16 *SD*. As the interaction between motor and OT/PT increased by 1 *SD*, externalizing problem behaviors increased by .14 *SD*. Ultimately, OT/PT was a significant moderator in the model. Figure 6 shows the significant moderating effects of OT/PT for externalizing problem behaviors.

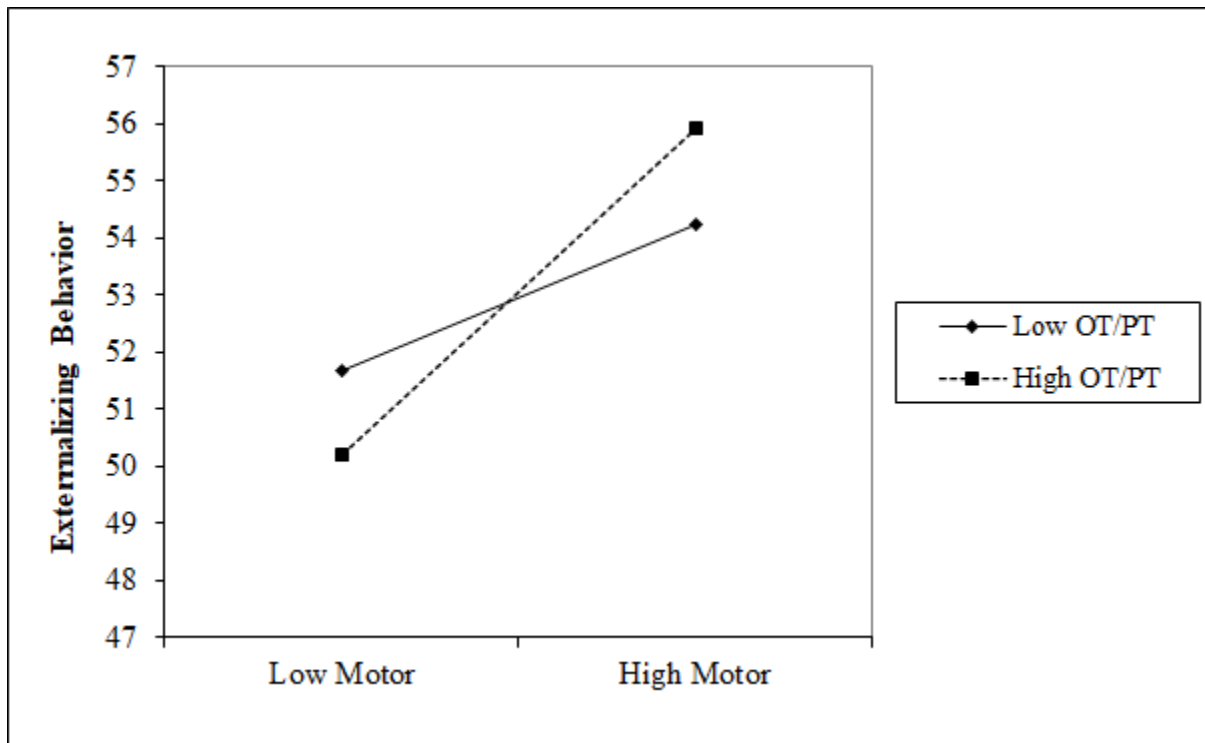
Table 9*Moderation Hierarchical Regression Model: Motor and Externalizing Problem Behaviors*

Variable	Externalizing problem behavior			
	R^2	b	SE	β
Step 1	.08***			
Motor		1.78	0.62	0.17**
Marital Status		-2.71	1.19	-0.13*
BPD		0.98	1.48	0.04
PDA		-3.71	1.25	-0.17**
ROP		0.31	1.35	0.01
OT/PT		0.71	1.26	0.03
Step 2	.09*			
Motor		1.14	0.69	0.11
Marital Status		-2.80	1.18	-0.13*
BPD		0.89	1.47	0.04
PDA		-3.47	1.24	-0.16*
ROP		0.03	1.35	0.00
OT/PT		0.09	1.28	0.00
Motor X OT/PT		1.58	0.72	0.14*

* $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 6

OT/PT Moderation Effects on Motor and Externalizing Behavior



Note. Low OT/PT = did not receive OT/PT; High OT/PT = received or receiving OT/PT

Summary

A preliminary analysis was performed to ensure that all assumptions of hierarchical multiple regression analysis were met. The current study included 314 participants who met the inclusion criteria. The missing data was completely random based on Little's MCAR test, and it was determined to be adequate based on a power analysis using G*Power 3.1 (Faul et al., 2009).

Six hierarchical regression analyses were utilized to examine the moderating effects of special child services (EIP, ST, and OT/PT) on the association between neurodevelopmental skills (cognitive, communication, and motor) and behaviors (internalizing and externalizing behaviors) in extremely preterm children. The method described by Cohen et al. (2013) was

employed to generate the six hierarchical regression models. The first step of each regression analysis included the outcome, predictor variable, moderator, and control variables while the second step included the interaction term between the predictor variable and the moderator. If the interaction term was found to be statistically significant, the presence of moderation was indicated.

The first and second hierarchical regressions examined the moderating effects of EIP on cognitive skills and behaviors, internalizing and externalizing problems. The interaction terms did not show significant effects, although other factors like marital status and PDA were found to be statistically significantly associated with externalizing problem behaviors. The third hierarchical regression analyzed the moderating effects of ST on communication skills and behaviors, internalizing and externalizing problems. While there was a statistically significant association between speech therapy and internalizing problem behaviors, the interaction term did not explain a statistically significant amount of variance. Similarly, for externalizing problem behaviors, marital status, and PDA were found to be statistically significantly associated, although speech therapy had no significant moderating impact.

The fifth and sixth hierarchical regressions examined the moderating effects of EIP on cognitive skills and behaviors, internalizing and externalizing problems. While OT/PT did not statistically significantly moderate the association between motor skills and internalizing behaviors, marital status and OT/PT were statistically significantly associated with internalizing problems. In the sixth hierarchical regression, OT/PT was found to have a statistically significant moderating effect on the relationship between motor skills and externalizing problem behaviors, along with marital status and PDA having a statistically significant association with externalizing problems.

CHAPTER V

DISCUSSION

The current retrospective study examined the moderating effects of special child services such as EIPs and therapies on the association between neurodevelopmental skills and behaviors while controlling for sociodemographic status and medical history in extremely preterm children through Sameroff's transactional model of development. Six multiple hierarchical regression analyses were utilized to examine these relationships using a subset of NRN data collected from both the GDB and follow-up databases from a site based in Dallas, Texas. The first research question assessed whether EIPs moderated the association between cognitive skills and behavior categorized as internalizing and externalizing problems. The second research question assessed the moderating role of ST on the association between communication skills and behavior categorized as internalizing and externalizing problems. The third research question assessed the moderating role of OT/PT on the association between motor skills and behavior categorized as internalizing and externalizing problems.

Moderation Effects of Early Intervention Programs

Firstly, the current study sought to investigate the moderating effects of EIPs on the association between cognitive skills and behavior problems. In hierarchical regression analysis, EIPs were not found to be a statistically significant moderator in the association between cognitive skills and behavior problems. With regard to the relationship between cognitive skills and problem behaviors, the current study did not find a statistically significant association with internalizing problem behaviors but did find an association with externalizing behaviors. This is in contrast to past research, which suggested that lower cognitive skills were statistically significantly associated with internalizing problem behaviors when considering

sociodemographic and medical factors (Cheng et al., 2014; Lowe et al., 2019). With regard to other factors associated with internalizing behaviors, the current study found that marital status and PDA contributed regardless of cognitive skills.

These findings indicated that although EIPs did not enhance or diminish the relationship between cognitive skills and behavior problems, higher cognitive skills were associated with higher externalizing problems in extremely preterm children. This was also contrary to past research findings regarding the association of cognitive skills and problem behaviors. Past findings suggested that cognition and behavior had a negative association in preterm children, meaning lower cognitive skills were associated with higher behavior difficulties (Rogers & Hintz, 2016; Vohr, 2014; Woythaler, 2019). In addition, Nordhov et al. (2012) found that parents who received an early intervention program called MITP reported lower perceived difficulties and fewer behavior problems at 5 years, indicating improved behavioral outcomes for preterm infants in the intervention group compared to the control group.

Despite the statistically non-significant results for the moderating role of EIPs, the effectiveness of EIPs should not be dismissed. Factors such as intensity, duration, and the age at which intervention was started may affect the effectiveness of such programs. EIPs also varied depending on the geographical location of the preterm child. In fact, specific service qualifications for EIPs may vary by state. For example, according to Texas Health and Human Services (n.d.b), a child could qualify for early intervention if a developmental delay were greater than 25% in one or more areas of development. However, if the delay was only in the area of communication, the threshold was 33%. Future research should replicate the current study with a more diverse sample to account for the difference in EIPs among states. This would

provide a more thorough understanding of the effectiveness of EIPs and the factors that may impact their success.

Moderation Effects of Speech Therapy

Secondly, the current study sought to investigate the moderating effects of ST on the association between communication skills and problem behaviors. In hierarchical regression analysis, ST was not found to be a statistically significant moderator in the association between communication skills and problem behaviors. Regarding the relationship between communication skills and problem behaviors, the current study did not find a statistically significant association with internalizing and externalizing problem behaviors. This is also in contrast to past research, which suggested that lower communication skills are statistically significantly associated with internalizing problem behaviors when considering sociodemographic and medical factors (Lowe et al., 2019; Petersen et al., 2013). The current findings indicated that ST did not enhance or reduce the relationship between communication skills and behavior problems. With regards to other factors associated with problem behaviors, ST and PDA influenced internalizing problem behaviors regardless of communication skills. Also, when investigating externalizing problem behaviors, marital status, and PDA appeared to be influencing factors regardless of communication skills.

Since ST showed a positive association with internalizing behavior, ST should be regarded as an important factor in influencing internalizing problem behaviors. One possible explanation for this positive association is that acquiring and improving communication skills may be challenging for extremely preterm children as they may experience greater delays in communication (Adams-Chapman et al., 2015). Thus, as preterm children take part in speech therapy, their increased ability to communicate emotions may result in a more visible expression

of internalizing behaviors such as somatic complaints, withdrawal, and anxiety. Perhaps, further research should examine the processes that may lead to an increase in internalizing problem behaviors in extremely preterm children. By knowing these processes, therapists may be adjusted to reduce any potentially harmful effects on overall internalizing difficulties.

Moderation Effects of Occupational and/or Physical Therapy

Lastly, the current study sought to investigate the moderating effects of OT/PT in the association between motor skills and problem behaviors. In hierarchical regression analysis, OT/PT was found to be a statistically significant moderator in the association between cognitive skills and externalizing behavior problems. Figure 6 illustrates the increased steepness of the slope for participants receiving OT/PT, indicating that receiving OT/PT strengthens the positive relationship between motor composite scores and externalizing behavior problems. Therefore, extremely preterm children receiving OT/PT displayed a higher rate of increase in externalizing behavior as their motor skills improved, highlighting the impact of OT/PT on behavior outcomes. This is in contrast to past research, which suggested that lower motor skills are statistically significantly associated with internalizing problem behaviors when considering sociodemographic and medical factors (Lowe et al., 2019).

With regards to the relationship between motor skills and problem behaviors, the current study found that OT/PT has a statistically significant positive relationship with internalizing behavior regardless of sociodemographic and medical factors, but this was not the case for externalizing behaviors. The current findings revealed that regardless of motor skills, receiving OT/PT is associated with an increase in internalizing behavior. Furthermore, marital status showed a statistically significant association with internalizing behaviors, indicating that being married decreased the likelihood of such behaviors. Moreover, receiving OT/PT amplified the

link between motor skills and externalizing behaviors. Marital status and PDA also exhibited a statistically significant negative relationship with externalizing behaviors, suggesting that being married and having a diagnosis of PDA reduced the likelihood of externalizing behaviors.

A possible explanation for the positive moderating role of OT/PT in the association between motor skills and externalizing behavior is that children with motor delays may have a higher likelihood of displaying externalizing behaviors such as attention problems and aggression. Conversely, as extremely preterm children improve their motor skills, they become more mobile and are better able to express their frustrations externally. It may be worthwhile for future research to investigate the underlying processes that contribute to the increase in externalizing behavior when extremely preterm children receive OT/PT. By understanding these processes, therapies can be adjusted to effectively mitigate any potential adverse effects on overall externalizing problem behaviors.

Strengths and Limitations

The current study's strengths allowed the researcher to make significant contributions to existing research and literature by focusing on the moderating role of special child services in the association of neurodevelopment and behavior in extremely preterm children. First, the study utilized data from the NRN, a nationally recognized research organization known for its rigorous methodologies and multi-center study designs. NRN studies typically involve collecting data from large sample sizes, enabling the researcher of the current study to include 314 participants, despite only involving a single NRN site. This large sample size increased the statistical power and generalizability of the study findings, as it represented a considerable number of individuals within the neonatal population.

Due to its greater statistical power, the study had an increased likelihood of finding statistically significant associations between variables, resulting in more substantial and reliable findings. Furthermore, the study's large sample size strengthened the findings' generalizability. Although constrained to a single NRN site, the findings from this sample are nevertheless pertinent to the extremely preterm population, particularly in the Dallas, Texas area. The study's external validity is strengthened by utilizing a large sample of extremely preterm children, allowing for more robust results and larger implications in medical care and policy development.

Second, the established protocols and necessary certification for study methods ensured further validity and reliability of the study's data (NICHD & NRN, 2019b). Their implementation safeguarded that NRN examiners adhered to a consistent set of norms and processes, reducing variance and strengthening uniformity. Moreover, NRN examiners were required to submit yearly research certifications to maintain their knowledge and abilities, which reduced variability in study methods (NICHD & NRN, 2019b). By continually improving their skills, NRN examiners had the capacity to maintain a high level of competence and precision in their data collection processes.

Third, the study included procedures that were not considered standard of care, such as the administration of BSID-III, CBCL/1.5-5, and specific neurological examinations. These assessments provided in-depth information on participants' neurological function, as well as their behavioral and emotional development. This information was often used to provide a diagnosis, guidance, and make appropriate referrals to necessary services.

The BSID-III and CBCL/1.5-5 are both extensively used assessment tools for examining children's neurodevelopment and problem behaviors. These evaluations have been useful in providing physicians and researchers with a better knowledge of the developmental progress of

extremely preterm children. They allow for the identification of possible neurodevelopmental abnormalities that may necessitate additional intervention. Furthermore, these evaluation instruments enable the examination of problematic behaviors displayed by extremely preterm children, revealing insight into their general behavioral well-being. The use of these instruments leads to an in-depth assessment of the neurodevelopmental outcomes of extremely preterm children and provides significant information for targeted interventions and support.

While the current study had its strengths, it also had some limitations. The retrospective data obtained from the NRN did not include information about the frequency and timing or the specific nature and extent of the therapies that the participants received. Additionally, the data did not consider the participant's involvement in a NICU or neurobehavioral follow-up program, which is known to provide timely referrals to therapeutic services such as EIPs, ST, OT, and PT. Therefore, it is possible that some participants received therapy for a longer period of time than others or that some participants did not attend as many NICU follow-up or neuro/behavioral clinic visits as others. Additionally, the generalizability of the results may be limited due to variations in follow-up care received by EPTs, as not all of them receive care in a NICU program or primary care clinic specializing in comprehensive care.

Another potential limitation is that the behavior of the children was evaluated based on information gathered from parent interviews, which may be subject to biases such as underreporting or overreporting of the child's behavior. The information collected on the use of special child services was also based on parent reports, which may be limited by the parents' comprehension of the specific services their child may be receiving. Furthermore, as the interview was conducted near the end of the visit, participant fatigue may also be a concern. The developmental assessment only provided a snapshot of the child's performance on the day of the

assessment. Any changes in routine, hunger during the assessment, or inadequate sleep before the assessment could potentially impact the assessment's results.

Lastly, 50% of the BSID-III assessment were conducted in Spanish. While the BSID-III assessments were conducted in Spanish by a certified NRN administrator, it is important to note that the BSID-III assessment was not specifically standardized for the Spanish-speaking population in Latin American countries. Further research is necessary to prove the validity and reliability of developmental assessments suited to Spanish-speaking children to ensure accuracy and inclusivity.

Implications and Future Research

Investigating the role of special child services in the neurodevelopment and behavior of extremely preterm children has important implications for clinical practices. The current study sought to provide further understanding of how special child services, such as early intervention programs and therapies could potentially improve the neurodevelopmental and behavioral skills of extremely preterm children. Therefore, it is possible to adjust specialized care services to meet the distinctive needs of extremely preterm children. Moreover, this study may serve as a foundation for evidence-based interventions that may become standard practices across various therapies and clinics, thus improving the neurodevelopmental and behavioral outcomes of preterm children.

The study implied that speech therapy did not statistically moderate the association between communication skills and problem behavior. However, it found that speech therapy was statistically significantly associated with internalizing behaviors regardless of the communication skills of extremely preterm children. Additionally, OT/PT statistically significantly moderated the association between motor skills and externalizing behavior. These results further highlighted

the need for targeted and individualized interventions. The study suggested that a "one-size-fits-all" approach may not be effective due to the heterogeneity of the neurodevelopmental and behavioral outcomes of extremely preterm children. Addressing the variations in the impact of intervention services on behavioral outcomes allows healthcare practitioners, therapists, and educators to design a customized treatment plan. This tailored approach has the potential to enhance the positive effects of therapy, promote developmental trajectories, and improve the behaviors of extremely preterm children.

The current findings suggest that EIPs did not statistically significantly moderate the association between cognitive skills and problem behaviors of extremely preterm children. There are various reasons why EIPs did not appear to strengthen or weaken the relationship between neurodevelopment and problems. First, contextual factors such as parental involvement, home environment, as well as access to the intervention service may have played a role. Parents of extremely preterm children face greater stress and responsibilities, which can affect their ability to provide involvement and a supportive home environment. As these services may vary by geographical location, financial resources, and healthcare support, inadequate access to these services may limit the moderation of the association between cognitive skills and behavior in extremely preterm children.

Second, the variability in implementation of the programs may vary from one intervention program to another. Extremely preterm children often require specialized interventions to address their cognitive and behavioral needs. Typically, the purpose of EIPs is to improve developmental outcomes only and may not be designed to specifically target the behaviors of children with developmental delays. Furthermore, factors such as training, funding, and availability may lead to inconsistencies in the timing and intensity of services available for

children. These differences can contribute to variations in the effectiveness of the programs across various settings and providers.

Third, although the current study focused on extremely preterm children, the neurodevelopmental and behavioral outcomes may still vary due to the complex nature of extreme prematurity. While some extremely preterm children may only need a small amount of intervention, some may need more intensive interventions. The complex interplay between neurodevelopmental and behavioral outcomes contributes to the effectiveness of early intervention programs. Due to the higher risk of developing health problems, developmental delays, and behavioral issues, preterm children need active monitoring of their overall health. Thus, early identification and intervention for neurodevelopmental and behavioral issues are crucial in the first few years of a preterm child's life (Fefferman et al., 2017).

With the support of NICU and neurobehavioral follow-up clinics, healthcare providers may identify neurodevelopmental and behavioral issues in advance and provide recommendations for intervention in a timely manner. Routine developmental evaluations conducted by follow-up clinics, along with targeted interventions provided by early intervention programs and therapy agencies that are tailored to meet the individual needs of each preterm child, are useful for optimizing their developmental outcomes (Andrews et al., 2014). Consequently, clinicians may offer recommendations and provide suitable assistance to families to improve the behavioral outcomes of preterm children.

Support from the NICU and neurobehavioral follow-up clinics is important in the coordination of care for preterm infants (Bockli et al., 2014). Since healthcare providers are usually involved in assisting families with identifying the proper care for preterm children, identifying the barriers to successful parent-provider relationships is vital. It is essential for

researchers to determine how to encourage successful caregiver-provider relationships and build rapport with other healthcare providers and the primary caregivers of the preterm child. Typically, these providers are also the sources of referrals for therapies such as infant stimulation, ST, OT, and PT. Thus, excellent communication between the caregiver and providers may improve the neurodevelopmental and behavioral outcomes of preterm children (Adama et al., 2022). A minority of NICU follow-up clinics function as the primary medical provider for preterm children and include evaluation and management of neurodevelopment and behavior issues. Meanwhile, most neurobehavioral follow-up clinics primarily focus on neurodevelopment and behavior. Both types of clinics complement or enhance community-based primary care. By offering continual monitoring, care coordination, and family support, both types of follow-up clinics may aid families in improving the health, developmental, and behavioral outcomes of preterm children.

The timing of special child services should also be investigated for future research. Early intervention takes advantage of brain plasticity and is particularly crucial for extremely preterm children. During early childhood, the brain undergoes a rapid and complex process of growth that involves various stages of development (Gilmore et al., 2018). Understanding the interaction between the critical period and early intervention is crucial for maximizing the efficacy of interventions that promote early childhood development.

The intensity of the intervention is also a key factor in determining the effectiveness of special child services. Factors such as frequency, duration, and consistency of special child services may either ameliorate or exacerbate behavior outcomes (McManus et al., 2019). For extremely preterm children, frequent and consistent monitoring of development and delivery of therapies may decrease developmental delays. However, for some children, a less intensive

intervention may be more appropriate based on their temperament and behavior. It is essential to consider the individual differences of each child and tailor the therapies accordingly. As these interventions are specifically targeted at improving particular skills, it is important for researchers to explore how the timing and intensity of special child services may enhance behavior outcomes.

Lastly, future research should also aim to compare the effectiveness of special child services with other interventions, such as early childhood school programs and behavior therapies. One such program is Early Head Start (EHS), which provides families with comprehensive early childhood development services, prioritizing infants and toddlers who are at risk for developmental delays due to disability, low income, and other factors that may affect development (Love et al., 2013). EHS not only supports the child but also the family through family engagement and support, recognizing the crucial role of family involvement in their child's development. While EHS is renowned for its school readiness goal, it also promotes healthy development by offering health services such as medical, dental, and mental health services. The provision of healthcare services guarantees that infants and toddlers receive the essential medical attention they require.

Applied Behavior Analysis (ABA) is a behavior intervention commonly employed to address behavioral difficulties in children, including those with developmental disorders. While it is well-known for its use in treating autism spectrum disorder (ASD), ABA has been proven to be evidence-based and is also effective in addressing a range of behavioral problems in children (Foxy, 2008). The success of ABA in improving behavior in children with developmental disorders requires multidisciplinary collaboration. This collaboration involves the primary caregivers, therapists, and other individuals involved in the child's care working together to

provide consistent support and guidance to the child. Unfortunately, the cost of ABA may be high, and publicly funded centers offering ABA services may have long waiting lists (Rivard, 2017).

Conclusion

The role of special child services in the neurodevelopment and behavior of extremely preterm children has important clinical implications. This study emphasizes the need for focused therapies, as ST is associated with internalizing behaviors independent of communication abilities, while OT/PT moderates the relationship between motor skills and externalizing behavior. Because of the variability in results, customized therapy plans and frequent monitoring of neurodevelopment and behavior in extremely preterm children are crucial. NICUs and neurobehavioral clinics are also critical in diagnosing and resolving problems. To maximize outcomes for preterm infants, further study should be conducted to investigate the timing, intensity, and comparison of treatments such as early childhood school programs and other behavioral therapies.

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APPENDIX A

TWU IRB



Texas Woman's University
Institutional Review Board (IRB)

irb@twu.edu

<https://www.twu.edu/institutional-review-board-irb/>

April 12, 2023

Kristine Tolentino-Plata
Human Development, Family Studies, and Counseling

Re: IRB Not Required for IRB-FY2023-90 The Role of Special Child Services in Extremely Preterm Children's Neurodevelopment and Behavior

Dear Kristine Tolentino-Plata,

The above referenced project has been received by the TWU IRB - Denton and it has been determined that this project does not require IRB review.

Since all data are de-identified, this study does not need IRB review or approval. Exempt review, category 4 applies to secondary analysis of identifiable information or biospecimens. The dataset you will use is already de-identified, therefore the study does not need IRB review.

If you have any questions or need additional information, please contact the IRB at irb@twu.edu or refer to the [IRB website](#).

Sincerely,

TWU IRB - Denton

APPENDIX B

UTSW IRB



Human Research Protection Program

December 19, 2022

To: Roy Heyne, MD
Professor

From: Erik Soliz, MS, CIP 
IRB Operations Program Manager
Human Research Protection Program Office

RE: Not Human Subjects Research

Project Title: **The Role of Special Child Services in Extremely Preterm Children's Neurodevelopment and Behavior**

The UT Southwestern Human Research Protection Program (HRPP) has reviewed the above referenced project and determined that the use of de-identified data does not meet the definition of human subjects' research under 45 CFR 46.102 and therefore does not require IRB approval or oversight.

If you have any questions related to this communication or the UT Southwestern HRPP, please call 214-648-3060.

APPENDIX C

NEONATAL RESEARCH NETWORK DATA USER AGREEMENT

ZK

Zaterka-Baxter, Kristin <kzaterka@rti.org>
To: Kristine Tolentino-Plata
Cc: Roy Heyne; Archer, Stephanie (NIH/NICHD) [E]; Walsh, Michele (NIH/NICHD) [E]; Das, Abhik; Myra Wyckoff
Retention Policy No Auto Deletion (50 years)

Expires 4/1/2073

EXTERNAL MAIL

Good morning, Kristine,

We acknowledge receipt of your agreement and thus, use of UTSW data as proposed.

I acknowledge that I have read and agree to comply with the NICHD Neonatal Research Network Registry Grantee Site Data Use Agreement.

ID	First Name	Last Name	Center and Site Affiliation (choose all that apply)	Today's Date	I acknowledge that I have read and agree to comply with the Supplemental Agreement with Research Staff for the Use of Data from the NICHD Neonatal Research Network.	
332	I agree	Kristine	Tolentino-Plata	04-1 Dallas: Parkland Memorial Hospital;04-2 Dallas: Children's Medical Center;04-3 Dallas: Clements University Hospital;	4/12/2023	I agree

I acknowledge that I have read and agree to comply with the Supplemental Agreement with Research Staff for the Use of Data from the NICHD Neonatal Research Network.

Thank you,

Kris Zaterka-Baxter, BSN, CCRP
Clinical Study Specialist for the Neonatal Research Network Data Coordinating Center

RTI International | Analytics, Management & Operations
O: 919-485-7750 | C: 919-414-1911 | E: kzaterka@rti.org