The outcomes of cognitive, motor, and behavioral development of low-birth-weight and preterm infants

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2016

Dedication

Dedicated to my fiancé Delano, my parents Carla and Marcus, my brother Marcus, and my Godmother Ty and her family, especially my Godsister Sydney, who was my inspiration for this project.

Acknowledgments

A very special thank you to my advisor, who not only guided me through my project, but also through my entire time in this program: Dr. Patricia Hogue, PhD PA-C

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Introduction

Background

The prevalence of preterm and low-birth-weight births is increasing worldwide due to a number of factors, such as maternal age and the use of assisted-reproductive technologies. Although this number is increasing, mortality is also decreasing due to improved prenatal management. Since the early 1980's, there has been an advancement in the use of neonatal resuscitation, ventilation, and nutrition. The use of glucocorticoids has also become a popular practice in ensuring that preterm babies have developed lungs upon birth (Zabransky, 2013).

Identification of the problem

Even though the numbers of death of preterm and low-birth-weight infants is decreasing, they are still considered high-risk infants (Kara, Gunel, Acikel, Yigit, & Arslan, 2015). There is now concern that although the number of deaths has decreased, the prevalence of morbidities is still increased. Preterm and low-birth-weight-infants have been seen to have a higher risk for neurodevelopmental impairments (Greene, Patra, Nelson, & Silvestri, 2012; Velikos et al., 2015). Heightening the concern, it is unclear why these infants are at a higher risk than normal infants.

Statement of the problem

Infants who are born prematurely have a higher risk of surviving today than are those who were born 10-15 years ago, but there may be risks of these infants developing chronic conditions and handicaps (Zabransky, 2013). It is important for these risks to be identified so that they may be avoided by both mothers and clinicians.

Statement of the purpose

Many studies have been developed to determine if preterm and low-birth-weight infants are in fact more at risk than are full-term infants. Furthermore, there has also been studies developed to determine if there are risk factors that increases the risk of neurodevelopmental problems in high-risk infants. The purpose of this project is to research studies that have been developed to determine if preterm and low-birth-weight infants are indeed at a higher risk of developing neurodevelopmental impairments.

Short Literature Review

Studies have been done to assess how well preterm and low-birth-weight infants are developing in terms of cognitive, behavioral, and motor. It has been found that 54% of preterm and low-birth-weight infants perform as well cognitively as those infants born full-term, whereas only 8.5% of preterm and low-birth-weight infants are cognitively impaired (Ross, Foran, Barbot, Sossin, & Perlman, 2016). Furthermore, those children who were cognitively impaired were more likely to have other comorbidities that resulted from a respiratory illness or brain injury. It was also found that although 54% of preterm and low-birth-weight infants performed as well as full-term infants, they were more likely to have behavior problems such as ADHD than were full-term infants (Ross et al., 2016).

It has also been noted that the greater the gestational age at which preterm and low-birth-weight infants are born, the greater the chance of having little to no impairments. In a study designed to determine neurofunctional outcomes of these infants, the Neurofunctional Scale (NFS) was used in which a score of 0 indicated normal function, 1 indicated mild impairment of function, 2 indicated moderate impairment of function, 3 indicated severe impairment of function, and 4 indicated function as impossible. It was found that at 2 years of age, 92% of

babies born at 25 weeks had NFS<3 and 62% of babies born at 24 weeks had NFS<3. Babies born at 23 weeks, however, all had NFS of 3 or greater (Uccella et al., 2015).

Definitions

- Preterm infants: infants born <37 weeks
- Full-term infants: infants born >37 weeks
- Low-birth-weight: infants born with a birth weight under 2500g
- Extremely low-birth-weight: infants born with a birth weight under 1000g
- Assisted-reproductive technologies: technologies used to increase the chance of reproduction (i.e. IVF)
- IVF: In vitro fertilization. The combination of an egg and sperm in a laboratory dish to create an embryo, which is then transferred into the uterus.
- Prenatal management: care of both infant and mother before the birth
- Neonatal: newborn
- Resuscitation: return of life or consciousness
- Ventilation: the movement of air into and out of the lungs
- Neurodevelopment: development of the brain
- Neurofunctional: relating to the ability of the brain to initiate functions (i.e. thinking, actions) of an individual
- Multiples: twins, triplets, etc.
- Antenatal glucocorticoids: medications used to ensure appropriate lung development of preterm infants.
- Post-conceptual age: weeks of age at birth + weeks of age since birth
- Bronchopulmonary dysplasia (BPD):

- Intraventricular hemorrhage (IVH):
- Corrected age: subtract the number of weeks born before 40 weeks gestation from the chronological age
- Mental Developmental Index (MDI): a standardized measure used in the Bayley Scales of Infant Development used in the follow-up of high risk infants to assess any risks of deficits of mental development.
- Internalizing behaviors: behaviors that affects him or herself rather than others.
- Externalizing behaviors: behaviors exhibited by a person that affects others.
- Autism spectrum disorder (ASD): a group of developmental disabilities that cause significant social, behavior, and communication challenges.
- Gaze aversion: looking away when performing face-to-face interactions. Often related to ASD.
- Endpoint nystagmus: jerky, physiological rapid movement of the eyes when attempts are made to fixate on an area that is outside of the visual field.
- Neurosensory Motor Development Assessment Questionnaire (NSMDA): questionnaire that assesses the motor development of children.
- Gross Motor Functional Classification Scale (GMFCS): a five-level classification scale that assesses the gross motor function of children with cerebral palsy.
- Movement Assessment of Infants (MAI): motor behavior assessment of muscle tone, primitive reflexes, automatic reactions, and volitional movements.
- Alberta Infant Motor Scale (AIMS): assessment of gross motor maturation in prone, supine, sitting, and standing in infants up to 18 months.

- Cerebral palsy: loss or impairment of motor function due to brain damage. Can occur before, during, or immediately after birth.
- Hyoptonia: decreased muscle tone and strength
- Hypertonia: abnormal increase in muscle tension and inability for the muscle to stretch
- Epoch: a particular period of time marked by a specific event.

Search Terms

The search terms that have been used for this research include cognitive, premature infants, development, developmental outcomes, behavioral disorders and motor via PubMed, Ebsco, and Google Scholar.

Research Questions

Are preterm and low-birth-weight infants more susceptible to cognitive, behavioral, and motor developmental problems than are full-term infants? Are there prenatal and neonatal risk factors that contributes to this higher risk?

Scope

The research designs included in this project are those that are retrospective, as some studies focus on old data from the infants' birth and compare it to data collected at least a year later; and prospective, as other studies focus on collected data at birth and the follow up that occurs years later. The population will consist of infants born all over the world as there is not a lot of studies only focused in the United States.

Summary

Although studies have shown an improvement in the mortality of preterm and low-birth-weight infants, their risks for developmental impairment are still high. Many studies have been developed to determine how high their risk of developing impairment in cognition, behavior, and

motor skills. Knowing both the prenatal and postnatal risks that these infants face is beneficial to both the clinician and the parents. This information will allow the clinicians to be able to inform the parents of the risks and what to expect in the development of their infants, and also how to treat them. This information will also allow the parents to receive early interventions if needed. The studies reviewed in this project will hopefully help with the continuing improvement of the mortality rates of preterm and low-birth-weight infants, and will hopefully begin to help both clinicians and parents improve the developmental outcomes of these infants.

Literature Review

Risk Factors of Giving Birth to a High Risk Infant

In order to discuss the risk of preterm and low-birth-weight infants developing neurodevelopmental impairments, it is important to examine what risk factors can mothers have that may contribute to their newborn infant becoming a high risk infant. Many factors have been found to contribute to the risk of mothers giving birth to premature and low-birth-weight infants. These factors include nutrition, substance use, prenatal stress, and medical problems such as high blood pressure, certain types of infections, kidney or lung problems, and problems with the reproductive system ("High-risk infants," 2000; Knight & Smith, 2016).

Nutrition. Low maternal BMI is the primary factor associated with preterm labor in mothers who are underweight. Low maternal BMI can also be a contributing factor in the fetus developing intrauterine growth restriction (IUGR). Alternatively, mothers who are overweight or obese have the risk of developing pre-eclampsia, gestational diabetes, and hypertension. High maternal BMI also carries neonatal risk factors, which include macrosomia, low Apgar score, cerebral palsy, seizures, and stillbirth. It is also important for mothers to ensure that they are receiving an adequate amount of folate and Vitamin D, as deficiency is a risk factor for small for gestational age (SGA) and low birth weight infants (Knight & Smith, 2016).

Substance Use. Smoking during pregnancy can lead to many neonate complications. These include pre-term birth, fetal growth restriction, intraventricular hemorrhage, bronchopulmonary dysplasia, and stillbirth. It can also contribute to decreased academic performance and high blood pressure in later childhood and adolescence. Alcohol use during pregnancy also contributes to preterm birth, as well as spontaneous abortion, fetal alcohol spectrum disorder, and poor childhood disorder (Knight & Smith, 2016).

Prenatal Stress. It has been reported that 70.2% of women experience a stressful life event during pregnancy. Those at the highest risk are under 25, unmarried, African-American, and have an education less than high school. These women are not necessarily at risk of having preterm infants, but have been found to have their infants at lower gestational age than those mothers who have low stressors (Knight & Smith, 2016).

Other Risk Factors. Other risk factors of giving birth to a preterm infant include older maternal age, increased use of assisted reproductive technologies such as in vitro fertilization (IVF) and birth of multiples. These risk factors are due in part to increased effectiveness of prenatal management such as antenatal glucocorticoids, neonatal resuscitation techniques, ventilator strategies, and nutrition. Because of the improvement in prenatal manage, more preterm infants are surviving (Zabransky, 2013).

Bayley-III Scale

Many of the studies discussed in this project use the Bayley-III scale to determine the susceptibility of high-risk infants to neurodevelopmental issues. The Bayley-III is designed to determine if infants and toddlers are developing normally, and if there is any delay in their development (Albers & Grieve, 2007). This test was developed for children aged 1 to 42 months (Michalec, 2011). Professionals use the Bayley-III to assess the child's strengths and weaknesses in specific areas, as well as to monitor their progress during intervention. The Bayley-III measures development on five scales: Cognitive, Language, Motor, Social-Emotional, and Adaptive Behavior scales (Albers & Grieve, 2007).

Cognitive. The Cognitive scale assesses how the infant or toddler thinks and learn within their environment. This scale is designed to test how the child plays, information processing, memory and habituation skills, and reasoning abilities (Michalec, 2011).

Language. The Language scale have two subscales, Receptive and Expressive Communication. Receptive Communication assesses "the child's auditory acuity and ability to understand and respond to verbal stimuli," whereas Expressive Communication assesses the child's "ability to vocalize, name pictures and objects, and communicate with others" (Albers & Grieve, 2007).

Motor. The Motor scale is also divided into two subscales: Fine Motor and Gross Motor. Fine Motor measure the child's ability to perform eye movements, perceptual-motor integration, motor planning, and motor speed, whereas Gross Motor measures the child's ability to move their upper and lower extremities, and torso (Albers & Grieve, 2007).

Social-Emotional and Adaptive Behavior. The Social-Emotional and Adaptive Behavior scales are questionnaires that are completed by the child's primary caregiver. The Social-Emotional scale measures how the child is developing emotionally, and the Adaptive Behavior scale measures how the child is able to adapt in different environments (Albers & Grieve, 2007).

Cognitive Outcomes of Preterm and Low-Birth-Weight Infants

Although preterm and low-birth-weight infants are now more likely to survive, morbidity is increased in terms of cognition. These infants are more likely than full-term infants to have cognitive deficits, as well as language impairments. A retrospective study was performed by G.S. Ross et al. to determine the profiles of low-birth-weight and preterm infants as far as cognitive and language and whether these profiles are associated with demographic, perinatal, and behavior problems. 117 infants were evaluated in their study at 18 months post-conceptual age, in which their average birth weight was 858 ± 174g and average gestational age was 27 ± 2 weeks. This study used cognitive, receptive language, and expressive language scores taken from

the Bayley examination. Overall, children in this study scored average in cognitive and receptive language at 90.8 ± 14 and 90.3 ± 16.9, respectively; and in the low average range in expressive language at 84.5 ± 18.7 (Ross et al., 2016).

The children were further divided into distinct groups. These groups include Consistently High, which is defined by cognitive, receptive language, and expressive language scores above 0.97 SD above the mean; Consistently Average, which is defined by all scores within 1 SD of the mean; Average with Delayed Expressive Language, defined as average cognitive and receptive language scores but expressive language scores 1 SD below the mean; and Consistently Low, defined as cognitive and receptive language scores greater than 2 SD below the mean and expressive language scores at 1.5 SD below the mean. Of the sample studied, 17% of children were Consistently High, 54% were Consistently Average, 21% were Average with Delayed Expressive Language, and 8.5% were Consistently Low (Ross et al., 2016).

Demographic, perinatal, and behavioral variables were used to further assess factors that contributed to the scores of these preterm and low-birth-weight infants. As far as social class. The Consistently High group had the highest percentage in the upper to upper middle class at 50%. The Consistently Average group followed at 30% in the upper to upper middle class, Consistently Low at 20%, and Average with Delayed Expressive Language at 8%. To assess perinatal factors, this study focused on bronchopulmonary dysplasia (BPD) and intraventricular hemorrhage (IVH) to compare the infant's risks. It was found that the Consistently Low group was most likely to have BPD and IVH, in which 70% of the infants had BPD and 33% had IVH. They were followed by the Consistently Average group at 41% and 9% respectively, Average with Delayed Expressive Language group at 38% and 5% respectively, and the Consistently High group at 5% and 0% respectively. In terms of behavior, the Consistently Low group were

found to most likely have behavior problems than the other three groups, whereas the Consistently High group were less likely to have behavior problems (Ross et al., 2016).

Kara et al. developed a study in Italy to determine the differences in cognitive, language, and motor developments in high-risk infants by gestational age and birth weight. Their study included 160 high-risk infants who were born at a gestation age ≤ 32 weeks, and a birth weight ≤ 1500g who were between the corrected ages of one month and 12 months. These infants were further divided into two groups in terms of their gestational age: <30 weeks and 30-32 weeks. They were also divided into two groups in terms of their birth weight: ≤1000g and 1001g-1500g. The Bayley-III scale was used to assess cognitive and language development in these infants. It was found that infants in all groups were within normal limits of the Bayley-III scores and there was no statistical difference in between each group (Kara et al., 2015). Motor development in these infants will be discussed in a later section.

M.M. Greene et al. performed a retrospective study to assess neurodevelopmental performance in preterm infants at 8-12 months of corrected age by using the Bayley-III scale. They included 85 preterm babies born in 2008 who were cared for in a NICU in an academic medical center. Each infant was administered the Bayley-III test. Overall, this study found that the Cognitive Index was the highest score for the majority of preterm infants at 64%, while the Language Index was the lowest score in 53% of infants, indicating issues with language in preterm infants. Bivariate analyses that was performed in this study revealed that infants with severely abnormal head ultrasound, public health insurance, oxygen dependence at discharge and older post-conceptual age at discharge were related to these infants obtaining lower cognitive, language, and motor index scores. Small for gestational age was also related to lower cognitive

and motor index scores, while race/ethnicity was significantly related to language and motor index scores (Greene et al., 2012).

Johnson et al. performed a prospective study involving preterm infants at 2 years corrected age in the East Midlands of the UK. The purpose of their study was to define the neurodevelopmental outcomes for these children and define the risk factors or these outcomes. They examined 1130 infants born between 32-36 weeks, and compared them to 1255 infants born at full-term (37-42 weeks). They found that pre-term infants were significantly more likely have moderate to severe cognitive impairment than were full-term infants. Additionally, they found that boys who were born preterm were significantly more likely to have moderate to severe cognitive impairment than were girls. They also found that preterm infants were at an increased risk of having moderate to severe neurodevelopmental disability than are full-term infants (Johnson et al., 2015).

Woythaler et al. developed a prospective study to examine preterm infants born between 34 weeks, 0 days and 36 weeks, 6 days and how ready they are to begin kindergarten as compared to full-term infants with the hypothesis that these preterm infants are less ready for kindergarten than are full-term infants. They found that preterm infants had a lower mean total school readiness score (164.9/285.8) than did full-term infants (175.2/285.8). The mean scores in all of the subscales involved in the total school readiness score (which included reading, math, and expressive language) were all lower in preterm infants. Additionally, they found that preterm infants with a Mental Developmental Index (MDI) score at <70 or 70-84 at 24 months of age were more likely to achieve a score in the bottom 5% for total school readiness. However, the majority of the infants with MDI score <70 improved between 24 months and kindergarten (Woythaler, McCormick, Mao, & Smith, 2015).

Behavior Outcomes of Preterm and Low-Birth-Weight Infants

Preterm infants have been found to more likely have behavioral issues, which in turn can affect their learning abilities. They have increased rates of both internalizing behaviors, such as anxiety and depression, and externalizing behaviors, such as aggression and attention problems. G.S. Ross et al. was mentioned previously on their findings of cognitive outcomes. They also used a Child Behavior Checklist (CBCL) to assess behavior and psychological problems in preterm infants in their retrospective study. They evaluated the scores for their risks of ADHD, Internalizing behaviors, Externalizing behaviors, and Total Behavior Problems, with a score of 65-69 defined as Borderline and a score >10 defined as Clinical. They found that the majority of preterm infants remained in the normal range (score <65) for all ADHD, internalizing behaviors, externalizing behaviors, and total behavior problems. Only 15% of preterm children were found to have Borderline or Clinical scores on ADHD problems, 6% on Internalizing Problems, 7% on both Externalizing Problems and Total Behavior Problems. They also compared the children in the distinctive groups defined previously when assessing cognitive outcomes of preterm infants. They found that infants in the Consistently Low group had high scores in ADHD problems, Internalizing Problems, Externalizing Problems, and Total Behavior Problems, and these scores were significantly higher than all three of the other groups (Ross et al., 2016).

Woythaler et al. found in their study mentioned earlier regarding preterm infants and their outcomes at kindergarten that preterm infants have an increased risk of having behavioral issues leading to more school suspensions. They also found that preterm infants have more difficulties in controlling their emotions which in turn affects their performance in school. They have an increased risk of attention, behavioral, and school problems than do those infants who were born full-term (Woythaler et al., 2015).

Pineda et al. created a study to determine the risk of autism spectrum disorder (ASD) at two years of age of preterm infants by examining their early social behaviors. Their main finding was the fact that preterm infants who tested positive for ASD were associated with an absence of gaze aversion and an absence of endpoint nystagmus. Gaze aversion has been associated with better language scores on the Bayley-III, and endpoint nystagmus during the visual orientation task has been associated with better langue, cognitive, and motor scores on the Bayley-III. Therefore, preterm infants with ASD where gaze aversion and endpoint nystagmus were absent were more likely to have impaired developmental outcome (Pineda, Melchior, Oberle, Inder, & Rogers, 2015).

Motor Outcomes of Preterm and Low-Birth-Weight Infants

According to the American Academy of Pediatrics, infants who are preterm and considered very low birth weight infants (<1500g) should receive a neuromotor evaluation at least twice in the first two years of life. This is recommended, as while survival of these high-risk infants are increasing, the rate of occurrence of motor disorders has also increased in high-risk infants. It has been reported that gross motor skills, fine motor skills, and mental skills are affected in preterm and very low birth weight infants. As mentioned before, Kara et al. developed a study to examine the differences in cognitive, language, and motor developments in high-risk infants by gestational age and birth weight using the Neurosensory Motor Development Assessment Questionnaire (NSMDA) and Bayley-III scales. However, in this study, it was found that there was no statistically significant difference in cognitive, language, or motor by gestational age or by birth weight (Kara et al., 2015).

Uccella et al. created a retrospective study in Europe that examined the neurodevelopmental outcome of preterm infants born between 23 weeks, 0 days gestation and 25

weeks, 6 days gestation at 2 years of age. They were evaluated with the neurofunctional scale as well at the Griffith's scale. The neurofunctional scale consisted of the follow scores: 0—normal function; 1—mild impairment of function; 2—moderate impairment of function; 3—severe impairment of function; 4—function not possible. The Griffith's scale consisted of six subscales—locomotor, personal-social, hearing-speech, eye-hand coordination, performance and logical scales. These six subscales give the total score called the general quotient (GQ). GQ can be defined as follows: normal ≥88, mild cognitive delay between 76 and 87, and severe cognitive deficit <76. Uccella et al. found that 74% of the infants examined at two years of age had a neurofunctional score of <3. Furthermore, they found that 62% of infants born at 24 weeks had a neurofunctional score of <3 as compared to 92% of infants born at 25 weeks. Griffith's GQ was ≥76 in 56% of infants. Furthermore, 44% of those infants were born at 24 weeks, and 73% were born at 25 weeks. Therefore, the greater the gestational age at birth, the greater the outcome (Uccella et al., 2015).

As mentioned before, M.M. Greene et al. performed a retrospective study to assess neurodevelopmental performance in preterm infants at 8-12 months of corrected age by using the Bayley-III scale. It was found that 22% of preterm infants had mildly delayed Motor Index Scores; 47% had mildly delayed Gross Motor Subscale scores; and 12% had significantly delayed Gross Motor Subscale scores. Furthermore, they found that the Motor Index Score was the lowest score on the Bayley-III scale in 39% of infants (Greene et al., 2012).

Adams-Chapman et al. developed a prospective study in which they hypothesized that preterm infants who have feeding difficulties in early infancy is associated with language delay later in childhood. Of the infants that were found to have dysfunctional feeding, it was found that they had significantly lower scores in cognitive and language on the Bayley-III scale.

Furthermore, they found that infants with a GMFCS≥2 were more likely to have feeding difficulties leading to the language delay. However, they also found that 50% of those reported to have difficulty feeding have no evidence of motor impairment, which suggests that there are other factors that are contributing to the feeding difficulties (Adams-Chapman, Bann, Vaucher, & Stoll, 2013).

Lefebvre et al. created a retrospective study to "correlate the 4-month Movement Assessment of Infants (MAI) and Alberta Infant Motor Scale (AIMS) and the 10- to 12-month AIMS assessments with neurodevelopmental outcomes at 18 months based on the Bayley-III and the diagnosis of neuro-sensory deficits on medical assessment." They found that more than half of infants at four months corrected age had an MAI score ≥14 classifying them as high-risk, or an AIMS score <5th percentile. 16% of infants scored exactly at the 5th percentile on the AIMS. They further found that 2/3 of infants were considered high-risk compared to 1/3 of infants who were considered as low-risk based on both tests. At follow-up at 10-12 months of corrected age, 86% of infants improved during that time between 4 months and 10-12 months. At 18 months corrected age, 47% of infants had an impairment, 14% of those infants had severe impairments. Overall, the study found that preterm infants had better neurodevelopmental outcomes at 18 months if they scored ≤13 on the MAI at 4 months or scored ≥5th percentile on the 4-month or 10- to 12-month AIMS (Lefebvre, Gagnon, Luu, Lupien, & Dorval).

Bernardo et al. performed a study that examined if there were any cognitive and motor functioning changes in infants born at their perinatal center in Cleveland, Ohio with cerebral palsy or severe hypotonia or hypertonia at 20 months. They found that there was no differences in cognitive and motor functioning between birth and 20 months in preterm infants with cerebral

palsy or hypo/hypertonia. Furthermore, they found the gross motor function also has no differences between the two periods in these infants (Bernardo et al., 2015).

Summary

The majority of the studies discussed have shown that morbidity in these infants are increased. They have shown that this increase is due to the risk factors that are associated with mothers giving birth to a preterm or low-birth-weight infant. These studies have shown that preterm and low-birth-weight infants are more likely to have cognitive and motor deficits as well as behavior issues later in childhood than are full-term infants. They are also more likely to have lower scores on developmental assessments such as the Bayley-III scale that was used in a few of the studies. These findings combined with the known risk factors of mothers giving birth to preterm and low-birth-weight infants can help clinicians to further improve the morbidities found in these infants.

Discussion

Summary

Although preterm and low-birth-weight infants are now more likely to survive, morbidity is increased in terms of cognition. These infants are more likely than full-term infants to have cognitive deficits, as well as language impairments. Preterm infants also have been found to more likely have behavioral issues, which in turn can affect their learning abilities. They have increased rates of both internalizing behaviors, such as anxiety and depression, and externalizing behaviors, such as aggression and attention problems (Ross et al., 2016). The rate of occurrence of motor disorders has also increased in high-risk infants. It has been reported that gross motor skills, fine motor skills, and mental skills are affected in preterm and very low birth weight infants. For this reason, the American Academy of Pediatrics recommend that infants who are preterm and considered very low birth weight infants (<1500g) should receive a neuromotor evaluation at least twice in the first two years of life (Kara et al., 2015).

Restate and Answered Questions

The purpose of this project was to research studies that have been developed to determine if preterm and low-birth-weight infants are indeed at a higher risk of developing neurodevelopmental impairments. Are preterm and low-birth-weight infants more susceptible to cognitive, behavioral, and motor developmental problems than are full-term infants? Are there prenatal and neonatal risk factors that contributes to this higher risk? According the studies reviewed above, preterm and low-birth-weight infants are indeed more susceptible to cognitive, behavior, and motor developmental problems than are full-term infants. The risk factors that were found to contribute to this higher risk include nutrition, substance use such as smoking, prenatal stress, medical problems such as high blood pressure, certain types of infections, kidney or lung problems, problems with the reproductive system , older maternal age, increased use of

assisted reproductive technologies such as in vitro fertilization (IVF) and birth of multiples ("High-risk infants," 2000; Knight & Smith, 2016; Zabransky, 2013).

Discussion

The majority of the studies above have indicated that premature and low-birth-weight infants are more susceptible to neurodevelopmental issues. They were found more likely to have moderate to severe cognitive impairment than are full-term infants (Johnson et al., 2015). These infants were also more likely to have behavioral problems such as ADHD and autism (Pineda et al., 2015; Ross et al., 2016). They were found to have high neurofunctional scores and low general quotient scores from the Griffith's scales, indicating motor impairment (Uccella et al., 2015). Some studies, such as the study produced by Greene et al., used the Bayley-III to evaluate neurodevelopmental issues in preterm and low-birth-weight infants in which they found that these infants have lower scores on the Bayley-III than do full term infants, most specifically in language and motor (Greene et al., 2012).

Although preterm infants are more likely to have neurodevelopmental issues, there has been evidence of improvement. Younge et al. discussed a study by the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) Neonatal Research Network in which they "reported that neurodevelopmental outcomes did not improve…in infants born 22-24 weeks' gestation between 1993 and 2004." In response to this study, Younge et al. performed a study where they observed neurodevelopmental outcomes of infants born at 22-24 weeks' gestation in two epochs. Epoch 1 included infants born 1998 to 2004 and Epoch 2 included infants born 2005 to 2011 after the NICHD Neonatal Research Network study was released. They found that mortality and neurodevelopmental issues were decreased in Epoch 2.

This finding was attributed to the increased knowledge and preventative measures taken to ensure the survival of preterm and low-birth-weight infants (Younge et al.).

The fact that the above mentioned study found evidence of improvement in mortality and neurodevelopmental issues of preterm and low-birth-weight infants shows the importance of early intervention. Infants born prematurely and/or with low-birth weights should be evaluated as early as possible to ensure that they are receiving the appropriate intervention. If these infants receive immediate intervention, this will help these children as well as their parents overcome the possible neurodevelopmental issues and allow them to gain social success (Velikos et al., 2015). The use of the Bayley-III scale has also shown to be beneficial, as it determines an infant's eligibility to receive early intervention as well as monitor his or her progress (Greene et al., 2012).

Limitations

The most common limitation amongst the studies discussed above was the sample size. G.S. Ross et al. stated that the results from the small sample sizes may not accurately reflect the total population of pre-term and low-birth-weight infants (Ross et al., 2016). Another common limitation was the lack of follow-up from parents and their infants. Some studies used the reliance of the parents' reports on their infant's progress in development, which could have underestimated the true deficits of the infant (Adams-Chapman et al., 2013; Johnson et al., 2015). Finally, the use of the Bayley-II and the Bayley-III in the same study showed some discrepancy, as the Bayley-III is shown to overestimate cognitive performance as compared to the Bayley-II (Younge et al.).

Implications for Clinical PAs

Now that there is research that indicates increased morbidity in preterm and low-birth-weight infants, physician assistants and other clinicians can use this information in conjunction with parents to make early obstetrical and neonatal care decisions (Younge et al.). There have been several studies that indicates that mothers of pre-term and low-birth-weight infants feel that they have lower parental efficacy and experience more stress due to their lack of knowledge in caring for a high-risk infant. Increasing their knowledge has a positive effect on the development of these infants (Hess, Teti, & Hussey-Gardner, 2004). As clinicians, we can increase their knowledge by educating parents on their risks of having a pre-term or low-birth-weight infant. In the instance that their infant does fall into that category, physician assistants can further educate parents on preventative measures such as giving steroids for lung development and enter their children into early intervention programs so that they may develop normally and have a successful social life.

Recommendations for Future Research

Further research should include larger sample sizes in order to more accurately determine the risks of infants having negative developmental outcomes if they are born pre-term or with a low birth weight. An incentive should also be given to parents so that they are encouraged to follow-up and complete the study. Finally, only the most recent developmental scales should be used in future studies in order to receive the most accurate results.

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Abstract

Objective: The purpose of this project is to research studies that have been developed to determine if preterm and low-birth-weight infants are at a higher risk of developing cognitive, behavioral, and motor developmental impairments.

Method: The majority of the studies researched for this project were retrospective studies which followed-up with infants 1-4 years later and assessed their progress in development with the use of different developmental scales such as the Bayley-III scale and the Gross Motor Functional Classification Scale (GMFCS).

Results: The majority of the studies discussed have shown that morbidity in these infants are increased. They have shown that this increase is due to the risk factors that are associated with mothers giving birth to a preterm or low-birth-weight infant.

Conclusion: The results discussed in this project is detrimental in the approach in care of preterm and low-birth-weight infants by both physician assistants and parents.