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The Effects of Pediatric Traumatic Brain Injury on Sexual Criminal Offense

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Walden University
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Abstract

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MA, Walden University, 2016

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Dissertation Submitted in Partial Fulfillment

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Forensic Psychology/Criminology

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Abstract

Traumatic brain injury during childhood and adolescence is a significant social problem and is particularly damaging to long term cognitive and mental health. Major growth and maturation occur within the brain from age six months to 25 years and any interruption to this process can be detrimental to long term cognitive and emotional adjustment. Research has shown that pediatric traumatic brain injury can cause aggression, agitation, mood disorder, and socially inappropriate behavior. However, the study of how a traumatic brain injury during the time of pediatric development could potentially affect future sexually inappropriate behavior has not been explored. This archival study included 58 participants who had sustained a pediatric traumatic brain injury (between ages 2 and 20). The independent variables (IV) under consideration in this study are diagnosis of pediatric traumatic brain injury. The dependent variables (DV) in this study were age of participant at the time of injury, severity of the injury, location of injury within the brain, and presence of criminal record positive for sexual criminal offense. Multiple regression was used to determine if any of the dependent variables had an effect of the likelihood of sexual criminal offense as an adult. The study revealed that the severity of the brain injury was scientifically significant within the data as a possible predictor of future criminal or sexual criminal behaviors. It is an important psychosocial issue to determine the potential effects that pediatric traumatic brain injury may have on adult behaviors such as sexual criminal conduct. The results of this study can help to mitigate behaviors and form more effective treatment plans to prevent behaviors.

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Dedication

I dedicate this to my family who held me up during this long journey. My wonderful supportive husband who tolerated my absence and preoccupation with my education during the last 14 years. You understood the importance of my journey and supported me when I was close to the breaking point. We have made it through so much and my love for you cannot be measured. To my parents who provided enduring encouragement especially when my sanity began to waiver. A huge thank you to my Mom for all the proofreading. My sons who I have strived to set an example for. As I have always told you that nothing worth having is easy. You can do anything you set your mind to and you are never too old to reach your dreams. And last but certainly not least, Dr. Owen Perlman, who has been my professional mentor for the last 30 years. You taught me to believe in myself and strive to be something more than those around me. Thank you so much for seeing in me what I couldn't.

I will forever be grateful to all of you.

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Chapter 1: Introduction to the Study

Introduction

The Center for Disease Control and Prevention (CDC) reports that traumatic brain injury (TBI) is a leading cause of death and disability in childhood (CDC, 2014). Survivors are often plagued with lifelong disabilities relating to cognition, psychological health, adaptive/social behavior, and academic and executive functioning (Prasad et al., 2017). Pediatric traumatic brain injury is brain trauma that occurs during infancy, childhood, or adolescence while the brain is still actively in the maturation process. Maladaptive social behavior is common after pediatric traumatic brain injury and has been well documented in literature including aggression, agitation, mood disorder, and sexually inappropriate behavior (Li & Liu, 2013). However, sexually inappropriate behavior (SIB) leading to an adult sexual criminal offense has received less literary attention.

While previous research has explored the connections between traumatic brain injury and the potential for maladaptive and criminal behaviors (Fazel et al., 2011; Luukkainen et al., 2012; McKinlay et al., 2014; Vaughn et al., 2014), previous studies have not specifically examined the impact that pediatric TBI has on SIB leading to sexual criminal offending. Understanding the connections between pediatric traumatic brain injury and adult sexual criminal offense can assist in improving prevention programming. In this chapter, the background of the study is explored as well as identifying the research problem and questions.

Background

Traumatic brain injury during childhood and adolescence is a significant social problem and is particularly damaging to long term cognitive and mental health (Crowe et al., 2012; Li & Liu, 2013; Schrieff-Elson et al., 2017). Adolescence is the most dynamic time of human growth and development within the brain, second only to infancy, in terms of the rate of developmental occurring within the brain (Arain et al., 2013). Research by Arain et al. (2013) discussed brain maturation and that the brain does not reach its neuroplasticity peak until around age 24. Trauma incurred during childhood and adolescence while active neuroplasticity is occurring can significantly alter myelination, which stunts the maturation process. An interruption to the maturation process leads to emotional and cognitive stunting, causing social and emotional difficulties. Li and Liu (2013) examined children who sustained pediatric traumatic brain injury and found evidence of slowed brain maturation, causing persistent mood and behavior changes. Treble-Barna et al. (2017) studied childhood TBI and outcomes related to neurocognition and social functioning. Participants showed persistent neuropsychological and behavioral deficits well into young adulthood. Crowe et al. (2012) examined early pediatric TBI to document its impact on long term cognitive functioning. Participants consistently demonstrated impaired intellectual and behavioral functioning after early childhood brain injury. Evidence based research shows a tendency toward long term deficits and lifelong emotional and social struggles after early traumatic brain injury.

Previous research has examined how pediatric traumatic brain injury can lead to emotional stunting and blunting. de Sousa et al. (2011) examined relationships between traumatic brain injury and apathy and lack of emotional arousal. It was found that participants were consistently less empathetic and had lowered emotional arousal than controls when shown pleasant and unpleasant video content. Ryan et al. (2016) compared emotional responses related to injury severity in participants who sustained a pediatric TBI. Participants had significantly poorer emotion perception and this correlated with changes within the brain on imaging. These findings bring awareness to the significant social and emotional impact these injuries have on the victims. Ryan et al. (2014) studied long term predictors of sociocognitive outcomes in individuals that suffered pediatric traumatic brain injury. Research showed that the more severe the injury, the more severe and persistent the sociocognitive problems were for the participants. The long-term effects of these injuries can be devastating to the child's social and emotional health leading to long term behavioral dysfunction.

A study by Simpson et al. (2013) explored the prevalence of SIB after traumatic brain injury at any age, with results showing a positive occurrence rate of 8.9% of individuals with traumatic brain injury that displayed sexually inappropriate behavior and individuals who had more severe brain injuries or who were injured during adolescence were significantly more likely to display SIB (Simpson et al., 2013). Examining the research conducted by Crowe et al. (2012) and de Sousa et al. (2011) leads to the likelihood of a connection between pediatric TBI and SIB. Pediatric traumatic brain injury has been linked to social, emotional, and cognitive dysfunction causing maladaptive behaviors and involvement in the legal system (Chitasabesan et al., 2015; Kaba et al., 2014; Kennedy et al., 2017). Research has examined relationships between traumatic brain injury sustained as an adult and subsequent SIB leading to sexual criminal offense. The gap in literature is the lack of research specifically dedicated to the potential relationship between pediatric traumatic brain injury and subsequent SIB leading to sexual criminal offense.

The study of this relationship could bring positive social change by helping to create more effective treatments and early interventions to prevent the psychosocial side effects of pediatric traumatic brain injury. Treatment programs that are properly trained to handle a client's constellation of injuries and what behaviors it can potentially cause as an adult, could provide additional useful information to add to the effective treatments that are provided. This forward thinking and planning could provide further understanding of the potential for SIB and sexual criminal offending due to the background knowledge of the trauma.

Problem Statement

Previous studies have demonstrated links between criminality and traumatic brain injury; however, they lack examination of the specific correlation between TBI and sexual criminal offending. Studies conducted by Blanchard et al. (2002); Blanchard et al. (2003); Langevin (2006); Langevin and Curnoe (2011); Simpson et al. (1999); and Simpson et al. (2001) all explored links between traumatic brain injury and sexual criminal offense but lack the distinction of pediatric injury (injury sustained between ages 5-20). Furthermore, within the last five years, no current studies have been conducted to examine any relationship between traumatic brain injury and SIB. There is a lack of studies that explore the specific relationship between pediatric TBI and SIB leading to criminal sexual offense. Specifically, that age at injury, severity of injury, and location of injury within the brain could have a direct correlation with the increased probability of sexual criminal offending. This study examined the relationship specifically between individuals that sustained a pediatric brain injury and the potential for sexual criminal offending.

Purpose of the Study

This study explored the correlations between pediatric traumatic brain injury and SIB leading to a sexual criminal offense. Closer examination is needed to understand how TBI during childhood or adolescence can affect the likelihood of SIB and sexual criminal offending. Previous research has explored TBI occurring at varying ages and the resulting sequelae; however, it has not specifically examined the relationship between pediatric brain injury and SIB leading to a sexual criminal offense (Ryan et al., 2014; Ryan et al., 2016; Simpson et al., 2013). This quantitative study explored potential links between sustaining a traumatic brain injury during childhood or adolescence and sexual criminal offending as an adult. The independent variables (IV) under consideration in this study are diagnosis of pediatric traumatic brain injury in all participants. The dependent variables (DV) in this study were age of participant at the time of injury, severity of the injury, location of injury within the brain, and presence of criminal record positive for sexual criminal offense.

Research Questions

A quantitative research study was designed to use for this study with three research questions and associated hypotheses:

1. *Does sustaining a traumatic brain injury prior to age 20 have an effect on SIB leading to sexual criminal offense?*
    a. H0: Sustaining a TBI prior to age 20 has no effect on the probability of sexual criminal offending.
    b. HA: Sustaining a TBI prior to age 20 has an effect on the probability of sexual criminal offending.
2. *Does the severity of injury that occurs prior to age 20 have an effect on SIB leading to sexual criminal offending?*
    a. H0: Severity of injury has no effect on the probability of sexual criminal offending.
    b. HA: Severity of injury has an effect on the probability of sexual criminal offending.
3. *Does the location of the trauma within the brain that occurs prior to age 20 have an effect on SIB leading to sexual criminal offending?*
    a. H0: Location of the trauma has no effect on sexual criminal offending.
    b. HA: Location of the trauma has an effect on sexual criminal offending.

Theoretical Framework

The theoretical framework for this study is the Integrated Theory of Sexual Offending. The integrated theory of sexual offending theorizes that sexual crimes occur as a result of interacting causal variables such as brain development, ecological, and socioeconomical factors (Ward & Beech, 2006). Lack of brain development and social maturation due to a pediatric brain injury can combine with ecological and socioeconomic factors to provide an antecedent for sexual criminal offending that supports the Integrated Theory of Sexual Offending framework. Humans, particularly males, are biologically driven to engage in sexual behavior and this natural urge is driven by the amygdala and limbic system (orbitofrontal cortex and prefrontal cortex), which are in the frontal lobe of the brain (Marshall & Barbaree, 1990). The frontal lobe's function is to control the primitive urges emitted from the limbic system and regulate personality, judgement, and impulse control. Sustaining a frontal lobe TBI can significantly impair the ability to control impulses and demonstrate good judgement in decision making (Roberts et al., 2018).

Brain injury at a young age coupled with socioeconomic factors can result in higher levels of social dysfunction and behavior dysregulation. Treble-Barna et al. (2017) report that children with more severe injuries and younger age at injury are associated with greater impairment and show lingering long-term deficits in a range of domains including impulse control and emotional reasoning. A study by Ryan et al. (2014) showed that participants with more severe brain injuries had poorer emotional regulation than controls and supported the theory that the immature "social brain" network is vulnerable to early disruption causing lifetime impairment. Pediatric TBI can cause slowed cognitive development, impulsivity, poor judgement, and decreased emotional/social maturity that can lead to isolation and poor peer relationships. These impairments fueled by lack of impulsive control can lead to aggressive behavior and criminal sexual offending. The proposed study explored how the integrated theory of sexual offending can be used to support the relationship between SIB and TBI.

Nature of the Study

The nature of this proposed study is quantitative and factorial. The study is archival because it utilized data that contains information that can be linked to individuals, though not necessarily to the individual's identity (Institutional Review Board for Social and Behavioral Sciences, n.d.). The data collection strategy for this proposed study is to examine archived case records from a large group of TBI survivors of various ages and injury severity level. Participant records with be accessed through multiple medical entities in Southeast Michigan. The variables addressed the potential of a relationship between pediatric TBI and SIB that leads to sexual criminal offending. The independent variables (IV) under consideration in this study are diagnosis of traumatic brain injury in all participants. The dependent variables (DV) in this study were age of participant at the time of injury, severity of the injury, location of injury within the brain, and presence of criminal record positive for sexual criminal offense. A two-way ANOVA would be conducted to examine the statistical effect of pediatric traumatic brain injury and/or the severity of that injury and the probability of committing a sexual criminal offense. This would be a 2x2 factorial design that examines two independent variables with four dependent variables (Mohammed et al., 2017). Regression analysis or t-test with moderation could be considered to examine if age at time of injury and/or severity of injury have effects on sexual criminal offending. Post hoc tests can be conducted to provide more information about the variations that are found within the analysis.

Definitions

The following list of terms and abbreviations provides relevant definitions pertaining to this research study. Other definitions may exist but may not represent the intended use for this study.

Axons: The long connecting nerve fibers that make up the electrical transmission system of the brain.

Axonal Injury: A type of traumatic brain injury where the axons are stretched and torn due to rapid acceleration and deceleration.

Frontal Lobe: The front part of the brain, behind the forehead, that is the control panel of the personality and other essential emotional functioning.

Glascow Coma Scale (GCS): A widely used standardized test to assess impaired cognition and coma.

Inferior to Superior: From lower to higher, in terms of brain development.

Limbic System: Consisting of the amygdala, hippocampus, and cingulate gyrus, the limbic system controls human basic responses; feeding, reproduction, and survival. Often referred to as the "lizard brain."

Motor Cortex: The part of the brain that is involved with the planning, control and execution of voluntary movements.

Myelin: The fatty protective coating on the axons that provides insulation and increases the functionality of the electrical impulses.

Myelinogenesis: The process of myelin coating generating on the axons in the brain.

Posterior to Anterior: From the back of the brain (occipital lobe) to the front of the brain (frontal lobe).

Posttraumatic Amnesia (PTA): A state of disorientation that may occur after traumatic brain injury that may last hours, days, or weeks.

Prefrontal Cortex: Located within the frontal lobe, this region is responsible for complex decision making and cognitive and social behaviors.

Pruning: This process of synaptic pruning causes axonal connections to be connected and disconnected as the brain matures, typically between ages two and sixteen.

Sexually Inappropriate Behavior (SIB): Behaviors that are considered sexual in nature and socially inappropriate.

Traumatic Brain Injury (TBI): A disruption of normal brain function caused by an injury to the brain from an outside source such as injury or accident.

Theory of Mind: A term used to define the assessment of a person's human degree of capacity for empathy for others.

Assumptions

The assumptions in this study are minimal but require recognition to account for reliability and validity. Due to this study utilizing secondary data, validity was assessed for reliability of the data collected (Mohajan, 2017). The data set was gathered from participant medical records within the residential facility in which they reside. Accurate reporting of participant record is the responsibility of the facility and other medical entities that had previously treated the participant. Some information within those records is from family and clinician reports. This study assumes that the records are accurate and historical. It assumes that clinicians reported proper information and that all appropriate data was collected during treatment. Some data needed for this study may be unavailable due to poor participant record. For the data regarding location of injury within the brain, it is assumed that the most appropriate and sophisticated testing methods were used for the time period in which that the injury occurred. These assumptions are necessary for the validity of the study results.

Scope and Delimitations

The scope of the study is to address the traumatic brain injury population to determine who is at greatest risk of future sexual criminal offending. This focus was chosen to help provide earlier appropriate interventions to this specific population. This study is a random sample of participants who had sustained a childhood or adolescent traumatic brain injury living in residential settings. The internal validity is moderate due to the potential for manipulation of two variables. Injury occurring during adolescence and the location of injury in the frontal lobe are statistically known to increase likelihood of maladaptive behavior and misunderstanding of social cues (Fazel et al., 2011; Li & Liu, 2013; Luukkainen et al., 2012; McKinlay et al., 2014; Vaughn et al., 2014). If these variables are changed, the outcome of the study would have lower internal validity.

This study's design allows it to be used within any similar population giving it high external validity. Using the data points from a different sample, the design could be applied and replicated yielding similar results. This study can be applied to the real world by addressing the potential for SIB after TBI which can lead to criminal behavior and involvement in the criminal justice system. It has application in being able to foresee possible behaviors and provide early interventions. It will assist in developing methods to measure behaviors to create programs that will provide education and proper monitoring methods to prevent criminal behaviors.

Included populations for this study were anyone with history of traumatic brain injury from birth to age twenty. All races and ethnicities and both genders were included. Excluded populations were anyone with premorbid histories of mental illness, SIB (criminal or otherwise), and any congenital birth defect affecting the brain, i.e., cerebral palsy. Validity protection within this study included the research instruments were consistent, there was no pre-testing of subjects, no participant dropouts, and all protocols were met. This study's results have broad generalizability because it can be applied to anyone with a traumatic brain injury, no matter the gender, race, ethnicity, or cultural background. No matter the location or setting, the results within that population should be the same.

Limitations

Limitations to this study include genetic makeup, congenital factors, socioeconomics, and psychosocial factors. Any of these factors could have an influence on the study's outcome in a small way, given that each person is an individual both genetically and personally. This study cannot account for each participant's socioeconomic and psychosocial situation. Given that the data set for this study is quantitative, there would be no biases to report.

Significance

The study examined the relationship between individuals that sustained a pediatric traumatic brain injury and sexual criminal offending. This study provided an original scientific contribution by providing information regarding direct links between pediatric TBI and SIB that lead to criminal sexual offending. This study may impact practical application by assisting individuals working with this population to understand the increased probability of SIB and work to place proper and adequate interventions early in the rehabilitation process. According to current research, juvenile sex offenders recidivate at a rate of 9.9% to 14.3% upon committing sexually oriented crimes (Spice et al., 2013).

This study could assist justice agencies and youth rehabilitation facilities to better understand the relationship between pediatric traumatic brain injury and resulting SIB and the potential for sexual criminal offense; thus, SIB within this demographic could be recognized and treated earlier in the rehabilitation process. This study could affect positive social change within the youth rehabilitation and juvenile justice communities. Positive social change may be achieved by understanding the potential for this behavior, such as triggers and why this crime occurs, thus leading to better interventions and potential reduction in recidivism rates for this demographic.

Summary

This study explores the effect of pediatric traumatic brain injury on the potential for adult sexual criminal offending. Relationships between traumatic brain injury and maladaptive behavior have been established in literature as well as long term outcomes from sustaining pediatric brain trauma. While research has been conducted to examine the connections between TBI and sexual criminal offense, sexual criminal offense as an adult related specifically to sustaining a pediatric brain trauma requires further examination. Understanding these connections could result in improved psychosocial outcomes and lessened strain on the legal and penal systems. Proper early interventions could improve relationships and reduce socioeconomic hardships.

Participants diagnosed with pediatric traumatic brain injury (independent variable) were compared with age of participant at the time of injury, severity of the injury, location of injury within the brain, and presence of criminal record positive for sexual criminal offense (dependent variables). Research questions were explored to examine how severity of injury, age at the time of injury, and location of the trauma within the brain affect the probability of future SIB and sexual criminal offending. The integrated theory of sexual offending is the theoretical framework modeled in this study, which theories that sexual crimes occur as a result of interacting genetic, biologic, and socioeconomic causal factors. This study was conducted in an archival fashion utilizing quantitative and factorial methods. This study's significance is projected as an original scientific contribution providing valuable information regarding direct links between individuals with pediatric traumatic brain injury and the probability of future sexual criminal offense.

In Chapter Two, detailed research is outlined regarding how pediatric trauma affects the brain, both initially and long term. Extensive research was conducted to provide causal relationships between pediatric traumatic brain injury and future maladaptive social behaviors and cognitive impairments. It also explores links between pediatric trauma and future criminal behavior leading to incarceration.

Chapter 2: Literature Review

Introduction

This chapter explores the brain's growth process throughout infancy, childhood, and adolescence. Neuroplasticity is the brain's ability to change and grow throughout an individual's lifespan. Although it slows after brain maturation, neuroplasticity is a continuous process within the brain until death. This chapter discusses how pediatric traumatic brain injury hinders the neuroplasticity process and often causes long term cognitive and behavioral dysfunction. It presents evidence that traumatic brain injury occurring at a young age can cause lack of social growth and emotional stunting, creating psychosocial disturbance (Babikian et al., 2015). Pediatric traumatic brain injury can lead to aggression and criminality. Although less common, sexually inappropriate behavior can occur after sustaining a pediatric brain injury. This behavior has the potential for sexual criminality and sexual criminal offending (Langevin & Curnoe, 2011). This chapter examines the relatedness of these phenomena and their relationship to the Integrated Theory of Sexual Offending. The central theme throughout this chapter is that traumatic brain injury sustained during peak time of brain maturation can be devastating to cognitive, behavioral, and social outcomes, leading to the potential for sexually inappropriate behavior and sexual criminal offending.

Literature Search Strategy

Literature review began with searching the Walden Library psychological and criminal justice databases to identify peer reviewed articles, scientific studies, and dissertations within the domains of forensic psychology, brain development, criminal justice, and traumatic brain injury. Searches were conducted regarding the concepts of pediatric brain injury, sex crime, incarceration, and inappropriate sexual behavior. Searches were aimed to examine studies from 2013 to 2018 for current research and a comprehensive search was conducted from 2000 to 2018 to discover any studies specific to this research study.

Specific databases searched included BioMedCentral, Bureau of Justice Statistics, Child Trends, Criminal Justice Database, Criminological Highlights, Dissertations at Walden University, Free Medicine Journals, Google Scholar, Medline, Merck Manual, National Science Foundation, Neuroscience Information Framework, Ovid, Oxford Criminology, Project Muse, ProQuest, PsycARTICLES, PsycBOOKS, Psychiatry Online, PsycINFO, PubMed, Sage, ScholarWorks, ScienceDirect, Taylor and Francis Online, and World Health Organization.

Keywords searched within these databases were *traumatic brain injury*, *pediatric traumatic brain injury*, *sexual offending*, *sexually inappropriate behavior*, and *hypersexuality*. The key terms searched were *sexual offending and TBI*, *juvenile sex offending*, *sexually inappropriate behavior after TBI*, *sequelae of pediatric TBI*, *juvenile sex offence and TBI*, *TBI and social dysfunction*, *TBI and sexual deviance*. Virtual Boolean search parameters were utilized to gather specific information and included multiple combinations of keywords. *Crime* AND *youth* AND *incarceration* yielded 581 results within the 2013 to 2018 timeframe; however, these results were not specific to only individuals who had sustained brain trauma and committed crime. *Brain injury* AND *crime* yielded 236 results, of which 205 were peer reviewed articles. Several articles were of relevance and were archived. Adding a third parameter of *sex* yielded 58 results and locating a few more articles worth reviewing. *Brain injury* AND *crime* AND *youth* yielded 9 articles and *brain injury* AND *sex* AND *crime* yielded 14 articles. Both of these searches revealed articles already gathered.

A search for *youth* AND *sex offender* yielded 840 results and adding the third parameter of *brain injury* yielded zero results. Changing the third parameter to *learning disability* yielded four results. The articles were related to individuals who were sexually abused and had not sexually offended. Searches for information using more specific Boolean parameters also yielded zero results. Combinations used were *brain injury* AND *youth* AND *sex crime*, *brain injury* AND *youth* AND *incarceration*, *brain injury* AND *youth* AND *sexual offender*, and *brain injury* AND *youth* AND *hypersexuality*.

Theoretical Foundation

The theoretical framework for the proposed study is the Integrated Theory of Sexual Offending (ITSO). The ITSO was developed by Ward and Beech in 2006 to better the sexual offending field by identifying a theory that included biological or inheritable traits that could increase the odds of individuals violating social norms (Ward & Beech, 2006). The Integrated Theory of Sexual Offending theorizes that sexual crimes occur as a result of interacting causal variables such as brain development, ecological, and socioeconomical factors (Ward & Beech, 2006). Pennington's Theory of Psychopathology influenced Ward and Beech when developing the ITSO by identifying four levels of analysis: etiological (genetic and environmental influences on the brain), brain mechanisms that are influenced by the etiological effects, neuropsychological analysis, and a symptoms analysis (Pennington, 2002). The ITSO provides framework to explain how the biological and environmental factors involved regarding traumatic brain injury, particularly frontal lobe injuries, can potentially influence sexual criminal offending.

In line with the ITSO theory, lack of brain development and social maturation due to a pediatric brain injury can combine with ecological and socioeconomic factors to provide an antecedent for sexual criminal offending that supports the Integrated Theory of Sexual Offending framework. Humans, particularly males, are biologically driven to engage in sexual behavior and this natural urge is driven by the amygdala and limbic system (orbitofrontal cortex and prefrontal cortex), which are in the frontal lobe of the brain (Marshall & Barbaree, 1990). The frontal lobe's function is to control the primitive urges emitted from the limbic system and regulate personality, judgement, and impulse control. Sustaining a frontal lobe TBI can significantly impair the ability to control impulses and demonstrate good judgement in decision making (Roberts et al., 2018).

In the adult population, the ITSO framework is supported in research conducted that supported links between frontal lobe brain injury and resulting antisocial behaviors (Rodriguez-Bailon et al., 2012; Szczepanski & Knight, 2014; Wortzel & Arciniegas, 2013). Similarly, this framework is supported in several studies related to injuries sustained as a child or adolescent (Langevin, 2006; Ryan et al., 2014; Ryan et al., 2016; Simpson et al., 1999; Simpson et al., 2001; and Vaughn et al., 2014). In the proposed study, the ITSO framework relates to the research questions: does a frontal lobe brain injury increase the odds of an individual violating social norms? Does a frontal lobe injury increase the odds of an individual committing a sexual criminal offense? Traumatic brain injury is an environmental factor that causes biological changes that influence and change behaviors and outcomes. Research has demonstrated that traumatic brain injury and the changes it causes in the brain can be a contributing factor to individuals violating social norms and committing sexual criminal offense.

Literature Review Related to Key Variables and/or Concepts

Brain Development and Neuroplasticity

By age five, the human brain is 90% of its adult weight and almost total adult volume (Yosida et al., 2013). The development of the matter and generation of connections begins in utero and continues until adulthood. The brain consists of two types of tissue with very distinct functions: *grey matter* and *white matter*. Grey matter, consisting of mostly myelinated neurons, controls the brain's thinking and calculating (Fields, 2008). The grey matter develops mostly back to front, with the back of the brain reaching maturity first and the frontal lobe and prefrontal cortex reaching maturity last (Konrad et al., 2013). White matter controls the signals occurring between the neurons and coordinates the parts of the brain working together (Fields, 2008). White matter development is slower to occur in the frontal, parietal, and temporal areas, which impacts the maturity of cognitive and behavioral functioning (Simmonds et al., 2014).

Myelinogenesis is the process of ensheathment of nerve axon fibers within the brain with a fatty coating (myelin) that helps to conduct signals between the areas of the brain more efficiently. Magnetic resonance imaging studies have demonstrated that myelinogenesis occurs from birth through adolescence, and the brain's neurocircuitry remains structurally and functionally vulnerable throughout that time (Arain et al., 2013). Myelinogenesis is dynamic and generally occurs from inferior to superior and posterior to anterior within the brain (Konrad et al., 2013). Babikian et al. (2015) identified three key time periods for myelinogenesis: birth to age 3, ages 7 to 9, and ages 10 to 12.

The cerebral cortex is the thin, outer layer of the brain, consisting of mostly grey matter, and the cerebrum is the inner part of the brain, consisting of mostly white matter. Many parts of the brain are involved in cognition, memory, and behavior; however, the *limbic system* and the *frontal lobe* play the largest roles (Konrad et al., 2013). These components are instrumental in cognitive, social, and emotional functioning. The limbic system consists of three vital structures: the *hypothalamus* that controls homeostasis and regulates our central nervous system, the *hippocampus* that converts short term memories into long term memories, and the *amygdala*, referred to as the “animal or lizard brain”, that is responsible for basic human needs and responses including fight or flight, anger, food, survival, and reproduction (Stuss & Knight, 2013).

The frontal lobe has two vital structures: the prefrontal cortex and the motor cortex. The prefrontal cortex manages complex, high level cognitive planning, sorting of emotions, and executive functioning. It is the center for personality, social control, and complex decision making (Stuss & Knight, 2013). Empathy and emotion generate from here, along with “right from wrong” social decisions. Secondly, the motor cortex that has connections to the spinal column and controls motor functions involved in all aspects of body movement. It is involved with fine motor control and motor functions related to speech and language (Stuss & Knight, 2013).

As the brain matures, the frontal lobe, particularly the prefrontal cortex, works to manage the instinctive animal impulses that generate from the limbic system, particularly the amygdala. The frontal lobe, particularly the prefrontal cortex, conforms, shapes, and sculpts behavior into the social mold into which it must fit (Pachalska et al., 2014). Its primary function is to inhibit undesirable behaviors by sorting through numerous responses and choosing the option that is the most fitting to cultural, moral, and social standards. Behavior and social responses are fine-tuned by the environment and learned experience, shaping the development of the brain overall. The frontal lobe, its components, and the timeline of their maturity are critical to social, cognitive, and emotional outcomes in adulthood.

Child Growth

Child growth is divided into periods of time defined as birth to 2 years of age, early childhood ages 3 to 6, middle childhood ages 7 to 9, late childhood 10 to 12, early adolescence ages 13 to 17, and late adolescence ages 18 and up (Simmonds et al., 2014). During the infancy and childhood stages, the brain is developing axonal connections and tracts. The cerebrum and cerebral cortex are maturing with the majority of white matter reaching full maturity around age seventeen (Simmonds et al., 2014). Adolescence is the most dynamic time of human growth and development within the brain, second only to infancy, in terms of the rate of developmental construction occurring within the brain (Arain et al., 2013). During this time, the development of proper social skills is at heightened risk for disruption because neural networks are actively undergoing rapid functional and structural maturation (Ryan et al, 2016). Significant developments in the limbic system and a surge of myelination occur during adolescence (Arain et al., 2013). Social affective abilities are improving, increasing Theory of Mind and empathy (Konrad et al., 2013). Around age 14 (the onset of puberty), the frontal lobe undergoes a massive pruning of axons, causing it to be extremely vulnerable to insult (Kolb et al., 2014). Coincidently, this is also the peak age for mental disorders to emerge.

After early adolescence and into the late adolescent years, there is continued growth in the frontal and limbic areas that reach maturity at different ages (Simmonds et al., 2014). Active neuroplasticity and brain maturation, particularly in the frontal lobe, occurs through age 25 (Arain et al., 2013). The prefrontal cortex is the last structure to complete development, not reaching maturity until the late twenties (Kolb et al., 2014; Babikian et al., 2015). The cingulum and uncinate fasciculus, critical to the communication of the limbic system with the prefrontal cortex, are the last areas to mature and do not reach maturity until the mid-thirties (Simmonds et al., 2014). A disruption to the myelinogenesis or structural development that occurs any time prior to the time of brain maturity can be devastating to an individual's cognitive, emotional, and social outcomes.

Traumatic Brain Injury

A brain injury is defined as any insult to the brain from an outside or inside source. A *traumatic brain injury* is a blow to the head that occurs from an external source as, i.e., car accident, sports, assault, abuse, etc. An *acquired brain injury* occurs from an internal source, i.e., stroke, hemorrhage, aneurysm, etc. The most common type of injury is traumatic brain injury caused by a whiplash type motion causing the brain to be thrust forward and backwards, forcefully slamming into the skull, causing a coup contrecoup injury (Levin et al., 1987). This motion creates two focal injuries: the coup injury in the frontal lobe (forehead area) and the contrecoup injury in the occipital lobe (back of the head) or side to side in the temporal areas, depending on the area of impact (Sharp et al., 2014). The whiplash motion causes the axons to be stretched and torn, causing diffuse axonal injury, or a disruption to the signaling system within the brain (Babikian et al, 2015; Sharp et al., 2014). There are two types of injury when a traumatic brain injury occurs: the *primary injury* and *secondary injury*. The primary injury is the impact itself, i.e., hemorrhage, blow to head, penetrating injury, etc., resulting in immediate neuronal death, known as necrosis (Schaller et al., 2015). The secondary injury is what occurs after the brain is injured, including brain swelling and apoptosis, or enzymatic cell death, which are devasting to the white matter and axons (Tomaszewski, et al., 2014). Brain homeostasis and autoregulation are disrupted due to persistent neuroinflammation and can cause protein breakdown and lead to neurodegeneration (Sharp et al., 2014; Schaller et al., 2015). Anoxic injury, due to lack of oxygen to tissues from reduced blood flow, can occur from excessive swelling and increased intercranial pressure (Schaller et al., 2015). Thus, due to these events, myelinogenesis and axonal pruning are hindered or halted. In cases of severe injury, areas are left with irreversible damage due to oxygen loss and apoptosis.

The severity of traumatic brain injury is measured by the Glascow Coma Scale (GCS), a neurological scale that gauge’s consciousness upon injury and subsequent assessments. GCS scoring, 0 to 15, is used to determine level of traumatic brain injury in an emergency and clinical setting:

- GCS score of 13 to 15 with loss of consciousness less than 30 minutes indicates mild traumatic brain injury. No penetrating injury and brain hemorrhage is very rare.
- GCS score of 9 to 12 with loss of consciousness less than 24 hours indicates moderate traumatic brain injury. Mild penetrating injury or brain hemorrhage and/or swelling may be possible.
- GCS score of 8 or less with loss of consciousness more than 24 hours indicates severe traumatic brain injury. Brain hemorrhage and/or swelling is likely and penetrating injury and/or skull fracture are possible.

The frontal lobe is considered the control center for an individual's personality. It is the most vulnerable area of the brain and the most common area of traumatic brain injury (Levin et al., 1987). Insult to the frontal lobe as it is developing can be devastating to the ability to continue myelinogenesis. Axonal injury, brain swelling, and cell death all inhibit the brain's ability to complete its natural maturation process. The brain prior to age 25 is undergoing pruning and myelinogenesis, and unmyelinated axons are more vulnerable to injury (Babikian et al, 2015). Li and Liu (2013) reported that the developing young brain is more sensitive to diffuse axonal brain injury, or whiplash type injuries, and is less likely to recover neuroplasticity as once thought. Injuries that occur at a young age can lead to more severe and permanent behavior and cognitive problems due to the lack of axonal recovery (Li & Liu, 2013).

Long Term Effects

A traumatic brain injury can cause cognitive, emotional, vocational, physical, and social deficits. The most common deficits are defined as frontal lobe syndrome, a clinical syndrome resulting from damage to the frontal lobe that involves areas including the anterior cingulate, prefrontal cortex, orbitofrontal cortex, and the frontal poles (Pirau & Lui, 2018; Krudop & Pijnenburg, 2015). Commonly, the long-term effects are a combination of these deficits:

- Impulsivity and poor judgement
- Aggression/irritability/profane/rude
- Perseveration (repetitive rumination or worry)
- Hypersexuality/sexually inappropriate behavior/disinhibition
- Loss of social skills/inappropriate behavior
- Anosognosia (lack of self-awareness into one's deficits)
- Cognitive deficits/impaired executive function

All the components of the frontal lobe work together in perfect harmony to shape the personality that is shown to the world, as it is essentially the brain's braking system. Our biology, environment, and external factors, including potential brain injury affect its development. A crucial part of its maturity is the development of the ability to regulate behavior and control impulses that generate from the limbic system. Dore et al. (2017) conducted a study of healthy adults to explore the neuronal mechanisms related to controlling emotional responses. Twenty adults, with a mean age of 24.6 years, screened negative for psychiatric disorder and depression. Using fMRI, participants were asked to view negative and neutral images in and out of the scanner and rate their emotional responses to each image. Results showed that the decision to regulate behavior occurred more frequently in participants exhibiting higher activity within the amygdala (Dore et al., 2017). The predictive relationship between amygdala activity and more frequent reappraisal choices was mediated by increased prefrontal activity (Dore et al., 2017). This finding supports that damage to the components and connections within the frontal lobe can lead to poor social functioning, poor emotional recognition/response, poor decision making, and impaired impulse control.

Aggression is a common side effect of traumatic brain injury and research in the fields of Neurobiology and Neurocriminology has further strengthened the associations between damage within the frontal lobe and aggression. Failure to recognize the emotional, social, and behavioral cues of others can lead to social dysfunction, behavior dyscontrol, and aggression toward others (Sabaz et al., 2014). A study conducted by Schlitz et al. (2013) sought to determine the frequency of brain dysfunction in incarcerated violent offenders. A sample of 287 inmates were examined (162 violent and 125 non-violent) along with 52 control non-offenders (Schlitz et al., 2013). MRI and CT scans, obtained while incarcerated, were reviewed by neuroradiologists to determine where they would fall on a three-point scale: normal, questionably abnormal, and abnormal in terms of frontal, temporal, lateral ventricle and 3rd ventricle anomalies (Schlitz et al., 2013). Violent prisoners had significantly higher overall brain pathology abnormalities than the other groups with 103 (64%) of the violent offenders displaying frontal and/or temporal lobe brain damage (Schlitz et al., 2013).

Sabaz et al. (2014) investigated the prevalence of challenging behaviors, particularly aggression and inappropriate social behavior, in an adult sample, ages 18 to 65 years, that had sustained severe traumatic brain injury. The sample consisted of 507 clients in a residential facility that underwent behavior analysis and behaviors were classified into subscales: Aggression (physical/verbal) and Inappropriate Behavior (sexual/antisocial). Results revealed that 54% of participants met criteria for challenging behavior and 49% displayed some form of aggression (Sabaz et al., 2014). 33% displayed some form of inappropriate behavior and longer periods of posttraumatic amnesia were significantly related to high levels of challenging behavior (Sabaz et al., 2014). 57% of the sample was injured under the age of 33 and 54% displayed all of the challenging behaviors (Sabaz et al., 2014).

Cristofori and colleagues (2015) examined aggression after penetrating head injury in Vietnam veterans. The study investigated attitudes toward aggressive thoughts and behaviors after traumatic brain injury. The sample consisted of 112 veterans who had sustained penetrating head injury during combat who underwent voxel-based lesion symptom mapping with CT scan and neurobattery (Cristofori et al., 2015). Participants with damage sustained to the dorsolateral prefrontal cortex had more positive implicit attitudes toward violence that under societal norms would be considered inappropriate (Cristofori et al., 2015). This study strongly endorses the role that the prefrontal cortex plays in moderating behavior, emotion, and empathy toward violence and aggression.

Decety et al. (2013) conducted similar research with violent offenders to identify potential patterns in brain pathology to better understand and predict behaviors related to lack of empathy and impulse control. A sample of eighty incarcerated male offenders, ages 18 to 50 years, were classified into three levels of psychopathy using the PCL-R (Decety et al., 2013). Twenty-seven offenders scored at 30 or above on the checklist indicating psychopathy and those who scored 20 or below were used as the offender control group (Decety et al., 2013). MRI scanning with video empathy eliciting dynamic scenarios was used to examine response in various brain centers. Offenders in the psychopathy group exhibited significantly less activation in the orbitofrontal cortex, demonstrating deficits in recognizing emotional cues from others by facial expression or body language (Decety et al., 2013). They showed deficits in recognizing others' pain responses showing deficits in the limbic system. The research conducted by Decety et al. (2013) and Schlitz et al. (2013) strongly confirms that individuals with frontal lobe dysfunction show deficits in recognizing emotional cues and displaying empathy towards others. These studies also strengthen previous research conducted by de Sousa et al. (2012), Spikman et al. (2013), and Ryan et al. (2017) regarding deficits in recognizing emotional cues and responses after frontal lobe damage.

Hypersexuality and Sexually Inappropriate Behavior

Inappropriate sexual behavior has been associated with severe traumatic brain injury and although it is one of the lesser occurring sequelae of traumatic brain injury, it has a negative effect on the emotional and social functioning of the affected individuals. Hypersexuality, a loss of sexual control manifesting hedonistic behavior, has been reported in cases of temporal lobe and basal frontal lesions by demonstration of inappropriate sexual expression (Komisaruk & del Cerro, 2015). Hypersexuality can occur without aggression, or it can manifest with aggression and a lack of sexual restraint. Disinhibition, a disregard for social convention and norms, is often seen in individuals with damage to the frontal or temporal lobe regions (Komisaruk & del Cerro, 2015). In a study of 67 men who sustained traumatic brain injury, fourteen (20%) reported hypersexuality with loss of control (Komisaruk & del Cerro, 2015). In the study conducted by Sabaz et al. (2014), inappropriate sexual behavior was exhibited by 18 of 507 (3%) participants. Hypersexual behavior can manifest in individuals with such brain damage due to lack of impulse control and disinhibition. Individuals with these behaviors can quickly push the boundaries of sexual criminal offence without close supervision.

Historically, lobectomies were performed to cease unwanted behavior, such as seizures or symptoms of mental illness and psychosis. The doctors learned that disconnecting the frontal lobe from the rest of the brain occasionally accomplished what they desired but more often, it created other problems, such as the case with McKenzie and Proctor in 1946. These patients after frontal lobe lobectomy exhibited apathy, impaired judgement and planning, and increased sexual behavior with social disinhibition (Komisaruk & del Cerro, 2015). The higher functions of the brain had been lost along with its social grace and finally tuned manners. Temporal lobectomies produced similar outcomes with even more pronounced sexual disinhibition such as public masturbation and self-abuse (Komisaruk & del Cerro, 2015). These historic medical cases were valuable learning tools to shed light on how intricate and valuable the connections are between the frontal and temporal lobes for learning social behaviors and impulse control.

Alnemari et al. (2016) conducted a literature review regarding the neural basis for sexually inappropriate behavior following traumatic brain injury. Sexual disinhibition, public exhibitionism, and altered sexual preference have been associated with frontal lobe and temporal lobe dysfunction after injury (Alnemari et al., 2016). The frontal lobes close connections to the hypothalamus and other limbic structures are the likely cause for these behaviors after trauma. Although not commonly seen, hypersexuality and/or philias, such as pedophilia or hebephilia, can manifest after injury to these very closely connected structures.

Alderman et al. (2009) examined ninety-one participants to determine associations between traumatic brain injury and inappropriate sexual behavior. Participants were 18-64 years of age and 75% of the sample was male. Over a period of three months, 699 incidents of inappropriate sexual behavior were recorded within 42% of the sample (Alderman et al., 2009). Most of the participants engaged in inappropriate sexual behavior less than ten times each over the three months while two participants accounted for 325 incidents (46%), 115 and 210 incidents respectively (Alderman et al., 2009). Verbal inappropriate comments were the most common behavior followed by obscene gestures and touching others (Alderman et al., 2009). The study noted that a majority of the sample had sustained a severe traumatic brain injury based on GCS; however, researchers did not attempt to correlate severity of injury to the occurrence rate for the inappropriate sexual behavior.

Simpson et al. (2013) examined the prevalence of sexually inappropriate behavior (SIB) within adult participants in a brain injury residential treatment setting. Participants were between 18-65 years of age and all had sustained severe traumatic brain injury. Measures included the clinicians observing and logging behaviors along with completing neurobattery with the participants. The study revealed a prevalence rate of 8.9% (45/507) for inappropriate sexual behaviors, 57% of which were sexually inappropriate comments (Simpson et al., 2013). Inappropriate touching logged 29.8% and exhibitionism and/or public masturbation logged 10.5% of all behaviors (Simpson et al., 2013). In 95% of the cases, sexually inappropriate behavior was accompanied by other challenging behaviors, such as aggression, adynamia, and perseveration, in that order (Simpson et al., 2013). Participants who sustained more severe injuries and who were injured at a younger age were significantly more likely to display SIB; although, the study only reports a mean age at time of injury of 32.7 years (Simpson et al., 2013). A breakdown of age at the time of injury for the participants was not fully disclosed in the data, which could of have been of great value to understand the potential outcomes of pediatric injury in further detail (Simpson et al., 2013).

James et al. (2015) sought to understand the behavior disturbances after traumatic brain injury and what behavior models could be expected. A sample of 301 individuals from seven residential facilities, with ages ranging from 16 to 76 years, were observed to record incidents of aggression and sexually inappropriate behavior in their living environment (James et al., 2015). The age at time of injury for the participants ranged from age one to 75. Behaviors were classed in four categories with four severity levels in each category to log behaviors such as touching, threats, aggression, exposing genitals, masturbation, etc. For those who displayed sexually inappropriate behavior, the risk intensified for verbal aggression and the risk of physical aggression steadily rose with the severity of the SIB being displayed (James et al., 2015). This study was limited as the age at time of injury range was very wide and it did not classify the participants in terms of injury severity.

James and Young (2013) conducted research to explore relationships between aggression and sexually inappropriate behavior after traumatic brain injury. The 152 participants were residents of a post-acute neurobehavioral residential program and were 16 to 72 years of age. 117 of the sample were noted to have sustained severe TBI while the other 35 participants were labeled mild or moderate. All participants underwent a nine-week period for continuous behavioral recordings and available neuropsychological testing data was also analyzed for 51% of the sample. Of the entire sample, 99 participants displayed SIB. The study revealed there was a clear correlation between traumatic brain injury and sexual inappropriate behavior (James & Young, 2013).

In the fore mentioned study conducted by Sabaz et al. (2014), the 507 adult participants were also analyzed for SIB data. Results revealed that eighteen participants (3.6%) displayed inappropriate sexual behavior, 162 participants (31.9%) displayed aggression, and 169 (33.3%) displayed inappropriate social behavior (Sabaz et al., 2014). Length of posttraumatic amnesia and greater time postinjury were significantly related to level of aggression. More than 80% of the sample displayed significantly impaired levels of psychosocial participation and the more severe the level of disability also correlated directly to greater levels of challenging behaviors (Sabaz et al., 2014).

Pediatric TBI

Sustaining a traumatic brain injury while the brain is still developing is devastating to the maturation process in a variety of ways. Insult to the frontal lobe during maturation slows myelinogenesis and hinders connections that are building between vital structures. These connections are the pathways to learning social norms and behaviors, and the ability to correct or regulate antisocial behaviors. When these are damaged, the ability to regulate behavior may be impaired leading to lack of emotional response and ability to self-regulate. Self-reported loss of emotional empathy after traumatic brain injury is in excess of 60% (Prasad et al., 2017). Often lack of social awareness is present and emotion or social cues from others are not recognized and/or social norms are not learned or retained. The long-term effects of a pediatric brain injury may not become evident soon after injury as the immature brain is undergoing widespread myelinogenesis making it seem like a moving target (Babikian et al, 2015). There are three significant factors that weigh in on the cognitive, emotional, and behavioral outcomes after pediatric traumatic brain injury: *the age of the individual at the time of the injury*, *the severity of the injury*, and *the area of the brain that is injured*. The brain is actively maturing until close to age thirty and injury anytime during this process can cause a hindrance of proper growth and connectivity in crucial areas, particularly the frontal lobe. Data regarding the age at the time of injury, severity of the injury, and the area of the brain affected can provide critical insight as to potential future behaviors and outcomes.

Age at Time of Injury

Sustaining an injury at a younger age is a contributing factor to long term deficits and behavior disturbance. Pediatric traumatic brain injuries, brain injuries sustained at age eighteen or younger, are associated with worse long term cognitive and psychosocial outcomes (Schrieff-Elson et al., 2017). Crowe et al. (2012) studied 181 children, one to thirteen years of age, at two years post injury. Those findings supported that moderate to severe TBI at an early age is associated with lowered intellectual functioning and increased probability of behavior/social problems. In that study, the middle childhood group showed the highest deficits compared to other groups, likely related to a critical time in brain development when the injury occurred (Crowe et al., 2012). Crowe et al. (2012) hypothesized that the children with the most severe injuries would show the lowest IQ scores upon testing was also supported.

Anderson and colleagues (2013) studied 93 children, ages five to sixteen, with a history of traumatic brain injury to explore social competence and contribution of cognitive and social deficits six months after injury. MRI scanning was completed within eight weeks of injury and neurobattery was given at six months post injury (Anderson et al., 2013). Social participation reported in the traumatic brain injury group was strained, with more severe injuries leading to greater social deficit (Anderson et al., 2013). Participants with severe traumatic brain injury displayed slower processing speed, poorer communication skills, social adjustment, and social participation, with younger age at injury and male gender also contributing poorer outcomes (Anderson et al., 2013).

Tomaszewski et al., (2014) examined twenty children, with a mean age of 13.35 years, with interview and cognitive battery. The aim of this research was to examine how functioning was disrupted by antisocial behavior post brain injury. Results revealed that 75% of the sample showed antisocial behaviors caused by their traumatic brain injury and development of frontal lobe syndrome (Tomaszewski, et al., 2014). Ten percent of the sample displayed sexual behavior and/or hypersexuality and 19 out of 20 displayed oversensitivity and anxiety (Tomaszewski, et al., 2014). Forty five percent of the sample displayed inappropriateness and aggressiveness with 70% displaying impulsiveness (Tomaszewski, et al., 2014). These behaviors in social settings can often be catalysts to escalated psychosocial problems. This study provided valuable information regarding the association of frontal lobe syndrome with pediatric TBI, but a limitation of the research is the small sample size.

Li and Liu (2013) researched fifty studies for literature supporting how children, birth to age 18 who sustained traumatic brain injuries, would be at risk for social and behavioral problems. These studies showed positive links between the age of traumatic brain injury and the resulting outcomes. One study reported children injured in adolescence had more behavior problems than those injured during middle childhood, that may give merit to the relationship of time of injury versus effect of injury (Li & Liu, 2013). Twenty to forty percent of children who suffered traumatic brain injury between 5 and 15 years of age displayed significant executive functioning skills (Li & Liu, 2013). Literature review also revealed that traumatic brain injury during childhood or adolescence causes significant damage to the neuroplasticity process; thus, giving way to a potentially higher risk of inappropriate behaviors, including sexual deviancy, and cognitive problems (Li & Liu, 2013).

Crowe et al. (2012) studied 53 children with traumatic brain injury that occurred prior to age three to assess behavior and cognitive impairments post injury. The traumatic brain injury group was found to have lower cognition and slower processing speed than controls (Crowe et al., 2012). An association was found between injury severity and level of cognitive impairment within the traumatic brain injury group. The limitation for this study was that the participants were still young and intellectually underdeveloped, leading to potential lack in research findings (Crowe et al., 2012).

Haarbauer et al. (2019) researched eighty children between six and eight years old and were tested at four to five years post injury. The aim of the study was to examine cognitive dysfunction during early elementary school after brain injury prior to six years of age with neurobattery and MRI. The participants in the traumatic brain injury group showed deficiencies in language, reading comprehension, and executive functioning (Haarbauer et al., 2019). They reported health complaints, such as headaches and sleep disturbance, that interfered with learning (Haarbauer et al., 2019). Participants that had abnormalities on early imaging were at increased risk for neurobehavioral problems such as aggression and impulsivity (Haarbauer et al., 2019).

Ryan et al. (2013) conducted longitudinal research sixteen years after participants had sustained pediatric traumatic brain injury to examine long term communication outcomes within this demographic. Thirty-four participants, with a mean age 20.62 years, were in the traumatic brain injury group, all injured between ages one and seven (Ryan et al., 2013). All were assessed with neurobattery that addressed cognitive, communication, and emotional impairments. The traumatic brain injury group displayed significantly greater social communication difficulties and poorer emotional perception, compared to controls, that often caused external behaviors (Ryan et al., 2013). These deficits elicit feelings of exclusion and rejection which strengthen negative social views and fuel socially inappropriate behaviors.

Ryan and colleagues (2017) again studied eighty-four children who sustained traumatic brain injury between the ages of 5.5 and 15 years old with MRI and neurobattery. The aim of testing was to examine the effect of traumatic brain injury on Theory of Mind, defined as the use of facial expressions to convey emotions. Neurobattery consisted of Theory of Mind testing where participants discussed the characters emotions by the look on their face, their actions, etc. (Ryan et al., 2017). The poorest outcomes from testing were seen in the moderate brain injury group, who performed significantly lower than controls, for recognizing facial emotions in Theory of Mind tasks (Ryan et al., 2017).

Bigler et al. (2013) researched twelve children aged eight to twelve years who had sustained traumatic brain injury. Participants were assessed with MRI and neurobattery approximately 2.5 years post injury to determine social outcomes after pediatric brain injury. All twelve participants had MRI identified frontotemporolimbic brain damage on MRI and 83% of the sample displayed multiple areas of social-emotional functional impairment compared to controls (Bigler et al., 2013). Two of the twelve participants displayed normal intelligence levels and no social-emotional impairment on testing. This data contributes to the research of Babikian et al, (2015) that pediatric brain injuries are like hitting a moving target, referring to the rate and timing of brain maturation in certain areas.

Severity of Injury

The severity of the injury sustained plays a significant role in long term outcomes. While mild injuries can produce some long-lasting symptoms, moderate to severe injuries are likely to cause lifelong deficits such as mood disorders and behavior changes. The presence of axonal injury and traumatic lesion help to determine the severity of injury along with length of posttraumatic amnesia (PTA). Ponsford et al. (2014) longitudinally examined 141 participants with traumatic brain injury over a ten-year span at the two-year, five year, and ten-year intervals to examine aspects of cognitive and behavioral functioning over time past injury. The age range was broad with a mean age at injury 34.91 years. Injury severity was gauged by length of PTA from mild (less than 24 hours) to very severe (greater than 28 days) (Ponsford et al., 2014). Participants that sustained severe injuries reported persistent cognitive and mood difficulties with impulsive behaviors consistently over the ten-year span (Ponsford et al., 2014). For participants with moderate to very severe injuries, cognitive and mood problems worsened over the span, with only participants with mild injuries seeing improvements over time (Ponsford et al., 2014).

Rosenberg et al. (2018) examined thirty-two participants that had sustained moderate to severe traumatic brain injury to determine an impairment in emotional recognition using neurobattery and emotional expression samples. The participants demonstrated deficits in emotion recognition and impairments in their recognition of social emotional cues (Rosenberg et al., 2018). Researchers noted the lack of intact emotion recognition and its impact on psychosocial functioning within the sample (Rosenberg et al., 2018). Many of these individuals experience social and vocational hardships due to these deficits.

Spikman et al. (2013) studied fifty-one participants that had sustained moderate to severe traumatic brain injury to determine deficits in facial emotion recognition and impaired self-awareness. Participants had a mean age of 37.5 years and were examined with neurobattery. The traumatic brain injury group performed significantly poorer than controls on facial recognition testing with fear and sadness ranking the least recognized emotions (Spikman et al., 2013). Proxy questionnaires were found to show significant discrepancy in behavior ratings compared to the traumatic brain injury group's ratings, revealing impaired self-awareness and lack of insight (Spikman et al., 2013). This finding of impaired facial recognition, particularly fear and sadness, contributes to the potential for misinterpreted social cues, aggression, and sexual criminal offence.

de Sousa et al. (2012) studied twenty-one adult participants, 21 to 65 years of age, with severe traumatic brain injury to examine deficits in emotional response and social behavior. The method was self-report neurobattery and gauging facial muscle response, skin conductance, and arousal ratings while viewing emotionally motivating videos that contained pleasant and unpleasant material (de Sousa et al., 2012). Those with severe traumatic brain injury displayed less ability to empathize and had reduced facial response for emotional content (de Sousa et al., 2012). Compared to controls, the traumatic brain injury group showed limited smiling to pleasant video clips and frowning to unpleasant video clips revealing impaired emotional response to social stimuli (de Sousa et al., 2012). Empathy response was significantly lower in the TBI group than controls. Some displayed loss of emotional control and the participants with higher levels of injury severity displayed lower levels of emotional empathy, emotional control, and ability to recognize the emotions of others (de Sousa et al., 2012). Reduced ability in these areas can contribute to occurrence of SIB which can lead to sexual criminal offense.

Severe pediatric injuries that are associated with the poorest long-term outcomes. This population experiences persistent neurological, physical, and psychosocial deficits that typically worsen over time (Schrieff-Elson et al., 2017). Because neuroplasticity operates on optimal biological synergy, plasticity within the brain after injury is likely disrupted and abnormal, causing a lack of healing and slowed or ceased progression of vitals connections (Schrieff-Elson et al., 2017). Children who sustain severe traumatic brain injury are three times more likely to develop a psychiatric disorder or mental illness and 30 to 50% develop symptoms of ADHD (Li & Liu, 2013). Even though many children seem to function normally after a traumatic brain injury, the effects of the trauma may take months or years to surface as the child ages and develops, failing to reach social, academic, and emotionally age-appropriate goals (Schrieff-Elson et al., 2017).

Ryan et al. (2016) conducted longitudinal research on seventy-eight children with traumatic brain injury that occurred between ages five and fifteen to examine long term social and cognitive outcomes. Participants underwent MRI two to eight weeks post injury and were reexamined at 12 months and 24 months with neurobattery and parental questionnaires (Ryan et al., 2016). For participants with severe traumatic brain injury, social problems significantly increased from 12 to 24 months and were worse than those reported in the moderate and mild groups (Ryan et al., 2016). Researchers surmised this could be related to the diffuse axonal injury seen within severe traumatic brain injury that disrupts structural connectivity in neural networks, particularly in the immature developing brain (Ryan et al., 2016).

Literature analysis by Li and Liu (2013) revealed that up to fifty percent of brain injured children within the studies had evidence of behavioral and social issues within home and school. Personality change was strongly tied to injury severity and was evident in 60% of the children with severe brain injury, while it appeared in only 5% of the children with mild to moderate brain injury (Li & Liu, 2013). Defiant disorders were seen in 20% to 40% of the children injured between ages six and fourteen with no relation to the injury severity (Li & Liu, 2013). Those with severe traumatic brain injury also had rates of psychiatric disorders that were three times that of the orthopedic comparisons (Li & Liu, 2013). Males injured in middle childhood displayed significantly more reactive and proactive aggression, especially out of frustration (Li & Liu, 2013).

Treble-Barna et al. (2017) studied fifty-two children who sustained brain injury between ages three and seven to examine long term neuropsychological outcomes. Children were assessed with neurobattery at 6 months, 12 months, 18 months, and 3.5 years post injury. The severe injury group demonstrated persistent neuropsychological impairment into young adulthood with slower processing speed, executive functioning, and compromised behavior control (Treble-Barna et al., 2017). The children with severe injury performed lower on testing than the children with moderate brain injury and significantly lower than controls (Treble-Barna et al., 2017). This study provided a large longitudinal cohort with a childhood sample being followed for longer than five years post injury.

Prasad et al. (2018) studied 79 children who sustained traumatic brain injury between ages two and fifteen to examine the cognitive impact of injury and educational outcomes. Children with severe traumatic brain injury consistently used higher levels of school services and had low cognitive competency ratings compared to children with mild to moderate traumatic brain injury (Prasad et al., 2017). Children who were injured at younger ages demonstrated lower academic skills and received benefit from self-contained classrooms (Prasad et al., 2017).

Area of Brain Injury

The area of the brain that is affected by an injury can also predict deficits and behaviors that are likely to occur. Frontal lobe syndromes and neurobehavioral disorders are common after frontal lobe injuries. Research has consistently found that damage to the frontal lobe causes antisocial behaviors and changes in personality that were not present prior to injury (Decety et al., 2013; Keightley et al., 2014; Pehlivanova et al., 2018; Schlitz et al., 2013; Szczepanski & Knight, 2014). Case studies, such as the famous Phineas Gage in 1848 and, more recently, PG, the polish Phineas Gage in 2007, are two of countless examples portraying how traumatic brain injury within the frontal lobe can bring about altered behavior and personality (Damasio et al., (1994); Pachalska et al., 2014). Both men had penetrating injuries to the frontal lobe with documented frontal lobe syndrome, i.e., aggressiveness, impulsiveness, poor judgment, irritability, and socially inappropriate behavior (Pachalska et al., 2014). PG was assessed with neurobattery at 12 months and 24 months post injury. Testing revealed that his symptoms of hyperorality, aggression, restlessness, impulsivity, inappropriateness, poor judgement, excessive jocularity, irritability, and perseveration all worsened between 12 months and 24 months (Pachalska et al., 2014).

Meta-analysis conducted by Fumagalli and Priori (2012) revealed an abundance of case studies from physicians, which dated back to 1923, citing less than optimal outcomes from lobotomies involving the frontal lobe in attempts to cease a variety of unwanted behaviors from depression to psychosis. Three different methods were used for these procedures. When first attempted, doctors two small holes drilled into the frontal lobe and then alcohol was injected to interrupt neural pathways. A second method was later attempted using a leucotome, a long metal wire that would enter the small holes and sever the connections when moved back and forth. Finally, in an attempt to improve the success of the procedure, a long metal rod was inserted through the eye socket and moved side to side, severing connections between the thalamus and the frontal lobe. Occasionally, the patient would have a slight improvement in the ailment the doctors were trying to cure, but more often the patients developed symptoms of frontal lobe syndrome and were clinically worse than before their medical intervention (Fumagalli & Priori, 2012). Many lost their sense of morality and social construct, and researchers began to realize that the frontal lobe structures were intricately linked and are directly involved with mitigating abnormal moral behavior (Fumagalli & Priori, 2012).

Literature review conducted by Szczepanski and Knight (2014) examined the role of the prefrontal cortex and its association to impaired social and emotional functioning after traumatic brain injury. Lesions in the ventrolateral prefrontal cortex and/or inferior frontal gyrus caused lack of inhibitory control, decreased flexibility, and lack of emotional empathy (Szczepanski & Knight, 2014). Damage to the orbitofrontal cortex was associated with loss of inhibitory and emotional control and an impaired ability to function effectively in social situations (Szczepanski & Knight, 2014). Medial orbital and ventromedial prefrontal cortex damage were associated with profound changes in social behavior such as poor emotional reactions/decision making, lack of affect, and inappropriate social behavior (Szczepanski & Knight, 2014). Medial prefrontal cortex lesions showed poor decision making in social and nonsocial contexts (Szczepanski & Knight, 2014). These deficits interfere with real life decision making and have profound negative effects on relationships.

Cortical thinning, or the thinning of the cerebral cortex due to damage and cell loss, can be a result of traumatic brain injury and can occur no matter how severe the injury is. It often is a result of cumulative traumatic brain injuries. Cortical thinning as a result of traumatic brain injury has been identified in a study by Keightley et al., (2014). The study examined thirteen youth participants post mild traumatic brain injury with fMRI and neuropsychological measures. Results revealed significant correlation between a thinner prefrontal cortex and slowed response speeds and impaired executive functioning compared to controls (Keightley et al., 2014). Additionally, a study conducted by Govindarajan et al. (2015) found correlations between cortical thinning and traumatic brain injury. A sample of seventy-five adults, aged 18 to 50 years, were examined with fMRI to examine cortical thickness in the brain lobes after documented traumatic brain injury. fMRI was conducted at approximately 24 hours post injury and again at three months post injury. Scanning found that significant reduction in cortical thickness was seen in the temporal and parietal regions baseline and again at ninety days post injury (Govindarajan et al., 2015). This research provides evidence that cortical thickness could be used as a measure to identify changes within the brain after traumatic injury.

Cortical thinning has also been linked to impulsive behavior in a study by Pehlivanova et al. (2018). A sample of 427 youths, ages 9 to 24 years, were examined using fMRI and a choice-based neuro-battery. Results revealed that diminished cortical thickness in the prefrontal cortex and orbitofrontal cortex were strongly associated with impulsivity on the battery tests (Pehlivanova et al., 2018). It was noted that the correlation was dependent on the severity of the lesions, therefore, the more severe the injury the greater the level of impulsivity. This strengthens the research conducted by Keightley et al. (2014) and Govindarajan et al. (2015) that revealed that cortical thinning can occur in individuals with traumatic brain injury. Additionally, these studies correlate to research conducted by Decety et al. (2013) and Schlitz et al. (2013) that frontal lobe dysfunction is associated with impulsivity and antisocial behaviors.

Literature conducted by Bannon et al. (2015) examined studies conducted on adult participants with history of traumatic brain injury to analyze structural brain lesions and associations to aggression and/or violent behaviors. Associations were found with frontal lobe damage causing impaired ability to anticipate consequences and poor social functioning (Bannon et al., 2015). Multiple studies found that early onset of traumatic brain injury was associated with more severe and impulsive behavior with greater physical and verbal violence (Bannon et al., 2015). Right ventromedial prefrontal cortex lesions were linked to marked disturbances with social and interpersonal behaviors, inability to learn from mistakes, and blunted emotional reactions (Bannon et al., 2015). Analysis concluded that lesions within the frontal lobe from traumatic brain injury were significantly associated with the potential for aggressive behavior and that frontal lesions incurred earlier in life caused more widespread harmful impairment than those incurred at later ages (Bannon et al., 2015).

Rodriguez-Bailon et al. (2012) conducted research with nine adults with a mean age of 29.4 years who sustained frontal damage traumatic brain injury to highlight executive deficits after injury. Frontal lobe lesions were confirmed on neuroimaging and participants were assessed with neurobattery. Results showed that lesions in the prefrontal cortex interfered with conflict resolution and lead to disruption in the executive control network, which is responsible for solving conflicting situations (Rodriguez-Bailon et al., 2012). To further strengthen this research, Wood and Worthington (2017) conducted literature review to explore how traumatic brain injury can affect social behavior and long-term executive functioning. Within the literature reviewed, the area of the brain that was damaged by the injury greatly correlated to the type of impairment reported. Impulsivity correlated to the limbic areas while disinhibition and impulsive aggression correlated to damage found in the anterior cingulate and prefrontal cortex, which is a key component to the behavioral braking system (Wood & Worthington, 2017). Disordered behavior, poor emotion recognition, and poor decision making were associated with damage in the prefrontal and orbitofrontal cortices (Wood & Worthington, 2017). This is consistent with impulsive, instinctive urges that generate from the limbic system and the prefrontal cortex system that is meant to control them.

Meta-analysis was conducted by Kumar et al (2019) regarding studies conducted with participants that had sustained traumatic brain injury to gather prevalence data of psychiatric disorders that develop post injury and the psychosocial impact that occurs. Mania, a state of heightened arousal and mood that can cause behavioral flares, was associated with lesions in the temporal poles and orbitofrontal cortex (Kumar et al., 2019). Psychotic disorders were associated with lesions within the frontal and temporal lobes that lead to an increase in the limbic activity and personality change was associated with lesions in the orbitofrontal cortex and amygdala (Kumar et al., 2019). Aggression was associated with lesions within the frontal lobe, particularly the left side (Kumar et al., 2019). The orbitofrontal cortex, prefrontal cortex, and cingulate cortex form a regulatory mechanism to inhibit the impulses of the amygdala and this mechanism is lost in individuals with damage in these areas.

Meta-analysis was also conducted by Wortzel and Arciniegas (2013) who examined multiple studies that involved individuals who had sustained traumatic brain injuries. It was noted that elevated aggression was observed in individuals with frontal lesions, particularly the mediofrontal and orbitofrontal cortices, compared to lesions within other parts of the brain (Wortzel & Arciniegas, 2013). Additionally, a relationship was established between the cingulum, which connects the prefrontal cortex with the orbitofrontal cortex and surface of the frontal lobe, and levels of impulsivity. When this connection is compromised, a significant increase in aggression could occur (Wortzel & Arciniegas, 2013).

There is substantial research that shows that pediatric traumatic brain injury coupled with frontal lobe damage can significantly affect behavior and personality outcomes. Research was conducted by Anderson et al. (2013) with a pediatric traumatic brain injury sample of 93 participants aged five to fifteen years. The study aimed to examine social functioning at six months post brain injury based on injury influences. The research revealed that within their pediatric sample 84% had suffered frontal lobe damage (Anderson et al., 2013). Impaired social competence was seen throughout the sample, with poorer results associated with severe traumatic brain injury (Anderson et al., 2013). Slowed processing speed, poorer communication skills, and longer transition back into school was seen with the severe injury group (Anderson et al., 2013). Younger age at the time of injury was significantly associated to these deficits and to poorer friendship quality (Anderson et al., 2013).

A longitudinal study was conducted by Anderson et al. (2017), with a sample of 74 participants who sustained pediatric traumatic brain injury, ages five to sixteen years of age. The goal was to investigate social impairments and outcomes post injury at six months and 24 months after brain injury. Participants underwent MRI at the time of injury and were assessed with neurobattery two years after injury. Fifty-two percent of the traumatic brain injury group demonstrated frontal lobe pathology on imaging (Anderson et al., 2017). Poorer social relationships were related to greater lesion volume and greater number of lesions within this group (Anderson et al., 2017). Twenty-three percent demonstrated reduced social adjustment and poor social relationships with symptoms of aggression and overactivity at 24 months (Anderson et al., 2017). Younger age at injury, lower IQ, slower processing speed, and lack of empathy were all found on neurobattery and linked to impairment (Anderson et al., 2017).

Research was conducted by Catroppa et al. (2017), to investigate social and behavioral outcomes twelve months post pediatric traumatic brain injury. The sample consisted of 79 participants who sustained traumatic brain injury aged five to sixteen years. All participants had undergone MRI or CT at the time of injury and were assessed with neurobattery just after injury and again at twelve months post injury. At the one-year mark post injury, the majority of the traumatic brain injury sample exhibited social problems and externalized behaviors with the moderate and severe groups showing higher rates of externalized behaviors (Catroppa et al., 2017). Frontal lobe injury was a significant predictor for social competence and externalizing behavior problems when the children were tested just after injury (Catroppa et al., 2017). Injury severity contributed significantly to predicting social and behavioral outcomes as the moderate to severe injuries showed higher rates of impairment, particularly in externalizing problems (Catroppa et al., 2017). After twelve months, the predictor for the behaviors correlated with subcortical pathology (Catroppa et al., 2017). Overall, the severity of injury played a large role in the social outcome of the participant with more severe injuries indicating poorer outcomes.

A longitudinal study was conducted by Ryan and colleagues (2014) with a sample of 34 participants who had sustained pediatric traumatic brain injury between the ages of one and seven years. These participants were followed up sixteen years after participating in an original study conducted by the same researchers. The goal was to examine predictors of very long term sociocognitive functioning compared to peers after early traumatic brain injury. Participants agreed to a study follow up at sixteen years post injury (mean age 20.62) using MRI and neurobattery. The traumatic brain injury group revealed difficulty with nonverbal emotional cues, which emphasizes the vulnerability of the immature brain to injury (Ryan et al., 2014). Frontal lobe injury and reduced volume within the corpus collosum were associated with significantly poorer emotion perception with a sample of children who suffered early severe traumatic brain injury (Ryan et al., 2014). The traumatic brain injury group showed difficulty interpreting emotions, social messages, recognizing nonverbal cues, and semantic meanings. Facial emotion recognition was particularly poor within the severe injury group. These deficits were seen sixteen years post injury and were significant disruptions to normal functioning within this group. This finding adds to the research conducted by de Sousa et al, (2012), Prasad et al. (2017), and Spikman et al. (2013) that frontal lobe dysfunction affects emotion recognition.

Research conducted by Ryan et al. (2016) examined the longitudinal outcomes after pediatric traumatic brain injury. A sample of 78 participants, ages five to fifteen years, were scanned with MRI at two weeks post injury and parents were interviewed after 12 to 24 months to assess behavior, emotional status, and social functioning. This research revealed that 78% of their traumatic brain injury sample had sustained frontal lobe injury found on MRI (Ryan et al., 2016). Within that group, higher rates of social problems were significantly related to the frontal lobe lesions, particularly in the corpus callosum (Ryan et al., 2016). Social problems increased significantly from 12 to 24 months in the participants with severe traumatic brain injury and were worse than the behaviors reported in the mild to moderate group (Ryan et al., 2016). The severe traumatic brain injury group displayed poorer long-term social and behavioral outcomes than the other groups and controls (Ryan et al., 2016).

Dennis et al. (2017) conducted a meta-analysis of studies conducted on children who had suffered traumatic brain injuries under the age of eighteen. All studies included diffusion MRI to identify and classify white matter disruption after pediatric traumatic brain injury. In participants with post-acute injuries (two to five months post injury) marked decreases in fractional anisotropy, which is a measure of connectivity within the white matter of the brain (Dennis et al., 2017). In participants with chronic injuries (twelve months or more post injury), researchers found lowered fractional anisotropy in the corpus callosum and cerebellum (Dennis et al., 2017). Significantly lowered fractional anisotropy also correlated to injury severity with disruptions seen in nearly every white matter tract; however, the corpus callosum was the most cited area throughout the analysis (Dennis et al., 2017). This slowed connectivity related directly to slowed processing, executive functioning, and other cognitive impairments (Dennis et al., 2017).

Bigler et al. (2013) conducted research with 82 participants who had sustained pediatric traumatic brain injury to identify associations between areas of lesion and neuropsychological outcomes. The participants were eight to thirteen years of age and had all underwent MRI imaging at a minimum of six months post injury. White matter hyperintensities and areas of encephalomalacia, or tissue necrosis, were common in the participants and significantly associated with severity of injury (Bigler et al., 2013). Volume loss in the frontotemporal region and corpus callosum was common in the more severe injuries and contributed to slowed processing speed and other cognitive impairments (Bigler et al., 2013).

Pediatric traumatic brain injury interferes with the normal patterns and timing of myelination and connectivity and disrupts the time dependent on emergence of certain skills and social behaviors. The brain's biology is altered from the trauma and disruption of vital connections within the frontal lobe and prefrontal cortex. Frontal lobe syndrome can develop and create deficits in executive processes that increase the propensity toward socially inappropriate behavior. Poor impulse control and impaired decision making hinder the ability to control urges generated by hypersexuality. Younger age at time of injury, injury within the frontal lobe, and more severe injury are all significant predictors of behavior/social problems with the potential for criminal offense due to altered brain biology, poor emotional perception, poor social cue recognition, agitation, aggression, poor judgement, and impulsiveness.

Links to Criminality

With the challenging behaviors and symptoms of frontal lobe syndrome, criminality after traumatic brain injury has become a concerning community issue. Impulsivity, aggression, and poor decision making perpetuate and magnify the deficits that contribute to the climbing arrest and incarceration rates related to individuals with TBI. According to meta-analysis completed by Frost et al. (2013), the estimated prevalence rate of traumatic brain injury with loss of consciousness in the general adult population is 12%. According to research conducted for this study, the prevalence of traumatic brain injury within the correction system ranges from 24% to 100%, demonstrating that offenders have more than double the community rate, at minimum. This association is significant and overwhelming as traumatic brain injury continues to be identified in large percentages of offenders within the criminal justice system.

To demonstrate the association between TBI and criminality, The Denver County Jail and the Colorado Brain Injury Program conducted a pilot program research study to understand the prevalence rate of traumatic brain injury within their corrections system (Gafford et al., 2015). Students from the University of Denver interviewed and administered neurobattery to 80 inmates to screen for brain trauma. Seventy-seven inmates met criteria for traumatic brain injury on the administered testing and 52% fell into the moderate to severe injury range (Gafford et al., 2015). Eighty percent of the inmates met criteria for TBI, mental illness, substance abuse, and criminal history

(Gafford et al., 2015). Canada colleagues (2014) explored the prevalence of traumatic brain injury among adult offenders. This sample consisted of 235 male and female offenders housed within the Ontario Corrections System. 102 (43.4%) reported a history of TBI prior to offending and 84% reported injury severe enough to require hospitalization (Colantonio et al., 2014). Male offenders reported an average age of first TBI as 19.6 years and males with a TBI were on average younger than the male offenders who did not (Colantonio et al., 2014).

Within this same theme, Ray et al. (2014) researched inmates admitting to the Indiana State Prison System to determine prevalence of traumatic brain injury within the population. Incoming inmates were screened over a 28-day period totaling 831 offenders, ages 18 to 69 years (Ray et al., 2014). Screening revealed a prevalence rate of 35.7% reporting a history of TBI with the average age of first injury being 18.9 years of age with 4.3% of that group sustaining severe traumatic brain injury due to loss of consciousness for more than thirty minutes (Ray et al., 2014). Thirty eight percent of those with traumatic brain injury reported having at least one prior incarceration compared with 26.2% of the inmates who did not have a TBI (Ray et al., 2014). The prevalence of one TBI with loss of consciousness among the offenders was 65% males and 72% females (Ray et al., 2014).

McIssac et al. (2016) looked at how traumatic brain injury increased the risk of criminal justice involvement including incarceration. A cohort of 1.418 million participants living in Ontario Canada, aged 18 to 28 years, were identified through national medical and correction records. Information regarding occurrence of traumatic brain injury, arrests, and incarcerations were identified. Of the total participants, 77,519 (5.2%) had sustained a traumatic brain injury in the past according to the obtained records (McIssac et al., 2016). The incidence of incarceration among the participants who had sustained a traumatic brain injury was significantly higher than those who had not, revealing a three times greater risk of incarceration than those without a head injury (McIssac et al., 2016). For women with a TBI, the risk of incarceration was 2.76 times higher (McIssac et al., 2016).

Durand et al. (2017) conducted a literature review to explore the prevalence of TBI in prison populations. Thirty-three studies were identified that had a total of 9342 offenders ranging in age from 15.5 to 37.5 years (Durand et al., 2017). This review revealed prevalence rates of offenders that reported previous traumatic brain injury were 9.7% to 100% with an average of 46% (Durand et al., 2017). There was only one study in the research by Durand and colleagues that revealed a prevalence rate of 100%. This was a study conducted by Lewis et al. (1986) to examine the prevalence of TBI and mental illness in death row inmates. The sample consisted of fifteen inmates condemned to death, thirteen men and two women, in five different states (Lewis et al., 1986). All participants were examined with neurobattery and underwent extensive record review, i.e., CTs, educational records, hospital records, and previous testing. All fifteen inmates had a history of at least two brain injuries and most of them had sustained more than four over their lifetime (Lewis et al., 1986). Every inmate had sustained brain trauma during childhood and adolescence and all the injuries could be corroborated by family and/or medical records and/or visible physical injuries (Lewis et al., 1986). Thirteen of the fifteen inmates reported continued neurological and/or physical symptoms from these injuries including seizures, paralysis, visual, and cognitive deficits (Lewis et al., 1986). On neurobattery, 7/12 scored below 90, which indicates borderline intelligence deficiency (three participants had no result listed). All had record of mental illness stemming from after sustaining the brain trauma, including mania, psychosis, suicide attempts, and psychiatric hospitalizations (Lewis et al., 1986).

To add to the relevance of the research conducted by Lewis et al. (1986), Freedman and Hemenway (2000) examined a death row sample of sixteen inmates in California. Each participant was interviewed, and extensive background research was conducted for post-conviction investigation purposes including school, medical, and legal records. Twelve out of sixteen inmates had lifelong histories of traumatic brain injury and cognitive impairment (Freedman & Hemenway, 2000). Seven out of twelve inmates had a history of severe beatings causing unconsciousness, blackouts, headaches, mood changes, etc. (Freedman & Hemenway, 2000). The importance of the research conducted by Lewis et al. (1986) and Freedman and Hemenway (2000) cannot be overstated. These studies highlight the close association of traumatic brain injury, particularly cumulative TBI, and the potential for aggression and violence with corroborated evidence of injury, not just participant reports. The Lewis et al. (1986) sample highlighted the close association between pediatric brain injury and the potential for anti-social aggressive behavior with resulting violence.

Recidivism

Recidivism among offenders with traumatic brain injury is an issue that is often overlooked. Research conducted by Bonow et al. (2018) examined 6894 participants with traumatic brain injury to examine if those with TBI were at higher risk of subsequent offending post injury. Criminal records were assessed in the last five years post injury and 24.3% of the sample had sustained severe TBI based on GCS at time of injury (Bonow et al., 2018). Post hoc analysis was conducted to examine two groups: 25 years younger and 25 years and older. The greatest association was seen in the age group 25 years and older with unintentional injuries that influenced risk of arrest (Bonow et al., 2018). The TBI group had been arrested over five times as frequently as the participants in the uninjured group and the TBI group was at significantly greater risk for arrest due to violent offense (Bonow et al., 2018).

A study was conducted by Ray and Richardson (2017) to explore recidivism after traumatic brain injury among inmates in Marion County within the Indiana State Prison System. Over a thirty-day period all inmates were screened with neurobattery for TBI as part of the intake process with a total of 831 inmates screened and a sample of 151 inmates with positive history of traumatic brain injury were identified (Ray & Richardson, 2017). Approximately, 35.2% of the sample reported that their first brain injury had occurred at age fourteen or younger and 12.96% of the sample were coded as having sustained a severe injury (Ray & Richardson, 2017). Follow up data on these inmates was examined at 12 to 30 months of release date back into the community and during the follow up period, 53.64% of the TBI sample had been rearrested (Ray &

Richardson, 2017). Six months following release, 35.19% of the TBI sample had reoffended versus 25.77% of the non-TBI group and those with a history of TBI had a rate of recidivism 1.57 times higher than those who did not (Ray & Richardson, 2017).

Reentering the community after incarceration presents its challenges; doing so with the sequalae of traumatic brain injury makes this transition even more difficult. Nagele et al. (2018) evaluated inmates within the Pennsylvania Department of Corrections to identify the history of traumatic brain injury and determine neurocognitive and behavioral barriers to community reentry. One hundred sixty-three inmates participated in the initial TBI screening with 120 (76%) screening positive for traumatic brain injury (Nagele et al., 2018). Each participant had an average of 3.8 possible TBI events in their past occurring up to 21 years of age (Nagele et al., 2018). Roughly, 27.7% were diagnosed with severe cognitive impairment upon neurobattery with memory and problem-solving deficits seen in 65% and 58% of the sample, respectively (Nagele et al., 2018). The research by Nagele and colleagues (2018) further strengthens the research conducted by Ray and Richardson (2017).

Youth Offending After TBI

Pediatric traumatic brain injury is associated with elevated behaviors and deficits that inhibit proper transition into adulthood, leaving individuals emotionally stunted in emotionally charged situations. Poorly developed social skills and anti-social behavior increases with injury severity and heightens the risk of aggression, arrests, and incarceration. Kennedy et al. (2017) examined the link between pediatric traumatic brain injury and the risk of antisocial behavior. A sample of 10,612 participants who were born between 1991 and 1992 were interviewed and parental reports were gathered to identify TBI, orthopedic injuries and social problems. Eight hundred participants in the sample had sustained a TBI prior to age seventeen and this group had increased odds of substance use and conduct problems (Kennedy et al., 2017). The TBI group participants were also more likely to have committed at least one criminal offense and/or been in trouble with the police since time of injury (Kennedy et al., 2017).

The prevalence of traumatic brain injury within the juvenile justice system has not been fully examined. Due to the lack of screening protocols within correctional systems, an accurate estimate of this issue is not truly known. However, the literature that is published shows a clear picture of how the lack of social awareness and impulse control due to poor cognitive functioning contributes to antisocial behavior leading to potential criminality and incarceration. Case in point, Kaba et al. (2014) examined the prevalence of traumatic brain injury among incarcerated inmates in a juvenile facility in New York City. Over one year, newly admitted inmates were screened with neurobattery and categorized according to injury severity and occurrence, totaling 384 participants. At least one head injury was reported by 67.4% (259) of these inmates and 49.7% (191) were categorized as having sustained at least TBI with loss of consciousness (Kaba et al., 2014). Those participants were also more likely to recidivate, males more likely than females, 73.3% versus 37.5% respectively (Kaba et al., 2014). The incidence of TBI in the jail setting was significantly higher than the rate of the community, 67.4% versus 32% respectively (Kaba et al., 2014).

Chitsabesan et al. (2015) explored the prevalence of TBI within a cohort of juvenile offenders. The sample of ninety-three male offenders were between fifteen and eighteen years old and were examined with neurobattery questionnaires. 76 (82%) of the offenders reported sustaining a traumatic brain injury in their past with 44% reporting continued symptoms (Chitsabesan et al., 2015). Fourteen of the offenders had sustained moderate to severe brain injury and fourteen offenders reported more than three brain injuries in their past (Chitsabesan et al., 2015). 29% reported irritability, 24% reported frustration, and 28% reported poor concentration; all of which can contribute to aggression and anti-social behavior (Chitsabesan et al., 2015). Similarly, Farrer et al. (2013) examined studies regarding youth offenders to find prevalence rates of TBI and aggression. Using meta-analytic techniques, nine studies were gathered with a total of 1524 juvenile offenders (mean age of 15.7 years). 467 (30.6%) of those had a history of TBI and the juvenile offenders had 3.37 times higher odds of having a TBI than the control groups supporting the association between TBI and the potential for criminality (Farrer et al., 2013).

The Brain Injury Research Center of Mount Sinai conducted research in 2017 to examine the prevalence of traumatic brain injury within the Texas youth inmates. Over 4000 offenders, ages 18 to 22, were screened for history of traumatic brain injury occurrence and within the sample, 22% in state facilities and 41% in county facilities reported at least one TBI occurrence in the past (Brain Injury Research Center, 2017). Approximately 79% of inmates in the county correctional facilities and 56% of those in state correctional facilities reported having a brain injury before committing their first offense (Brain Injury Research Center, 2017). The offenders who sustained TBI prior to their first offence were more impulsive, aggressive, and cognitively impaired than the offenders who had offended prior to sustaining a TBI (Brain Injury Research Center, 2017). This is significant data to clearly associate TBI with criminality related to behaviors and cognitive impairments.

Meadham (2013) conducted research to explore risk of offending after self-reported traumatic brain injury during childhood. Ninety-eight male youth offenders, ages sixteen to eighteen, were interviewed regarding criminal history and possible traumatic brain injury events. 73.5% of the sample reported at least one head injury in their past and 17.3% reporting four or more head injury events (Meadham, 2013). The majority of injuries were mild, 38.9%, and 16% were moderate/severe (Meadham, 2013). The mean age of first conviction was thirteen and the mean number of convictions was 9.45 (Meadham, 2013). Post-concussion symptoms (forgetfulness, poor concentration, difficulty recalling items) were a significant predictor of reactive aggression and total number of convictions (Meadham, 2013).

Moore et al. (2014) examined the prevalence of traumatic brain injury among incarcerated juvenile offenders and the resulting offending behaviors. The sample consisted of 316 juvenile inmates with an age range of thirteen to twenty-one years. 32% reported a traumatic brain injury in their past with 13% reporting two or more (Moore et al., 2014). 92% of injuries were mild with 8.2% being categorized as moderate/severe (Moore et al., 2014). Those reporting a TBI were significantly more likely to have been incarcerated for twelve months or longer, recidivate with three or more arrests in their lifetime, and to have reoccurring episodes of aggression leading to fights (Moore et al., 2014).

Research was conducted by Jackson et al. (2017) to explore relationships between pediatric brain injury and subsequent criminal offense. Participants were gathered from a longitudinal cohort containing 2893 children ages birth to seven and 120 (4%) of that cohort had sustained a TBI (Jackson et al., 2017). Information gathered included neurobattery that had been conducted when the participants were seven years old and criminal records obtained from the Rhode Island Department of Corrections. Results showed that compared to controls the TBI group had 1.5 times the rate of arrests and conduct problems through age 33 (Jackson et al., 2017). The severe injury group had more than twice the rate of juvenile arrests than controls and showed strong association with adult behavior problems and lifetime arrest risk (Jackson et al., 2017).

The association between pediatric traumatic brain injury and criminal offending is not just a national concern. Researchers on an international level are investigating the links between pediatric TBI and the risk of resulting criminality. Case in point, Hughes et al (2015) reviewed research from various national studies within the United States, United Kingdom, and Australia and discovered the rate of traumatic brain injury among youth inmates (ages fourteen to eighteen) was 32% to 72.1% compared to 5% to 24% identified in self-report surveys from same age controls, suggesting a fourfold increase between incarcerated versus community dwelling individuals (Hughes et al, 2015). Fourteen inmates under eighteen who were on death row all reported traumatic brain injury in their past (Hughes et al, 2015). In Australia, Schofield et al. (2015) explored traumatic brain injury as a risk factor for criminal behavior in juvenile offenders. The sample consisted of 7694 individuals who had sustained a TBI at a mean age of 6.9 to 10.6 years and the age of follow up in the study was 12.5 to 16.6 years (Schofield et al., 2015). Compared to controls, traumatic brain injury significantly increased the risk of offending including violence offenses (Schofield et al., 2015).

Ryan and colleagues (2015) conducted longitudinal research on children admitted to a Melbourne Australia hospital with traumatic brain injury to investigate rates of externalizing behaviors at sixteen years post injury. Initially, 172 children under twelve were enrolled at admission but sixteen years later, only 55 of them could be located and continued to participate. Age range at sixteen year follow up was sixteen to thirty years and neurobattery had been conducted at enrollment and at sixteen years later (Ryan et al., 2015). Rates of externalizing behaviors among the TBI group after sixteen years was significantly elevated and was associated with poor communication and functioning skills (Ryan et al., 2015). The elevated association of externalizing behaviors among the sample predicted persistent offending patterns and risk of arrest/incarceration (Ryan et al., 2015).

Longitudinal research has been utilized to demonstrate the association between pediatric traumatic brain injury and criminality. As such, a study was conducted by Fazel et al. (2011) on a Swedish cohort over a 35-year span to examine the prevalence of criminality among individuals who had sustained pediatric traumatic brain injury. A sample of 22,914 individuals were gathered from the Swedish National Registry, born 1958 to 1994, and had sustained a traumatic brain injury based on national medical record (Fazel et al., 2011). This sample was then examined for criminal record within the national database. Of the sample, 2011 (8%) committed a violent crime after being diagnosed, which was a three-fold increase compared to the general population (Fazel et al., 2011). Participants with focal injuries had higher rates of criminality than those with diffuse injuries (Fazel et al., 2011). This study was significant in that the sample size was seven times larger than that of previous studies with similar outcomes, which strengthens the association between TBI and criminality.

Williams et al. (2018) conducted meta-analysis of studies that examined pediatric traumatic brain injury and risk of violent crime. Several studies were noted for longitudinal research on birth cohorts that were followed for an extended period of ten to fifteen years. The rate of TBI that occurred within the juvenile offenders in the samples was 30% to 60% (Williams et al., 2018). Those who had sustained a traumatic brain injury prior to age seventeen were four times more likely to have displayed offending behavior as an adult (Williams et al., 2018). Higher numbers of post injury arrests were linked to more severe injuries and loss of consciousness. TBI was associated with earlier age of arrest, incarceration, risk of violence, and more convictions (Williams et al., 2018).

Continuing this theme, McKinlay et al. (2014) explored a birth cohort of individuals with traumatic brain injury to evaluate the association between TBI and criminal offense. Longitudinal data was examined from the cohort over a 25 year span where 1265 children born in 1977 participated in the study and were followed up each year with questionnaires (McKinlay et al., 2014). At age 25, participants were questioned about any TBI events in their past and whether they had obtained treatment for that injury. These injuries were researched with hospital records with 266 participants having a verifiable traumatic brain injury event from birth to 21. 91% (243) sustained a mild traumatic brain injury while 9% (23) participants sustained a moderate/severe injury (McKinlay et al., 2014). Subgroups were identified based on when the injury occurred: birth to five, six to fifteen, and sixteen to twenty-one years of age and data from all the years of questionnaires and parental reports were analyzed. The participants who were hospitalized for their injuries were twice as likely to have drug and alcohol dependence (McKinlay et al., 2014). Sustaining a TBI was significantly associated with criminal behavior regardless of severity and the sixteen to twenty-one age group had increased risk of arrests and violent offence (McKinlay et al., 2014). The individuals injured between ages birth to five and six to fifteen were most likely to commit violent criminal offense, were more impulsive, and had a high rate of arrest (McKinlay et al., 2014).

Within this same theme, McKinlay et al. (2014) also examined a sample who had sustained pediatric brain injury to determine increased risk for offending behavior and if increased risk continued into adulthood. Two groups were identified totaling 124 participants who had sustained a traumatic brain injury from birth to seventeen (McKinlay et al., 2014). Participants were all at least five years post injury. Neurobattery was used to assess the participants and during structured interview, participants self-reported criminal/arrest history. Compared to controls, those in the moderate/severe injury group were more likely to have a criminal history and/or arrest record and scored significantly higher on the aggression scales (McKinlay et al., 2014).

Vaughn et al. (2014) studied youth offenders to explore if a history of traumatic brain injury was a risk factor to impulsivity resulting in juvenile offense. The sample consisted of fourteen to eighteen-year-old offenders that had been convicted of serious criminal offense in the juvenile courts totaling 1354 participants and of these participants, 30.35% responded YES to having a previous traumatic brain injury (Vaughn et al., 2014). The research found that the offenders with a history of TBI displayed higher rates of impulsivity and negative reactions to emotional encounters versus controls and the TBI group showed significance for higher levels of impulsivity and poor emotional control (Vaughn et al., 2014).

Research by Luukkainen et al. (2012) explored the connection between traumatic brain injury and criminality within an adolescent psychiatric facility in Finland. The sample consisted of 508 inpatients, ages twelve to seventeen. The study method included examination of admission data, medical records, and Finland’s national criminal registry. Prevalence of hospital treated TBI within the sample was 5.1% (26) and having a TBI was significantly associated with having a criminal record (Luukkainen et al., 2012). 53.8% of the TBI group had a criminal record versus 14.7% of the non-TBI group (Luukkainen et al., 2012). The TBI group had a higher incidence of committing violent crime, 42.9% versus 9.1% (Luukkainen et al., 2012). Having a TBI increased the likelihood of committing a crime 6.8-fold, the likelihood of committing a violent crime 5.9-fold, and the risk of conduct disorder up to 19-fold (Luukkainen et al., 2012).

Glenn and Raine (2014) analyzed studies conducted to explore neurobiological explanations for criminality. As in the studies mentioned in this review, Glenn and Raine reinforce the importance of the structures within the frontal lobe for regulating behavior and emotions. In particular, the anterior cingulate for conflict monitoring and avoidance learning and when damaged, individuals show aggression and disinhibited behavior (Glenn & Raine, 2014). Trauma to the amygdala region results in antisocial behavior with blunted emotional responses and reduced empathy (Glenn & Raine, 2014). Individuals that are injured prior to age twelve start offending earlier than those who sustained an injury after age twelve (Glenn & Raine, 2014). Research in Sweden noted a threefold increase in violent crime during adulthood after a childhood or adolescent TBI had occurred (Glenn & Raine, 2014). Similar research in Finland revealed a 1.6-fold increase, reinforcing that interrupted neurodevelopment can provide identifying factors for future antisocial behavioral outcomes.

Sexually Criminal Offending

There are gaps in the scientific research related to TBI and criminality specifically, TBI and its association with sexual criminal offenses. Sexual crimes occurring among the average adult population has been heavily researched; however, research related to the TBI community in relation to sex offense is quite scarce. Hypersexuality occurring after traumatic brain injury in adults has been explored, but sexual offenses committed by individuals with traumatic brain injury has yet to be truly examined. Connections between pedophilia and brain lesions has been discussed in research conducted by Mendez and Shapira (2011) in an adult sample. All participants in the sample were found to show pedophilic preferences and have frontal lobe or limbic system dysfunction due to lesion or disease (Mendez & Shapira, 2011). Lesions involving the cingulate region have been known to produce genital sensations in men and women that often brought on the urge for masturbation (Komisaruk & del Cerro, 2015). Impulsivity and disinhibition due to TBI inhibit the ability to control these sensations and urges, leading to the potential for sexually inappropriate behavior and sexual criminal offense.

Simpson et al. (1999) conducted a study of clients who attended a traumatic brain injury rehabilitation center for treatment. A sample of 445 participants were identified to explore the extent of sexual offending incidence after TBI. The age at the time of the study was 19 to 61 years and age at the time of injury was 4 to 58 years (Simpson et al., 1999). Researchers noted that only two of the participants were injured under ten years old and all others were injured at sixteen or older. Out of the total 445 participants sample, 29 (6.5%) had committed some form of sexual offense (Simpson et al., 1999). The most common offense was inappropriate touching, followed by exhibitionism and sexual aggression (Simpson et al., 1999). Limits to this study were that researchers did not report on which area of the brain was injured and the relationship between age and behavior within the sample of sexual offenders; these data points would have been helpful to identify outcomes with more specificity (Simpson et al., 1999).

Langevin (2006) studied a sample of 901 male adult sexual offenders to examine rate of occurrence for TBI within a forensic psychiatric setting. A total of 476 of those offenders screened positive for traumatic brain injury with 49.3% of that sample having at least one incident of loss of consciousness in their past (Langevin, 2006). Neuropsychological testing was reviewed on 168 cases and CT/MRIs were reviewed on

80 cases along with offender interviews. More of the TBI group had problems with alcohol consumption (59.4% versus 38%) and the TBI group was more prone to violence (48.5% versus 31.7%) compared to the control group (Langevin, 2006). Half of the sexual offenders had sustained a head injury leading to unconsciousness prior to the commission of their sexual offense and TBI group displayed more violence against strangers and exhibitionist behavior than controls (Langevin, 2006). Limits to this study were that researchers were unable to accurately group the offenders by injury severity and did not have sufficient data to examine the area of injury in the brain for the entire sample.

Simpson et al. (2001) noted that sexually inappropriate behavior is seen in approximately 8% of men post traumatic brain injury. Research was conducted by Simpson et al. (2001) on 25 male participants that were post traumatic brain injury, had a mean length of PTA of 87 days, and were all injured after age eighteen. It was hypothesized that a significantly higher percentage of the SIB group would have frontal lobe dysfunction than controls and that the neuropsychological findings would corroborate the neuroradiological findings (Simpson et al., 2001). Each participant in the SIB group had committed one or more of the following offenses: voyeurism, exhibitionism, frotteurism, toucherism, or overt sexual aggression (Simpson et al., 2001). Neuroradiological data used were CT scans completed on each participant within thirty days of initial injury. Results showed incidence of sexual offense was significantly higher in the SIB group (Simpson et al., 2001). The neuropsychological profiles of the SIB group showed significantly higher levels of frontal system dysfunction, both cognitively and behaviorally, due to damage, which is attributed to the origins of the SIB (Simpson et al., 2001). Only participants in the SIB group displayed conduct disorder behaviors such as making sexual comments and/or attempting to touch the examiner or physically threatening the examiner.

Rarer still is any research involving the relationship between pediatric brain injury and criminal sexual offense. Only three studies could be located within the current research that examined associations between pediatric traumatic brain injury and sexual criminal offense. A study by Langevin and Curnoe (2011) was conducted with 1,695 adult male sexually violent inmates to examine predictors of recidivism. Participants ranged in age from 12 to 84 years and were examined with PCL-R and neurobattery. The sample had a mean 2.65 sexual offenses and a mean 7.6 total offenses each (Langevin & Curnoe, 2011). The researchers found that neurodevelopmental insults that occurred during childhood development were related to criminal violence and psychopathic tendencies (Langevin & Curnoe, 2011). Brain dysfunction was a significant predictor of recidivism and being rendered unconscious at least once as a child was a predictor of sexual offense recidivism (Langevin & Curnoe, 2011). ADHD was also found to be a significant predictor of general recidivism and those who have suffered a traumatic brain injury often display ADHD symptoms (Langevin & Curnoe, 2011). This research reported the data related to potential age at time of injury but did not report severity or location of brain injury.

Blanchard et al. (2002) touched on this research gap by exploring the association of childhood traumatic brain injury and pedophilia. It was theorized that TBI during childhood increased the likelihood of pedophilic activity in males. The sample consisted of 1,206 participants, with a mean age of 34.88 years, that were referred to a sexology lab due to illegal sexual behavior (Blanchard et al., 2003). Each participant was examined with neurobattery and phallometric testing. 10.6% of the pedophilic participants reported sustaining traumatic brain injury prior to age six versus 4.5% of the non-pedophilic participants (Blanchard et al., 2003). Additionally, Blanchard et al., (2003) examined men who had committed pedophilic sex offenses to determine the significance of pediatric brain injury to their criminality. The sample was gathered by referral from parole, probation, or other legal source related to the participants sexual offending history. Researchers hypothesized that the pedophilic participants would be more likely to report traumatic brain injury occurrence before their thirteenth birthday (Blanchard et al., 2003). A sample of 685 participants underwent neuropsychological battery, companion interview, and phallometric testing (Blanchard et al., 2003). The sample was divided into pedophiles (70), hebephiles (225), teleiophiles (133), and undetermined (257). The pedophile group reported more incidence of TBI prior to age thirteen than the other participant groups (Blanchard et al., 2003). Overall, head injury reported after thirteen was associated with drug abuse and promiscuity (Blanchard et al., 2003). In these studies, the area of brain injury and severity of injury was not gathered nor reported. The research conducted by Blanchard et al., (2002) and Blanchard et al., (2003), demonstrate association between the risk of pedophilia and the disruption of neurodevelopment due to pediatric traumatic brain injury.

According to research by Finkelhor et al. (2009), the rate of juvenile sex offense rises around age 12 and plateaus after age 14 with 38% occurring between ages 12 to 14 and 46% occurring between ages 15 to 17. Juveniles account for 35.6% of offenders known to police departments to have committed sexual offenses against other juveniles and 63% of these juveniles are likely to reoffend within 36 months of release (Finkelhor et al., 2009). As seen in the research by de Sousa et al. (2012), Decety et al. (2013), Rosenberg et al. (2018), Ryan et al. (2017), Schlitz et al. (2013), Prasad et al. (2017), and Spikman et al. (2013), traumatic brain injury with frontal lobe injury can impair the ability to recognize facial expressions/emotions and reduce empathy. This can increase the risk of social misunderstandings leading to violence and/or sexual criminal offense. The research conducted by Bannon et al. (2015), Freedman and Hemenway (2000), Kumar et al. (2019), Lewis et al. (1986), Tomaszewski et al. 2014), Wood and Worthington (2017), Cristofori et al. (2015), Sabaz et al. (2014), Schlitz et al. (2013), and Langevin and Curnoe (2011) reinforces the association between TBI and aggression which can also lead to social disturbance with the potential for sexual criminal offense. Decety et al. (2013), Freedman and Hemenway (2000), Glenn and Raine (2014), Lewis et al. (1986), and Schlitz et al. (2013) also demonstrated the association between frontal lobe dysfunction and impaired emotional response with lack of empathy and impulse control.

Previous studies regarding TBI, SIB, and sexual criminality have not focused on pediatric injuries. James et al. (2015), Simpson et al. (2013), and James and Young (2013) explored the correlates of sexually inappropriate behavior and physical/verbal aggression after traumatic brain injury but this data did not focus on pediatric samples. These studies examined individuals after TBI and the occurrence of SIB with other symptoms such as verbal and/or physical aggression, and found they reflected separate clinical phenomena (James et al., 2015; James & Young, 2013). These studies cast a wide net of participants by age, focusing on generalizing the occurrence of these behaviors after TBI at any age. Disclosing the ages at which the participants were injured would have provided the opportunity to perhaps distinguish between pediatric versus adult injury and the prevalence therein. Langevin and Curnoe (2011) examined the prevalence of traumatic brain injury within an adult sexual offender group but cast a very wide net as a sample. A small percentage of the group were injured as children, but the study does not give any specifics related to those data points. Blanchard et al. (2003) examined the correlates of pediatric traumatic brain injury and pedophilia and while these studies are statistically significant to associate pediatric TBI with sexual criminal behavior, they are narrowing the scope of criminal behavior to only one type of crime. Additionally, Blanchard's research was based on participant reports and not actual confirmed data regarding age at injury.

Summary

Clear associations have been made within the research between pediatric traumatic brain injury and frontal lobe syndrome. Pediatric brain injury is associated with the potential for disinhibition, lack of impulse control, poor emotional empathy/response, aggression, and impaired judgement that can lead to socially maladaptive behaviors and the risk of criminal offense, including sexual criminal offense. Examining the research conducted by Blanchard et al. (2002), Blanchard et al. (2003), and Langevin and Curnoe (2011) clearly shows a connection between pediatric TBI and SIB. The key component missing in the Blanchard et al. (2003) research is that it only examined one type of sexual crime, pedophilia, and no other types of sexual crimes that are likely to be committed by individuals with cognitive impairment or lack of emotional recognition. The Langevin and Curnoe (2011) study is lacking data regarding severity and/or location of brain trauma.

The study addressed the gap in the literature regarding the association between pediatric traumatic brain injury and sexual criminal offense by examining the severity of the TBI, location of TBI within the brain, and age at which the TBI occurred. It is hypothesized that individuals who sustained severe frontal lobe injury prior to age 19 are more likely to have committed at least one act of sexual criminal offense than controls. Individuals with a combination of pediatric traumatic brain injury, frontal lobe syndrome, and criminality, are at high risk for committing sexual criminal offense due to the overwhelming research presented.

Chapter 3 addresses the study's methods and design as well as an explanation and justification for the study. It includes the rationale for the design, description of the population and sample to be studied, data collection, and the intended data analysis procedures. Chapter 3 concludes with a summary of the ethical procedures that were taken to protect the research participants.

Chapter 3: Research Method

Introduction

The purpose of this study was to explore the potential relationship between pediatric traumatic brain injury and SIB leading to criminal sexual offense as an adult. This study explored specifically if injury severity, location of brain injury, and age at the time of injury has an effect on SIB as an adult that leads to sexual criminal offending. This chapter describes the methodology that was utilized in the study. This chapter also explains the study's rationale and research design, the sample and population that was utilized, instrumentation, procedures for data collection and analysis, and the measures taken to ensure the ethical protection of the data used for research.

Research Design and Rationale

The variables of this study addressed the potential of a relationship between pediatric TBI and SIB that leads to sexual criminal offending. The variables that were examined are the age at which the injury occurred, severity of injury, and location of the brain injury within the brain. The independent variable (IV) under consideration in this study is the diagnosis of pediatric traumatic brain injury sustained at age twenty or younger versus control group. The dependent variables (DV) in this study are the age of participant at the time of injury, severity of the injury, and location of injury within the brain.

A multiple regression test was conducted to examine the statistical effect of pediatric traumatic brain injury and/or the severity of that injury, location of injury, and age of injury, and the probability of committing a sexual criminal offense. This would be a 2x2 factorial design that examines two independent variables with three dependent variables (Mohammed et al., 2017). Post hoc tests can be conducted to provide more information about the variations that are found within the analysis (Mohammed et al., 2017). There are no known time constraints consistent with this design choice.

Methodology

Population

The setting for the research study was archival utilizing records from multiple medical facilities within the State of Michigan that specialize in the treatment of traumatic brain injury. The population for the study consisted of resident case files. The sample included residents who had sustained a severe traumatic brain injury between three and twenty years of age. Disqualifying factors were premorbid history of any congenital disorders (i.e., Autism or Cerebral Palsy), neurodisease, (i.e. Multiple Sclerosis) and/or mental illness.

Sampling and Sampling Procedures

The qualifying participant pool could have been potentially quite large, reaching over 500 case files. Power analysis was used to determine the amount required for the study to avoid statistical inconclusion due to sample size being too small (Suresh & Chandrashekara, 2012). G*Power was used to design the test and determine the required sample size. Degrees of Freedom was set at 3 to represent the count of data that is allowed to vary. The statistically acceptable error rate was set at 0.05%. Power level was set at 80% to allow for statistical significance while keeping the sample size realistic.

With these parameters placed in G*Power, the recommended sample size was at least 55 participants.

Archival Data

Data collection was done through archival research, so no personal contact was made with participants; however, gathering this protected medical information required legal consent under the Health Insurance Portability and Accountability Act (HIPAA). Consent was obtained from each participant and/or participant's guardian by using a form developed for this study. This was conducted on the premises of the residential facility to maintain HIPAA compliance. Data points were recorded by hand from residential facility records. Appropriate steps were taken to maintain confidentiality of residential files and no identifying information was attached to any set of data points. All data remains anonymous and will be stored in a locked filing cabinet in my office.

Operationalization

Traumatic brain injury is defined as any injury to the head that results in long term physical, emotional, cognitive, and/or behavioral impairment. The sexual criminal offense variable is described as any offense that is sexually based in nature but could also be deemed criminal. Within the residential setting, criminal charges are usually not pursued and behavioral interventions are utilized to control the behavior. Potential offenses are inappropriate or unwanted touching or grabbing, which are common behaviors for many individuals diagnosed with a traumatic brain injury.

Data Analysis Plan

A multiple regression test was used to analyze the data collected. No covariates or confounding variables were used. Results were interpreted using SPSS Data Analysis Software.

Research Questions and Hypotheses

1. *Does sustaining a traumatic brain injury prior to age 20 have an effect on SIB leading to sexual criminal offense?*

    H0: Sustaining a TBI prior to age 20 has no effect on the probability of sexual criminal offending.

    HA: Sustaining a TBI prior to age 20 has an effect on the probability of sexual criminal offending.

2. *Does the severity of injury have an effect on SIB leading to sexual criminal offending?*

    H0: Severity of injury has no effect on the probability of sexual criminal offending.

    HA: Severity of injury has an effect on the probability of sexual criminal offending.

3. *Does the location of the trauma within the brain have an effect on SIB leading to sexual criminal offending?*

    H0: Location of the trauma has no effect on sexual criminal offending.

    HA: Location of the trauma has an effect on sexual criminal offending.

Threats to Validity

Threats to external validity in this study were minimal due to the use of archival research. Data was collected from the participant medical record held within the facility. These records were created by a combination of medical staff, family statements, patient memory, and other entities that have interacted with the participant. Potential error could have occurred while medical staff was charting or through inaccurate patient or family reporting of events. Threats to internal validity lie in the potential for error within the quantitative calculations. Care was taken to ensure that proper calculating methods were utilized, along with a secondary check of results for accuracy.

Ethical Procedures

Ethical considerations for this study were minimal. The data collected was archival; participants were not interviewed or tested. All data will remain anonymous. Data was obtained and maintained under HIPAA guidelines. All paper and electronic data will be maintained in a locked filing cabinet in my office. There were no rewards or incentives offered or given for participation in this study.

To initiate this research, I submitted Form A to Walden University's Institutional Review Board (IRB). The IRB is responsible for maintaining ethical compliance in accordance with U.S. Federal Regulations. An IRB representative reviewed this proposal to ensure the benefits outweigh any risk or harm to potential participants. This process precedes all data collection and analysis.

Summary

This chapter describes methods and processes for a quantitative study of the effect of pediatric traumatic brain injury on the potential for sexual criminal offense. Archival research was collected for analysis of this effect and a Chi Squared with Goodness of Fit test was used to analyze collected data. Data analysis includes comparison of predictor variables (pediatric traumatic brain injury and location of injury) and criterion variable (sexual criminal offense). G*Power analysis revealed a potential population of 55 which was gathered from residential living facilities in the State of Michigan. In chapter 4, the results of the study will be presented and the outcomes of potential correlations between variables will be discussed.

Chapter 4

Introduction

This study examined the relationships specifically between individuals that sustained a pediatric brain injury and sexual criminal offending as an adult. It explored the specific relationship between pediatric TBI and SIB leading to criminal sexual offense. Specifically, whether the age at the time of injury, the severity of injury, and/or the location of injury within the brain could have a direct correlation with the increased probability of sexual criminal offending later in life. There is a lack of scientific literature that confirms or denies the relationship between these entities.

This chapter explains the origin of the participant pool, selection process, and the process of data collection for the study. It reviews and analyzes research questions and hypotheses. Data analysis was completed through SPSS and results are presented. Validity, reliability, and assumptions are addressed.

Data Collection

The data collection strategy for this proposed study was to examine archived case records from a large group of TBI survivors of various ages and varying injury severity. Participant records were accessed through multiple medical entities in Southeast Michigan. Data collection was completed through archival research, so no personal contact was made with participants; however, gathering this protected medical information required legal consent under the Health Insurance Portability and Accountability Act (HIPAA). Written consent was obtained from each participant or participant guardian by using a form developed for this study. Data points were recorded by hand from residential facility record. Appropriate steps were taken to maintain confidentiality of residential files and no identifying information is attached to any set of data points.

Data was collected over a period of about 6 weeks. Participants were asked to voluntarily participate by signing a waiver. Participation entailed allowing access to their medical data for the purpose of gathering data points. Through archival screening, ninety-six people were identified as meeting study criteria. Fifty-six respondents gave written consent for participation with forty respondents either not responding or declining to participate. G-Power suggested utilizing 55 participants for validity purposes.

Data set was created and cleaned. Data points collected were gender, age at time of injury, location of injury, severity of injury, inappropriate behavior/aggravation (IB/AGG), sexually inappropriate behavior (SIB), and criminal sexually inappropriate behavior (SIB CRIM). Location of injury was categorized as frontal, temporal, occipital, or anoxic. Severity of injury was categorized as mild, moderate, or severe. Inappropriate Behavior/Aggressive Behavior Aggression (IB/AGG) was categorized as any behavior outside of social norms and/or unwarranted emotional aggravation with others (i.e., yelling, swearing, aggressive verbal or physical contact, etc). Sexually Inappropriate Behavior (SIB) was categorized as any sexual conduct/behavior that was not consented to (i.e., touching, verbal statements, etc). Criminal Sexually Inappropriate Behavior (SIB CRIM) was categorized as any sexual behavior that resulted in arrest and/or criminal charges that may or may not have been dismissed. There were no deviations from the planned data collection method.

Using SPSS, multiple regression tests were conducted to examine the statistical effect of pediatric traumatic brain injury and/or the severity of that injury, location of injury, and age of injury, and the probability of resulting aggressive behavior, sexually aggressive behavior, and/or committing a sexual criminal offense.

The assumptions in this study were minimal but require recognition to account for reliability and validity. Due to this study utilizing secondary data, validity was assessed for reliability of the data collected (Mohajan, 2017). The data set was gathered from participant medical records within the residential facility in which they reside. Accurate reporting of participant record is the responsibility of the facility and other medical entities that had previously treated the participant. Some information within those records is from family and clinician reports. This study assumed that the fifty-six records were accurate and historical. It assumes that clinicians reported proper information and that all appropriate data was collected during treatment. Some data needed for this study was unavailable due to poor participant record. For the data regarding location of injury within the brain, it was assumed that the most appropriate and sophisticated testing methods were used for the time period in which that the injury occurred. These assumptions are necessary for the validity of the study results.

Results

Data analysis plan for RQ1- A multiple regression test was run with SPSS to analyze the independent variable, Sexually Inappropriate Behavior, with the dependent variable, Age.

RQ1- *Does sustaining a traumatic brain injury prior to age 20 have an effect on SIB leading to sexual criminal offense?*

A logistic regression analysis to investigate if sustaining a traumatic brain injury prior to age 20 has an effect on SIB leading to sexual criminal offense was conducted. The dependent variable was Sexual Criminal Behavior and the predictor variable, Age was tested a priori to verify there was no violation of the assumption of the linearity of the logit. The predictor variable, Age, in the logistic regression analysis was found not to contribute to the model. The unstandardized Beta weight for the Constant; B = [-1.306], SE = [1.126], Wald = [1.347], p = .246. The unstandardized Beta weight for the predictor variable: B = [-.058], SE = [.075], Wald = [.613], p = .943. Therefore, I reject the alternative hypothesis that sustaining a traumatic brain injury prior to age 20 has an effect on SIB leading to sexual criminal offense and retain the null hypothesis that sustaining a traumatic brain injury prior to age 20 does not have an effect on SIB leading to sexual criminal offense. Similar results were found for RQ3.

When examining the data, participants that displayed all levels of behavior varied in age from 2-20 years of age and participants who only displayed inappropriate/aggressive behaviors varied in age from 3-20 years of age. There was no significance found relating to age and resulting behaviors.

RQ2- *Does the severity of injury have an effect on SIB leading to sexual criminal offending?*

H0: Severity of injury has no effect on the probability of sexual criminal offending.

HA: Severity of injury has an effect on the probability of sexual criminal offending.

A logistic regression analysis to investigate if the severity of injury has an effect on sexually inappropriate behavior leading to sexual criminal offense was conducted. The dependent variable was Sexual Criminal Behavior and the predictor variable, Severity was tested a priori to verify there was no violation of the assumption of the linearity of the logit. The predictor variable, Severity, in the logistic regression analysis was found not to contribute to the model. The unstandardized Beta weight for the Constant; B = [-1.306], SE = [1.126], Wald = [1.347], p = .246. The unstandardized Beta weight for the predictor variable: B = [-.058], SE = [.075], Wald = [.613], p = .943. Therefore, I reject the alternative hypothesis that the severity of the traumatic brain injury has no effect on SIB leading to sexual criminal offense and retain the null hypothesis that the severity of traumatic brain injury does have an effect on SIB leading to sexual criminal offense.

Three levels of injury severity were examined: mild, moderate, and severe. For every level of increased injury, the odds ratio for aggressive behavior increases by 163.9%. Seventy percent (41/58) of participants had suffered a severe injury, 18% (11/58) had suffered a moderate injury, and 10% (6/58) had suffered a mild injury. Of the 29 participants that displayed inappropriate/aggressive behavior, 86% (25/29) had suffered a severe injury. Of the 12 participants that displayed sexually inappropriate/aggressive behavior, 75% (9/12) had suffered a severe injury. All six of the participants who had displayed criminal sexually inappropriate behavior had suffered a severe injury.

RQ3- *Does the location of the trauma within the brain have an effect on SIB leading to sexual criminal offending?*

H0: Location of the trauma has no effect on sexual criminal offending.

HA: Location of the trauma has an effect on sexual criminal offending.

A logistic regression analysis to investigate if the location of the trauma within the brain has an effect on SIB leading to sexual criminal offense was conducted. The dependent variable was Sexual Criminal Behavior and the predictor variable, Age, was tested a priori to verify there was no violation of the assumption of the linearity of the logit. The predictor variable, Age, in the logistic regression analysis was found not to contribute to the model. The unstandardized Beta weight for the Constant; B = [-1.306], SE = [1.126], Wald = [1.347], p = .246. The unstandardized Beta weight for the predictor variable: B = [-.058], SE = [.075], Wald = [.613], p = .943. Therefore, I reject the alternative hypothesis that the location of the trauma within the brain has an effect on SIB leading to sexual criminal offense and retain the null hypothesis that the location of the trauma within the brain does not have an effect on SIB leading to sexual criminal offense. Similar results were found for RQ1.

When examining the data, it was determined that a large number of the total participants had suffered a frontal lobe injury (50 of 58). Therefore, validity was challenged when examining how IB/IGG/SIB was affected by the location of injury. To truly examine this question validly, more participants with frontal, occipital, temporal, or anoxic injuries should be gathered in equal numbers for best results.

Summary

My initial hypothesis for this scientific study was that RQ1: age of the participant at the time of injury and/or RQ2: location of the injury would have a direct effect on future aggressive behavior and/or sexual criminal offending as an adult. In contrast, the severity of the injury is the catalyst for the reported behaviors. While working in the clinical realm, location and age seemed to create patterns with the clients; however, this study showed no statistical significance for age at time of injury and location of the injury. Given the frontal lobe is the center that provides emotion and behavior control, it was a surprising finding.

The study showed that RQ3: severity of the injury was statistically significant and was the biggest indication of future aggressive behavior that could lead to sexual criminal offense. It revealed a probability of inappropriate behavior/aggression increasing by 163.9% with each level of severity, mild to severe. All behavior categories revealed that participants with severe injuries were most likely to demonstrate behaviors (IB/AGG 86%; SIB 75%; SIB CRIM 100%.) Working within this field takes on a new perspective with the new data that statically it is the severity of injury that has the most significant effect on post injury behaviors, aggression, and adult sexual criminal offending.

Chapter 5

Introduction

This study examined the relationships specifically between individuals that sustained a pediatric brain injury and sexual criminal offending as an adult. It explored the specific relationship between pediatric TBI and SIB leading to criminal sexual offense. Specifically, whether the age at the time of injury, the severity of injury, and/or the location of injury within the brain could have a direct correlation with the increased probability of sexual criminal offending later in life. There was a lack of scientific literature that confirms or denies the relationship between these entities. This study data found that the severity of the brain injury has the most significant effect on the potential for future IB/AGG, SIB, and SIB CRIM as an adult. This data contradicted the original hypothesis that age at the time of injury would be the most significant factor leading to these behaviors. Upon data review, age and injury location were not statistically significant in causing or predicting aggressive, inappropriate, or criminal behaviors after brain injury.

Interpretation of the Findings

In Chapter 2, the literature review showed that aggressive behavior was likely after frontal lobe injuries, coupled with my clinical experience, created a theory that the location of injury could provide a significant finding. In studies regarding pediatric TBI, researchers found that suffering the injury at a younger age increased the likelihood of inappropriate behavior as an adult but not specifically sexually inappropriate behavior or sexual criminal behavior. In this study, no clinical significance was found between age and location of injury despite the literature review findings. Participants range in age from 2-20 years of age and this study found that a range of behaviors occurred in participants of all ages with no significance. This finding contradicts the literature findings; however, all six participants that displayed the most severe behaviors suffered a severe frontal brain injury.

All injury severity levels demonstrated inappropriate/aggressive behavior; 70% (41/58) severe, 10% (6/58) moderate, and 18% (11/58) mild. More behaviors were seen across the data when speaking of severe injuries. Of the 29 participants that displayed inappropriate/aggressive behavior, 86% (25/29) had suffered a severe injury. Of the 12 participants that displayed sexually inappropriate/aggressive behavior, 75% (9/12) had suffered a severe injury. Fifty-five percent (32/58) of participants suffered a severe frontal brain injury and all six of the participants who had displayed criminal sexually inappropriate behavior had suffered a severe frontal brain injury. The frontal lobe plays a vital role in personality and self-control so an injury to this area would certainly affect the ability to self-monitor and control one's behaviors.

This study does not solve the motivating problem of sexual criminal offending after traumatic brain injury, but it does contribute scientific data to assisting with positive change within the brain injury community. Brain injury awareness and prevention is key to lowering risk and rates of occurrence. Multiple injuries can have devastating consequences for emotional and behavioral responses, especially after frontal lobe injury.

Limitations of the Study

Validity and reliability limitations for this study were of average concern. The data set was gathered from participant medical records within the residential facility in which they reside. Accurate reporting of participant record is the responsibility of the facility and other medical entities that had previously treated the participant. Some information within those records was obtained from family and clinician reports. This study assumed that the records were accurate and historical. It is assumed that clinicians reported proper information and that all appropriate data was collected during treatment. This study's results have broad generalizability because it can be applied to anyone with a traumatic brain injury, no matter the gender, race, ethnicity, or cultural background. No matter the location or setting, the results within that population should be the same.

One limitation of note is that the data was skewed to one side; frontal lobe injury participants made up 49 of 58 participants. A study to potentially examine even numbered groups of participants in each injury severity category to better examine the outcomes for moderate and severe injury participants could produce different findings. There are two additional questions that could be explored in new studies. Does the length of time that has lapsed since the date of injury have an effect on the behavior? Does the length of time that has lapsed since the injury cause the behavior to intensify? Are there any triggers for the behaviors?

The theoretical framework chosen for this study was the Integrated Theory of Sexual Offending. It theorizes that sexual crimes occur as a result of interacting causal variables such as brain development, ecological, and socioeconomical factors (Ward &

Beech, 2006). Lack of brain development and social maturation due to a pediatric brain injury can combine with ecological and socioeconomic factors to provide an antecedent for sexual criminal offending that supports the Integrated Theory of Sexual Offending framework. This framework choice was appropriate for this study because the incident of brain injury combined with socioeconomic factors can lead to socially inappropriate behavior. That inappropriate behavior can lead to larger problems with other entities including law enforcement.

While age at the time of injury was not found to be statistically significant in this study, the Integrated Theory of Sexual Offending framework still applies. The children and adolescents who sustain a brain injury of any severity are still at risk for low brain development and certain socioeconomic factors that can lead to limited resources for care and management of the injury itself. After a pediatric brain injury, it is vital to have the appropriate after care and treatment opportunities to mitigate the injury process and damage. Proper therapies, medications, and interventions are vital to the best outcomes, which may not be available in all areas or within all economic statuses. Without these opportunities being available, the outcomes for these young people are poor and negative behaviors can result in disciplines within the home, schools, or correctional facilities that could have been prevented.

Recommendations

This study found that suffering a severe frontal traumatic brain injury can be a significant factor in predicting future inappropriate, aggressive, or even criminal behavior. The recommendations going forward with this data are two-fold. First is brain injury awareness and prevention, which has grown publicly over the last decade. Secondly, programs and communities need more awareness and potential treatments to be proactive regarding the potential outcomes after these types of injuries. Being reactive to the behaviors of these individuals can be dangerous to them and the community as a whole.

Targets for the information in this study would be the administration within the brain injury residential facilities not only in Michigan but nationwide. Additionally, leaders within the brain injury community such as the Michigan Brain Injury Association as well as the American Brain Injury Association could use this information when lobbying for changes within the facilities and medical laws to protect patients. Better understanding of the behaviors can lead to better outcomes in their treatment. This information can help entities be more proactive with assessments and treatments instead of reactive. The more that is known regarding the area of the brain that is injured and the severity of the injury, the better we can predict behavior patterns.

Further research into the statistically significant results found regarding the severity of injury increasing the chances of aggressive and/or sexually criminal behavior could be helpful in the law enforcement and corrections arenas. Exploring these behaviors within a correctional population would be informational. Meta-analysis of 52,540 adult offenders: TBI prevalence was 45.8% across all studies and 32.0% for moderate-to-severe TBI (Hunter, et., al. 2023). Given that the rate of brain injury occurrence within the correctional population is so high, a better understanding of these behaviors within correctional facilities could only benefit the care of the inmates and the safety of the staff. Delving further into the information found that the chances of aggressive behavior increase dramatically with more severe injuries, could provide better information to assist programs and law enforcement in dealing with people that have documented severe brain injuries. Knowing the potential someone has for aggressive and/or inappropriate behavior can keep the individual and others safe.

Implications

The information discovered in this study could be impactful and positive for social change within brain injury treatment programs, correctional facilities, and communities. Historically, correctional facilities have been resistant to accepting and utilizing behavioral data/information regarding inmates. Furthermore, most states do not screen for brain injury upon admission to the facility. Proper screening and education are imperative to ensure inmate and officer safety. Many inmates in the nation's jails and prisons have suffered at least one traumatic brain injury in the past. This information coupled with proper screening, could be exponentially helpful to the inmate's success within the facility. Inappropriate behaviors that are not properly diagnosed lead to more reprimands and longer sentences. Positive social change can be achieved with the correctional facilities willingness to implement this line of questioning into their screening process. Better understanding of the inmate’s deficits and behaviors will lead to better placement decisions and lower rates of unnecessary disciplinary actions.

An empirical implication of this research includes how it can be implemented into real time screening for correctional facilities. Utilizing this data to develop a nationwide screening tool for use within correctional facilities would allow staff to recognize inmates who have this injury background to provide the appropriate diagnosis upon admission and for development of treatment plans. As previously stated, inappropriate behaviors cause the inmate to be disciplined with the potential of time added to their sentence. Being proactive within the facility due to their diagnosis would help to reduce behaviors that put the inmate, other inmates, and correctional staff at risk.

Another implication that arises is working to provide equal opportunities for care and programming across socioeconomic statuses. Children and adolescents from rural areas and/or poor urban areas are at a disadvantage compared to some due to lack of access to proper screening and treatments within their homes, schools, and communities. Improvements are needed to ensure that everyone has access to appropriate opportunities within their schools and communities for care after these injuries. Proactive measures must be taken to prevent potential poor outcomes within these communities, such as working with schools and community centers to provide guidance and tools to identify these injuries and guide the children to proper treatments programs.

Another implication is for effective use within TBI treatment programs. Currently, programs utilize screening tools to assess patients upon admission to understand severity of injury and potential for behaviors. This data could help them better understand the potential a patient has for behaviors and be proactive to prevent them. This could include avoidance of triggers that cause behaviors and negative consequences for behaviors. Many patients with behaviors are placed on a reward system to obtain positive compliance with tasks such as showering and taking medication. Rewards often include an outing of their choice or small monetary incentive. With the negative behaviors those rewards work in reverse, such as no target behaviors being shown for a week equals a reward, thus taking away the reward when a behavior is witnessed.

Conclusion

This study examined the effects of pediatric traumatic brain injury on adult sexual criminal offending. The results were not what was predicted in the original hypothesis. Data analysis confirmed that the severity of the brain trauma was the significant factor to have an impact on aggressive and/or inappropriate behavior. Clinical experience gave indication that the location of the injury would be a significant factor to dictate behavior. While the sample size was small, the results were an important discovery within the brain injury community. Whether it is in a brain injury treatment program, correctional facility, school, or community setting, it is important to understand the potential behaviors that may arise and be proactive in their treatment. This scientific information can provide a positive impact for social change to assist programs, communities, and individuals alike to improve proactive and protective measures for these vulnerable individuals.

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