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Efficacy of a Minnesota Statute Enacted to Reduce Inflicted Traumatic Brain Injuries

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Abstract

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Abstract

This quantitative research is on the efficacy of Minnesota Statute 144.574 enacted in 2005 in response to the growing awareness of behavior leading to inflicted Traumatic Brain Injuries (iTBI) in infants and children. The model for this research is grounded in the Theory of Reasoned Action wherein the education of new parents which graphically explains physiologic changes to the structural architecture of the brain post-trauma, paired with their signature on a social contract (SC), demonstrated a reduction in incidence. Because the enacted statute does not include the signing of a SC, nor does it require face-to-face education as in the model, Statute 144.574 cannot claim to be completely grounded in medical science. The result is that neither legislators nor the medical and public health community know whether the statute is effective. This research explored the difference in the incidence pre-and post-enactment, in rural vs. urban communities, the proportion of incidence and ethnicity, and an ordinal shift in the distribution of severity. All births in Minnesota from 1998 through 2017 were included. Cases defined using International Classification of Disease were extracted from the brain and spinal cord injury, hospital discharge, and vital statistics, secondary databases. A Z-test was employed to compare the incidence in a control cohort born prior to enactment to the incidence in an interventional cohort born post-enactment. Results suggest the statute has not resulted in lowering incidence, have uncovered an unanticipated statistically significant increase in rural vs. urban incidence, yet point to a trend in favor of less severe iTBI. These results represent a positive social change grounded in society's imperative and social justice of protecting children by informing public health officials, caregivers, and legislators of the need for meaningful reform and strengthening of programs leading to lowering the incidence of iTBI in children in Minnesota.

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Dedication

I dedicate my research to my parents from whom I absorbed a curiosity about the world. My father is a polymath who appreciates theology and science as complementary. My mother was a nurse. This work is in keeping with their urgency to improve the lives of others.

I dedicate the construction and gears of logic herein with appreciation for my brother Theodore who has disassembled almost everything to examine how it works. With the noted exception of grandpa's pocket watch, he is able reassemble everything as well.

To my brother Stewart who continues challenged me to improve my writing through thoughtful feedback, this research project is grounded in issues of social justice.

And, I dedicate the journey and completed dissertation to my wife Carla who continues to support my love of learning.

Acknowledgments

I wish to acknowledge O. Douglas Wangensteen, Ph.D., my Honors Physiology Professor at the University of Minnesota. Dr. Wangensteen offered me space in his lab to perform research and in those three years taught me scientific methods. Dr. Wangensteen was Chair of the University of Minnesota Medical School Admissions committee, yet during many early morning conversations inspired me to choose research and Public Health as my path.

This research project was launched with the support and encouragement of Jon Roesler, Epidemiologist and Director at the Minnesota Department of Health. It was in conversations with Jon Roesler that I began to focus on injuries specifically to the brain. Jon handed me the baton and encouraged me to pursue evaluative research on the efficacy of public health policy to lower the incidence of brain injuries as a primary risk to health.

It is with most sincere gratitude I acknowledge my dissertation committee, Dr. Estes, Dr. McDoniel, and especially my Chair Dr. Raymond Panas, who is both an advocate and a mentor. Without the guidance of Dr. Panas this research project would have remained in the idea stage.

And, I acknowledge Walden University as an institution that encourages scholars to apply what is learned, to make a positive contribution, and seek social justice.

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Chapter 1: Introduction to the Study

At birth, a baby's head is by weight and size approximately one-third of its total body mass (Ogden et al., 2002). The muscles to support the head at birth are not developed (Yin, 1994). The nature of a disproportionately large mass riding on a flexible axis and saddle are prone to mechanisms of rodeo, such as whiplash (Panjabi et al., 1998). The brain itself floats in cerebral spinal fluid inside an oversized skull and is prone to axonal sheering when forces are rapidly applied (Smith, Meaney, & Shull, 2003).

Ontogenetic brain development begins in the fourth month of gestation with neuronal proliferation and organization of structures, and rapidly accelerates (Lan et al., 2000). The second part of gestation is characterized by axonal and dendritic sprouting with the formation of brain synapses and myelination continuing through infancy (de Graaf-Peters, & Hadders-Algra, 2006). Peak synaptic density in the prefrontal cortex may not occur until the age of 4 (Glanz et al., 2007). A brain injury that arrests development is not a singular acute event, the result is a wave of neural degenerative dysfunction and pathological disability (Lozano et al., 2015). Thus, injuries to the brain are annihilative, especially during critical stages of development (Toth et a., 2016).

The focus of this research was to evaluate the efficacy of a Minnesota state statute enacted as an intervention in response to growing alarm about the incidence of brain injuries in children as a primary mission of public health to protect the most vulnerable citizens of the state (Rosen, 2015).

Because the intervention comes in the form of health policy, understanding the grounding and legal authority of the policy cannot be understated. This quantitative research constitutes a

comparison of the incidence of brain injuries in a cohort of children born before the enactment to the incidence of the same cohort born in the state of Minnesota after enactment.

Background

Symptoms of Brain Injury

Symptomatic presentation consists of a composite cluster that may mimic the flu, including malaise, disruption in sleep rhythms, nausea, being sensitive or irritable, may manifest as inability to regulate temperature, changes in appetite, or delayed response to visual or auditory stimuli. Severe cases may present with worsening temperature regulation, respiratory and/or cardiovascular distress, and/or seizures.

Diagnosis

Cases of *traumatic brain injury* (TBI) are objectively characterized by no one clinical or radiographic finding, but rather by a constellation of findings (Duhaime et al., 1987). Diagnosis can be initially established, although not entirely conclusive, on discovery of damage to the retinal folds and retinal hemorrhaging (Gutierrez, Clements, & Averill, 2004; Mungan, 2007). The diagnosis is supported with findings of subdural or subarachnoid hemorrhages along with cerebral edema or brain swelling (Smith, 2003). Computerized tomography is used to confirm axonal injury (Oehmichen et al., 2008). Together, retinal hemorrhage, cerebral edema, and axonal injury form a classic diagnostic triad, each individually pointing to trauma.

Case Definition

The challenge is then to refine the case definition as a constellation of clinical and radiographic findings (Duhaime et al., 1987). The logical tether is the "classic triad”: retinal folds and traumatic retinoschisis characterized by abnormal splitting of the retina’s neurosensory

layers are (nearly) unique to abusive head trauma (Mungan, 2007), subdural or subarachnoid hemorrhages diagnosed with a computerized tomography are objective findings, and one in five cases of child maltreatment and abuse result in axonal injury and fatality (Oehmichen et al., 2008). Yet simply adopting the classic triad as a definition is neither definitive nor does it provide structure, such as allowing for any meaningful comparison across the literature. The International Classification of Diseases (ICD) codes are less subjective, and the use of standardized codes in a case definition serves to disambiguate the patient's condition. Changed in 1999 and beginning in 2012, ICD-10 codes are now used to code fatal cases (Parks et al., 2012). One of the challenges will be to bridge the ICD-9 and 10 codes to refine a case specific to the diagnosis and cause of injury. In emergency medicine, understanding the mechanism of injury, and determining the cause of injury, is part of the triage. Upon presentation to an emergency department or hospital, when the mechanism of injury is known, the case is assigned an external cause or event (E) code (Guyer, Berenholz, & Gallagher, 1990). Additionally, one might expect that when a patient is admitted, the medical records would reflect the mechanism of injury. Yet challenges persist in that state-based datasets use a broad range of criteria to define a traumatic brain injury (TBI) and inconsistently applied external cause (E) codes. Worse, it was found that one out of three hospitalization records were not associated with an E code (Coben, Steiner, Barrett, Merrill, & Adamson, 2006).

In response to the Traumatic Brain Injury Act of 1996, the E code, 995.55, has been used as definitive; 995.55 is both diagnostic and cause code, or either diagnostic and cause code. To test the specificity and sensitivity of 995.55, a study of California hospital inpatient data from 1998 through 2004 compared a strict use of the E code 995.55 which identified 366 cases of

shaken baby, and incidence of 5.1/100,000, with a more broad and inclusive external cause code to review the data. Employing the more inclusive definition and cause codes, more than 1,000 cases met the criteria for abusive head trauma (AHT), an incidence of 14.0/100,000 (Wirtz & Trent, 2008). Similar analysis of the use and utility of ICD codes used in research of child abuse, how codes were applied and factors affecting the reliability of code sets, found underutilization of the ICD-10 codes T74 and Y07, thus leading to an underestimation of the incidence (Scott, Tonmyr, Fraser, Walker, & McKenzie, 2009).

Incidence

Excluding uncomplicated fractures of the skull, nearly two-thirds of all pediatric head injuries, and more than 9 of 10 serious intracranial injuries, can be connected to child maltreatment (Billmire & Myers, 1985). Incidence estimates range from approximately 20 cases per 100,000 to more than 40 cases of inflicted or abusive head trauma per 100,000 (Jayawant et al., 1998). Because there was (is) no clear uniformity in the case definition, there are huge gaps in the reporting of head trauma and it is difficult to further narrow the incidence ranges.

Broadly, the data reveals that the majority of TBIs resulting from child maltreatment occur in the first 12 months (Alexander, Levitt, & Smith, 2001). A study of the incidence of AHT in Pennsylvania of 327 reported cases concluded that the incidence is 14.7/100,000 in the first 2 years of life. Broken down, the incidence in the first year was 26/100,000 and 3.4/100,000 in the second year (Dias et al., 2005). A closer look into the incidence appears to begin in Week 2 or 3, and to peak around Week 10 or 11—ages that correlate with early child development when infants may be colicky and crying is inconsolable (Lee, 2007). Even if it is unclear that the

incident case definition of head trauma is vague and does not explicitly focus on brain injuries, the take-away is that there is a precipitous drop in incidence from Year 1 to Year 2.

Sequelae

Narrowing the definition to TBI, in the United States there are an estimated 1.5 million annual cases, between 230,000 and 250,000 are sent to hospital, and an estimated 50,000 deaths are directly attributed to TBI (CDC, 2005). Data compiled by the American Academy of Pediatrics in 2001, as well as incidence updates in 2011, suggests a disproportionately high risk of injury and mortality in infants and children under the age of 2 (American Academy of Pediatrics, 2001). To put the incidence in context, roughly 6% of the total number of fatalities (3,000) are attributed to TBI, which is roughly 6-fold the number who will die from HIV/AIDS, and 20-fold the mortality from asthma (CDC, 2005).

Of hospitalized survivors, nearly 40% suffer impairments and long-term disability, including neurologic deficits, psychiatric and behavioral affects, as well as cognitive and motor difficulties (Thurman, Alverson, Dunn, Guerrero, & Sniezek, 1999). A 5-year follow-up study published in *Pediatrics* suggested that 68% of inflicted TBI victims had cognitive difficulty, motor deficits, visual defects, suffered seizures, were slow to apprehend language, and acted out (Barlow, Thomson, Johnson, & Minns, 2005). Using psychomotor and developmental indices, 36% were diagnosed as severe and were fully dependent on care, 16% were diagnosed as moderate, and 16% were mild. Additional difficulties were seen in adaptive functions, daily living skills, and socialization (Barlow et al., 2005).

Costs Associated with Traumatic Brain Injuries

In addition to costs associated with emergency department visits and hospitalization, the costs associated with follow-up care, support, foster care, add economic strain an already burdened healthcare system. Hospitalization costs alone, adjusted to 2018 dollars, is estimated to top $1.25 billion (Schneier, Shields, Hostetler, Xiang, & Smith, 2006). When comparing accidental TBI with inflicted or abusive traumatic brain injury, (a) there is a longer hospital stay (3.03 days vs. 9.25 days), (b) estimated hospital charges for traumatic brain injuries, adjusted to 2018 dollars, range from $21,000 to $91,000 (Ettaro, Berger, & Songer, 2004), and (c) medical costs associated with an inflicted brain injury can exceed $300,000 (Dias, 2005).

Another study in Colorado compared the length of hospital stay and costs associated with patients of inflicted head trauma and with unintentional head trauma. A review of hospital discharge data showed that patients diagnosed with inflicted head trauma remained in hospital on average 2 additional days (52% longer), ran up bills that were 90% higher that costs associated with unintentional head trauma patients (Libby, Sills, Thurston, & Orton, 2003).

Minnesota Statue 144.574

This research is on the efficacy of Minnesota State Statute 144.574, which was enacted as an intervention in response to the growing awareness of behavior tantamount to child abuse leading to brain injury in infants under 1 year old and in children through age 4, critical ages of development. The focus of this research is on brain injuries sustained when the brain is not fully developed.

Efficacy, in this case, means the success of Minnesota Statute 144.574 in modifying behavior and thus leading to a downward trend in incidence. To lay the groundwork, this

research will track the provenance of Minnesota Statute 144.574 in authoritative research through to a final form that reflects the compromising influence of lobbying that may have diminished the statute's efficacy. But efficacy also means the success of the statute in influencing the societal contexts that produce this behavior, through its contributions to political and public discourse, awareness, and attitudes. These attitudes concern more than opinions about the specific issue of what used to be called Shaken Baby Syndrome; rather, they concern societal attitudes related to the statute, including far-reaching attitudes about government responsibility to protect the most vulnerable in society, particularly when such responsibility challenges parental autonomy and power over their children, and the advisability and/or necessity of attributing culpability and involving the judiciary.

To explore societal contexts that inform and affect Minnesota Statute 144.574, this research will also look at areas of the statute still under intense debate among providers and policy makers. Minnesota Statute 144.574 is paired with legislation that mandates reporting of cases to law authorities, yet from the perspective of effective health care, such a mandate runs the risk of dissuading caregivers from seeking medical attention for the injured child for fear of facing criminal prosecution and the removal of the child from the home. On the other hand, the refusal to confront acts of violence causing irreparable injury raises the question of complicity, and the failure to protect the victim from repeated violence. The dilemma is further complicated by the fact that such injuries are caused, in the majority of cases, by the child's parent or caregiver, and prosecuting parents for acts against their children collides with powerful opinions about parental autonomy and prerogatives.

Nearly all areas of public health policy and implementation are informed by, and need to navigate, cultural and ideological tensions. Reducing brain injuries in children extends beyond parental rights and prerogatives to other hotly contested arguments about individual liberties, religious and cultural exceptionalism, yet there is no dissent on the imperatives of the state to protect both the collective and the most vulnerable. These arguments, often leading to an impasse, surround public education, mandated childhood vaccinations, parental corporal punishment, drug and alcohol use during pregnancy, the rights of parents to deny medical treatment of their children, state-mandated education standards, seatbelt and bicycle helmet use, prohibitions against genital mutilation (i.e., female circumcision), corporal punishment, the use of drugs, tobacco, and alcohol during pregnancy. The wide terrain where public standards designed for the collective good and/or the protection of the most vulnerable collide with widely held values, traditions, and hostility toward government policy in general.

Finally, because Minnesota Statute 144.574 represents a continuity of public and legislative scrutiny of what was previously mostly private and/or family matters, and joins the broad fray over fundamental societal values, this research will examine the seminal historical documents that have formed the established foundation for legal/judicial considerations of 144.574, which was designed as an intervention against behavior leading to traumatic injuries as well as other forms of child abuse. These documents are interdisciplinary, and ranges from social philosophy to religion to psychology to international law and human rights agreed upon by the community of nations and will continue to represent a degree of authority for public policy and legislation in the future.

Provenance of the Statute in Medical Research

The risks associated with brain injuries from abuse or maltreatment or shaking an infant led Congress to empower the Centers for Disease Control and Prevention (CDC) to collect surveillance data, both under the Traumatic Brain Injury Act of 1996 as well as the Children's Health Act of 2000 (Langlois, Marr, Mitchko, & Johnson, 2005). Yet the scope of brain injuries associated with abusive behaviors and mechanisms of injury needed to be accurately assessed before meaningful interventions, or legislative reform could be enacted.

Working within theoretical grounding, public health officials and Minnesota state legislators authored legislation modeled on the work of Dias, a New York pediatric neurologist who tracked nearly 95,000 births over 5 years to study the incidence of Abusive Head Trauma in a cohort group when parents were exposed to an educational program and voluntarily signed a social contract to not engage in behaviors tantamount to shaking an infant (Dias, Smith, Mazur, Li, & Shaffer, 2005).

In draft form, Minnesota Statute 144.574 mandated that parents of newborns be educated about the risks associated with TBI through the introduction of medical literature to parents prior to being discharged by the birthing center related to the sequelae of, and disabilities associated with, physiologic changes in the structural architecture of the brain as a result of trauma from coup-contrecoup or whiplash type injuries when shaking an infant or child (Bigler, 2016). And faithful to Dias' work, the first draft of the Minnesota legislation contained language requiring the signature of a personal CS not to engage in maltreatment tantamount to abuse.

This voluntary CS immediately came under attack from many directions, driven by a range of legal, administrative, sociological, and ideological motives, and it was stripped out of

the final version of Minnesota Statute 144.574. Prior to enactment, hospital lobbying groups introduced an argument that the record keeping of signed social contracts could introduce an unreasonable burden, and further, could introduce legal exposure to the educator and/or hospital in the event that a social contract were signed and then discovered in the follow-up of a traumatic event. Heeding caution, the final version did not include language that assured understanding of the material, nor did it include a requirement for a simple declarative social contract whereby the parents committed to not engaging in behavior tantamount to maltreatment or abuse.

The legislature considered this omission of the CS) as a necessary compromise that accommodated opposition to the statute. While crafting the legislation, Representative Joyce Peppin took the position that requirements should be kept to a minimum to ensure passage. Others, including Jane Swenson from the Midwest Children's Resource Center, viewed this then and now as corrosive to the bill's effectiveness, and even a betrayal of the public trust (Personal communication, August 10, 2016). It is unclear what effect education alone has had, since, because of the exclusion of the social contract, the statute has lost its basis in medical science. To understand the forces in play that led to the final version of the statute, I will examine the theoretical foundation of the debate, its conceptual framework, and the underlying ideologies and structures of American society itself.

Problem Statement

This compromise raises questions about whether the effectiveness of the statute is diminished because of its deviation from the research. Again, the State of Minnesota authored and enacted Minnesota Statute 144.574 based on pivotal research where there was a demonstrated reduction in the incidence of Abusive Head Trauma (AHT) when education was combined with a

voluntary CS. It is unknown if Minnesota Statute 144.574, without a voluntary CS has had the desired effect of lowering the incidence. Further, where much of the literature is predicated on an analysis of reductions in trauma to the head, the view of this research project is that "head trauma" is an indiscriminate surrogate for an analysis of injuries to the brain, where injuries to the brain represent a far greater threat to quality of life. Although Traumatic Brain Injury is defined under the U.S. Public Health Service Act, before this research there was no uniform case definition specific to *inflicted* Traumatic Brain Injuries (iTBI) as a subset of child maltreatment that has been operationalized with complete ICD diagnostic codes combined with cause or event codes.

Publicity and Changing Public Attitudes

A review of the CDC data on brain injury morbidity points to child maltreatment as the third leading cause of head and brain injuries in children, trailing only falls and motor vehicle crashes (Adekoya & White, 2002). Yet any epidemiological or comparative review has been confounded by terminological corruption and by the lack of uniformity in the description of injuries. There are cases where injuries consistent with subdural hematoma or hemorrhage in the retina without apparent trauma to the head or scalp. Further, there remained a view that injuries are part of childhood as a result of being tossed into the air or bounding as if "riding a bronco" on grandfather's knee. The American Academy of Pediatrics continued to employ the term "shaken baby" as an inclusive and global description rather than as a "mechanism" or "cause" of diffuse axonal injuries (Christian & Block, 2009). "Shaken baby" as a "syndrome" remained, as a diagnosis, unhitched from the cause of injury, and expressly did not carry the implied indictment of maltreatment.

Rather than a single punctuated lexical evolution, the term “shaken baby” was replaced stepwise by “whiplash,” yet retained the syndromic ambiguity as researchers explored the forces of whiplash as a primary mechanism or cause of injury. A number of models were developed to further explore the shear and impact forces between a rigid skull, an elastic tissue, and fluid dynamics resulting in injuries to the brain (Halabieh & Wan, 2008). The mechanical theory is based on the differences in specific density; the brain is calculated to have a density between 1.0412 and 1.0346 (Barber, Brockway, & Higgins, 1970) and is surrounded by cerebral spinal fluid (CSF) with a specific density of 1.00059 (Lui, Polis, & Cicutti, 1998). Although the brain is housed within the skull, each move relative to, yet independent of, the other. The brain floats in cerebral spinal fluid, and is moored by the arachnoid and dura tissue layers wrapping the brain and attached to the skull. In an abrupt collision, the brain accelerates through the CSF, cerebral spinal fluid is displaced in the opposite direction, and tensile shearing occurs. Where the brain collides with the interior of the skull and a compressive coup or cupping injury results. The brain is then washed back in the opposite direction by both a wave of CSF and a recoil force until colliding with the opposite side of the skull resulting in an even more pronounced contrecoup injury (Drew & Drew, 2004). Whiplash became understood as the cause, and coup contrecoup a descriptive diagnostic.

Although the term whiplash was descriptive and carried grounding in medical science, it pointed more to injuries in the cervical spine and later displaced with terms pointing to maltreatment and abuse, terms that are infused with emotion. The important sub context beginning to take shape was that the injuries were not entirely accidental (David, 1999). The

descriptive syndrome was replaced with injury, then trauma, and yet the literature seemed to conflate injuries to the head with those to the brain.

The evolving lexicon itself both reflects the change of public attitudes over time, and informs public and political positions on the issue. In this research project, the term “abusive” is replaced with “inflicted.” Employing the term inflicted implies causality – as opposed to accident - and “traumatic” as a trajectory leads to imperatives of public health, if not questions of criminality. However, to say that this new language moves toward criminalizing behavior is somewhat misleading in that *injury* still leaves open the possibility of accidental, rather than deliberate, causes. The term *criminalize* also suggests that previously lawful behavior is deemed unlawful, whereas inflicting grievous physical harm unto a child was illegal before the semantic shift. However, the semantic shift from *syndrome* to *injury* does recognize a precipitating event, a *cause,* and where the cause is identified as violence, it confronts public health policy with the question of whether to develop policies of mandatory documentation of potentially criminal behavior, as is now the case, for example, of suspected sexual abuse of minors.

Under the Uniform Definitions of Public Health version 1.0 and Recommended Data Elements, the CDC defines child abuse and neglect as "any act or series of acts of commission or omission by a parent or other caregiver that results in harm, potential for harm, or threat of harm to a child" (CDC, 2016; Leeb, 2008, p. 11). The definition specifically defines caregiver as "a person, or people, who at the time of the maltreatment is in a permanent (primary caregiver) or temporary (substitute caregiver) custodial role” (Leeb, 2008, p. 12). A custodial role is contextually understood as the person entrusted and directly responsible for the child’s welfare.

Therein arises an interesting and problematic gap in the definition: Can child maltreatment come in the form of a stranger?

The American Academy of Pediatrics (2009) recommends that doctors use the term "Abusive Head Trauma in Infants and Children", precisely for clarifying the causality and, by implication, intentionality or culpability. The definition for pediatric AHT, a subset of, and derived from, Child Maltreatment, does not rely on identifying a caregiver. Pediatric abusive head trauma is "an injury to the skull or intracranial contents of an infant or young child (<5 years of age) due to inflicted blunt impact and/or violent shaking" (Parks, Annest, Hill, & Karch, 2012, p. 10). The case definition specifically excludes unintentional injuries from neglectful supervision and gunshot wounds / stab wounds / penetrating trauma (Parks et al., 2012).

While pediatric abusive head traumas are inclusive of head, neck, and intracranial injuries, and point to coup contrecoup injuries as a result of whiplash as a mechanism of injury, they fail to precisely identify injuries to the brain; the term *head trauma* is thus an imprecise surrogate. While it is widely accepted that retinal and subdural hemorrhage are pathognomonic, there are cases of shaking and/or head trauma that do not result in hemorrhage. In this research project, the term inflicted Traumatic Brain Injury (iTBI) is specifically adopted to identify traumatic injuries precisely to the brain.

Purpose of this Study

Three years after the State of Minnesota enacted Statute 144.574, the Centers for Disease Control and Prevention assembled a panel of experts to consider the International Classification of Diseases (ICD-9) to develop uniform definitions to improve the consistency of research data and surveillance of child maltreatment (Leeb et al., 2008). In 2009, a draft of the CDC

recommendations was publicly offered for review, and in 2012 the CDC published their recommendations (Parks et al., 2012). Public health departments, including the (MDH), are using the CDC recommendations as starting point to review reported cases of head trauma in children (younger than 5 years old) with the goal of redefining education and legislation to further address brain injury from abuse.

The purpose of this quantitative research project was to determine if Minnesota Statute 144.574 had the desired effect of lowering the incidence of iTBI in children, by examining data collected from 1999 through 2017, when the lever of the statute is educating parents on the risks associated with brain injuries, and without an integral component of Dias' original study.

It is difficult to compare the effect of similar legislative initiatives across the country, because of evolving terminology, inconsistencies in the use of cause and diagnostic codes, and failures to perform evaluative research on the effects of policy. Thus, a secondary purpose of the study was to offer standardized diagnostic and cause ICD codes that further the evolution of the language and dialog away from discussions of syndromic injury toward one that acknowledges inflicted, and therefore preventable, injury.

This research project quantifies the effect of Minnesota Statute 144.574 on the incidence of traumatic brain injuries in children. This study is expected to inform future legislative decisions about implementation and enforcement of the existing statutory health policy or lay the groundwork for revising the existing statute for better efficacy.

Conceptual Framework

In a vacuum of information, behavior resulting in brain injuries in infants or children (including behavior that is spontaneous, chaotic, or mindless—whether or not consciously

directed) contributes to syndromic injury. By contrast, in a theoretical framework of reasoned action, inflicted brain injuries are abhorrent, behaviors are modifiable, and the predictable consequence of maltreatment is preventable. Where behavior modification is specific to child rearing, the theory is also grounded in educational models and learning (Kazdin, 2012).

The Theory of Reasoned Action (TRA) leading to behavioral modification is predicated on education and learning (Hale, Householder, & Greene, 2002). Education on child maltreatment is designed to equip parents with tools to understand and align with attitudes and subjective normatives specific to maltreatment. Evaluation of such programs to educate parents on the risks associated with maltreatment has been demonstrated to reduce abuse (Altman et al., 2011). Thus, the TRA is grounding for enactment of public to educate parents on the risks associated with maltreatment. The logic is that educating parents of newborns leads to a change in behavior and thus a reduction in incidence.

Untangling Terminology

The initial challenge is to further untangle terminology where previous studies have used imprecise diagnosis and loosely attributed causes to injuries, both leading to a continued underlying failure of rigorous research. Time traces the evolving terminology from shaken baby syndrome to shaken-impact then shaken-slam injury. The first descriptions of traumatic brain injury were cases of subdural hematoma and intraocular bleeding called “whiplash-shaken infant syndrome” (Caffrey, 1974). When a more clinical diagnosis of “pediatric neurotrauma” was briefly adopted, cause was unhitched. The language of Minnesota Statute 144.574 in 2005, although intending to address an increase observed in the incidence of brain injuries in children, was based on research and literature rooted in shaken baby syndrome. Dias’ publication (2005),

upon which Minnesota Statute 144.574 was based, carried imprecise language and coding to arbitrarily conflate child maltreatment, abusive head injuries, and traumatic brain injuries. Moreover, the relative arbitrary nature in which diagnostic and cause codes were applied to cases remains the challenge to any reasonable inter-study analysis (Parks, Annest, Hill, & Karch, 2012). To disambiguate requires a reach back into the literature to develop on a conceptual understanding from which a more precise case definition can be formed, thus leading to a definitive code set. The CDC empaneled experts to consider injuries to the skull and intracranial contents due to impact or "violent shaking." The syndromic language in shaken baby further evolved toward an understanding of the events leading to injury as "abuse" or "maltreatment." The panel considered injuries to the head, skull, face, and neck, yet these are still only a surrogate for brain injuries and are similar to diagnosing internal organ damage by examination of a contusion on the skin. Brain injuries may be coincidental with head injuries but they cannot be equated. The focus is on the contents of the skull rather than on injuries on the surface.

Positive Social Change

This study is expected lead to positive social change on a number of fronts. The publication of the study's findings in *Minnesota Medicine* would draw attention to a leading cause of infant injury and mortality. To the extent that the mission of state public health is to protect the most vulnerable and that the imperatives of social justice give rise to public health interventions, this study addresses the question: To what extent does Minnesota Statute 144.574 succeed in its mission?

From the standpoint of medical efficacy, questions have come from the medical community about whether the threat of legal consequences might inhibit parents from seeking

needed medical assistance. From a standpoint that maltreatment is often times carried out by a family member or friend, public health surveillance and intervention suggests there is a reluctance to report incidence because it rises to the level of criminal behavior and obligates testimony (Goldman, Avillion, & Evans, 2018). Regardless, an underutilization of external cause codes, whether as a result of reluctance of medical providers to get involved, or a lack of information about the cause of injury, underlies significant underreporting (Minns, Busuttil, LeFanu, & Edwards-Brown, 2004).

While this study does not take a position on the debate over criminal prosecution, it does lay out the evidence that Pediatric Abusive Head Trauma is caused by intentional acts on the part of caregivers, and by employing a precise lexicon that describes intentionality, this study lays the groundwork for resolving the problem of under-reporting on the part of both caregivers. By employing a precise lexicon that describes intentionality, this study lays the groundwork for resolving the problem of under-reporting on the part of both caregivers and the underutilization of external cause codes on the part of the medical community. This evidence and lexicon, in turn, offers the opportunity to improve medical provider training as a route to social change.

Finally, two Minnesota State Senators, Senator John Marty (Democratic Farmer Labor party of Minnesota) who sits on the committee for Health and Human Services Finance and Policy, and Republican Senator Jim Abeler, Chair of Human Services Reform Finance and Policy, have agreed to introduce the finding in the state legislature (Personal communication, January 12, 2018). If it is learned the statute has had the desired effect, the conclusions can be leveraged to further health policies and thus buttress similar initiatives where public health policy leads to better public health. If, on the other hand, the conclusions are that the statute has

not affected the incidence of inflicted Traumatic Brain Injuries in the state of Minnesota, the contribution of this research will constitute a push for meaningful statutory reform.

Summary

The imperatives of this project include an understanding the evolving terminology from syndromic to inflicted, with a focus on injuries to the brain rather than to the skull. The project begins with a careful case definition grounded in medical science and operationalized in the ICD that combines specific diagnostic and cause codes. The evolving lexicon itself both reflects the change of public attitudes over time and informs public and political positions on the issue that usher in social change.

Chapter 2 of this project tracks the historical and still evolving lexicon of iTBI and how that lexicon has influenced public perception and public (including judicial) policy. The chapter then establishes the sociological and legal foundations of public policy in Human Rights. Chapter 3 outlines the methodology within theoretical grounding, and the use of statistical software programmed to reach into the archives of the data collected by the Minnesota Department of Health and State of Minnesota. Chapter 4 presents the results of research questions: whether the statute was effective in lowering incidence; whether the statute operated differently in rural vs. urban communities; whether there was an overall downward trend in the incidence; and whether there has been a shift in severity toward less severity. It was not possible to analyze the third research question, that of proportionality of incidence and ethnicity. The final chapter includes a discussion of the results with implications for social change.

With the support of the Minnesota Department of Health, *Minnesota Medicine* has agreed to publish findings of this research project. Two Minnesota State Senators have agreed to review

and introduce the findings in the state legislature with a view toward reforming the existing statute and/or exploring other areas where similar statutes can buttress policy leading to better public health.

Chapter 2: Literature Review

Introduction

In Chapter 1 I laid out the provenance and complexities of Minnesota Statute 144.574, and the need to navigate cultural and ideological tensions as a background to the topics of inflicted Traumatic Brain Injuries, in this chapter I examine the selected literature—those studies that specifically inform, examine, parallel, and/or further the work of Dias, Smith, Mazur, Li, and Shaffer in 2005, and the implementation of policies and programs designed to lower the incidence of brain injuries as a result of maltreatment or abuse. It is difficult to ignore the many issues that weigh on Dias' research (2005), and some of the studies under review in this chapter treat the issue of child abuse, and specifically abusive head trauma (AHT), within a larger context of proper or effective parenting. None of these studies answers the central question of this thesis: whether legislative mandates to educate caregivers about brain injury without requiring them to sign the social contract that formed an integral component of the original study (Dias et al., 2005) are as effective as mandates that include a signed social contract. The biggest obstacle to answering this question is that there is no legislation with a mandatory signed social contract in North America with which to compare Minnesota Statute 144.574.

To identify literature relevant to this research, a database search combined traumatic brain injuries, child maltreatment, and health policy to narrow the project. The following databases were used: Google Scholar, MEDLINE with Full Text, PubMed, Thoreau, and WebMD. The following keywords and phrases were used: *traumatic brain injury, shaken baby syndrome, coup-contrecoup, whiplash, child abuse, child maltreatment, abusive head trauma* (and *AHT*), *brain injury sequelae, inflicted traumatic brain injury (*and *iTBI), child abuse,*

preventing child abuse, injury and violence prevention, non-accidental head injury, triggers for child abuse, case history, social contract (and *SC*), voluntary *commitment statement* (and *VCS*), and *parent education.*

Key Literature

The State of Minnesota began collecting data on head and brain injuries under the authority of the Congressional Traumatic Brain Injury Act of 1996, and the incidence of head trauma and brain injuries identified by incoming hospital and emergency department reports captured by Minnesota Department of Health (MDH) underlined the imperative to action.

Alert public health officials were alert to what appeared to be a significant risk of head injuries in infants under the age of 2 years old. Officials were alarmed by the trend that more than half of head injury fatalities were inflicted. These early observations were later validated in data published on the characteristics of fatal abusive head trauma in an analysis of national vital statistics (Parks, Kegler, Annest, & Mercy, 2011). A search of the literature from 2000 to 2004 suggests near universal agreement that shaking a baby leads to traumatic injuries and introduces retinal abnormality and intracranial hemorrhage as definitive of shaking or a sudden impact trauma (Morad et al., 2002). Mortality cited in clinical literature broadly ranged from 15–35% with survivors facing long-term neurological deficits, including language and cognition, as well as physical difficulties such as fine motor skills or gait. Data compiled by Parks et al. (2011) on fatal cases limited to under 5 years old between 2003 and 2007 resulted in 17,995 fatal cases of which 2,057 cases included injury codes consistent with AHT, and 2,806 cases included cause codes consistent with AHT. That not all cases included both an injury or diagnostic code consistent with AHT, and that not all cases included a cause code pointing specifically to AHT,

highlights either a troubling inconsistency in the literature related to case definitions. That the definitions continue to evolve also makes any reasonable comparative analysis difficult. Research published on an analysis employing an ICD code-based case definition for non-fatal abusive head trauma, hospital data from a nationwide inpatient survey, narrowed incidence to an alarming 32.3 per 100,000 in infants younger than 12 months Parks, Sugerman, Xu, & Coronado, 2012).

With nearly 10 years of cases collected, the State of Minnesota public health officials and state legislatures worked collaboratively to author Minnesota Statute 144.574 focusing on educating parents of neonates grounded in the best literature science at the time. Although the use of imprecise terms precisely undermined the objective, by 2005 the State of Minnesota enacted a statute based primarily on Dias' hospital-based program to educate parents implemented in eight regional hospitals in western New York. Dias' program appeared to reduce the incidence of abusive head trauma by requiring hospitals and birthing centers to provide education to new parents related to the risks of child maltreatment (Dias et al., 2005). Dias' detailed program, grounded in research, laid out the education of parents on the risks associated with "shaken impact syndrome" as a form of child abuse, and a prescription for counseling.

The publication of Dias' results, similarly compelled by an understanding of the risks to public health as a result of head trauma, and the imperative to prevent abusive head trauma among infants and young children, fundamentally informed the Minnesota Legislature. Dias had designed a hospital-based, parent education program structured on the premise that where head trauma is as a result of maltreatment or abuse, it would be most effective to focus on educating parents of neonates before being discharged from hospital. Information describing the violence

of shaking an infant and the effects of intracranial hemorrhage, as well as the sequelae of cognitive and motor deficits were presented to both parents whenever possible. Parents were counseled and taught alternatives for when, for example, a baby does not stop crying. And, parents were asked to sign a voluntary commitment statement (CS) affirming their receipt and understanding of the materials presented, and that they would not engage in abusive behavior (Dias et al., 2005).

Requesting a commitment statement (CS) serves both as a tool to improve attentive learning (a person understanding that there will be a commitment is more likely to be attentive to the material), to produce modification or changes in behavior, and to motivate compliance (Overton & MacVicar, 2008). On the other hand, it might be argued that first-hand knowledge is more likely to motivate change. A randomized trial of youths (12 to 20 years old) who engaged in risky behaviors leading to injury were interviewed in the emergency department while receiving care. Those who understood that their injuries were as a result of their behavior were 4.5 times more likely to use a seatbelt six months later even without a commitment statement (Dunn, Droesch, Johnston, & Rivara, 2004). Thus, it might be argued that understanding the risks and consequences associated with maltreatment, even without a commitment statement, modifies behavior.

Over five and a half years, Dias et al. (2005) tracked 94,409 infants from birth to 36 months looking for evidence that their program resulted in a reduction in incidence compared to historical incidence. The study examined and compared background and confounding socio-economic influences on the incidence of AHT were ruled out; no similar or explainable reduction in incidence was observed in a 6-year control population from 1996 to 2002 in the

Commonwealth of Pennsylvania, both a parallel time period and geographic proximity to the study western New York State. The cohort population serves to buttress arguments of scientific validity.

Dias et al. (2005) demonstrated a reduction of 47% from 41.5 cases per 100,000 in the control population to 22.2 cases per 100,000 in the incidence of infant brain injury over a period of 5.5 years in a cohort group exposed to an educational program that included a social contract. Again, a cohort comparator informs the methodology of this study and appears to settle the question of whether, given time and regardless of intervention, the incidence might trend downward.

More importantly, that there was a statistically significant reduction in incidence appears to validate the operative Theory of Reasoned Action, that explicitly behavior – in this case maltreatment – is affected by two components: our attitudes and subjective beliefs of that which is normative, and that both can be fundamentally shaped through education. Theories of Reasoned Action developed by Fishbein and Ajzen as it relates to behavioral modification operates on the level of establishing volitional control over one's behavior, one might suggest establishing consciousness. The approach as Fishbein proposed, is to look for antecedents that predict or explain a behavior as a basis for interventions that modify the behavior (Fishbein, 2007).

Six years after Alexander's study, Lee, Barr, Catherine, and Wicks (2007), published "A study by Age-related incidence of publicly reported shaken baby syndrome cases: is crying a trigger for shaking?" that supported Alexander's finding that abuse tends to begin within the first few months after birth. The incidence appears to begin in week 2 or 3, and to peak around week

10 or 11, ages that correlate with early child development when infants may be colicky and crying is inconsolable. The study observed that the first few months of infancy are when episodes of prolonged, inconsolable, and unpredictable crying are developmentally normal. Applying Fishbein's Theory of Reasoned Action we understand un-consolable crying to be a primary antecedent triggering abusive behavior.

Alexander's focus on parental reactions to antecedents makes a strong case under the constructs of the theory of reasoned action for a preventive program that alerts parents and raises their awareness of such potential reactions prophylactically. An evaluation of the adequacy and relevance of an educational program to by nurses of two birthing institutions lead to the conclusion that parent's knowledge about infant crying and frustrations that lead to maltreatment was increased (Goulet et al., 2009). The evaluation appears to respond to the question of how and by whom education is delivered, yet questions remain about education in the absence of key components to prevention; a sustained support structure for at-risk parents where support can take the form of respite care, of support groups led by trained staff, and of routine conversations with physicians during regular medical checkups. Public health officials are compelled by a sense of urgency; and imperative to act, and education is the tool in hand. Yet in the chapter "Long-term Impact of Prevention Programs to Promote Effective Parenting: Lasting Effects but Uncertain Processes" Sandler, Schoenfelder, Wolchik and MacKinnon (2011) reviewed some 46 experimental trials that explore parent-focused intervention programs. The authors argued that trials suggest preventative programs are effective, but there is a lack of evidence about what, exactly, accounts for this effectiveness. In "Pediatric Abusive Head Trauma: A Brief Overview," Brown et al. (2016) iterate arguments in favor of hospital-based educational programs with the

addition to ensure information about available community resources and support for overwhelmed parents is available as a way to significantly reduce incidence of abusive head injuries. One such program, called PURPLE Crying, was developed and tested by R. G. Barr (Barr et al., 2009).

Dias' pivotal finding anchors this research as it applies to public health and policy, and it is understood that the theoretical grounding includes a multi-dynamic interaction whereby the individual, the community, and the environment influence behavior (2005). Dias's conclusion that education functions as an intervention to reduce incidence was adopted as grounding during the enactment of a State of Minnesota Statute mandating parental education in all major birthing hospitals (Minnesota Statute, 2005). In order to comply with subdivision 1 of the statute, a hospital licensed in the state of Minnesota under sections 144.50 to 144.56 need only to make a video on the dangers associated with shaking an infant. The statute falls short of ensuring the information is delivered in person by medical staff with appropriate education and training.

That the program was instituted in hospital was not accidental, nor was it a matter of captive audience. A study on Abusive Health Trauma by Alexander, Levitt, and Smith (2001) predates Dias' study by four years. Alexander's examination of the data revealed the alarming trend; that the majority of traumatic brain injuries resulting from child maltreatment occur in the first year. Two studies bracket the highest rate of physical abuse in infants between 4 and 6 months of age, where the consequence of injury is amplified, results in permanently changes the trajectory of promise onto a path that includes remedial learning, leads to difficulties in acquiring language, and is associated with a variety of diminished adaptive functioning (Barlow, Thomson, Johnson, & Minns, 2005). The age bracketing of incidence is supported by Leventhal, Martin,

and Asnes (2010), with the incidence of abuse decreasing in the years that follow (Eisele et al., 2006; Keenan et al., 2003). Alexander et al.'s study underscores that physical abuse is the cause of most serious head injuries are in infants under the age of one, and that the median age of the first incident of AHT is only 4.1 months at the time of abuse (2001). This is important to understand because neonates and infants are in the earliest stages of physiological and brain development, and are more susceptible for head, neck and indeed brain injuries, and the long term the consequences of abuse are more traumatic.

Beyond the scientific and academic literature lies the growing volume of news sources targeting a wide audience, legal literature that continues to both influence the public and lay precedent in the courts, documentaries, and even published letters by legislators and organizations. The way cases of have been depicted in the press has informed and conditioned public attitudes, particularly in the perception of these acts as extreme criminal behavior. But while there is now a consensus in the health profession and among public health policy makers that shaking a baby is potentially lethal, the State still has not completely resolved the question of criminal prosecution of parents and other, especially young, caregivers.

Part of this ambivalence may be explained by the fact that high-profile prosecutions have entered the news stream so recently. The trial and conviction of the 19-year-old British au pair Louise Woodward for the death of eight-month-old Matthew Eappen in 1997 was followed gavel-to-gavel across the United Stated and in Great Britain on Court TV. Facts were introduced about a 911 call and subsequent admission to Boston's Children's Hospital. Matthew suffered a fractured skull and subdural hematoma. Within days Matthew Eappen fell into a coma. On February 9, 1997, Matthew Eappen died. Testimony from medical experts suggested a pattern of

abuse, violence, and slamming an infant against objects resulting in brain injuries. Outside the courtroom Dr. Deborah Eappen, an ophthalmologist, was the fodder of talk radio criticizing working mothers (Goldberg, 1997).

A post-conviction motion was heard by Judge Zobel, and then to the Supreme Judicial Court of Massachusetts. Although originally sentenced to 15 years for manslaughter, the sentence was reduced to 279 days of time served and Ms. Woodward was released. Judge Zobel's summary did not contradict the medical opinion that Matthew Eappen died from hemorrhagic bleeding in the brain but ruled the defendant's actions "were characterized by confusion, inexperience, frustration, immaturity and some anger, but not malice in the legal sense supporting a conviction for second-degree murder" (BBC News, 1997, para. 20).

Two current sensational examples give narrative to the attitudes and tensions surrounding the issue. A *Washington Post* story dated December 30, 2016, detailed the arrest of a mother, Deana Debrow-Conley, 26, for repeatedly shaking her infant, and for which she was charged in Philadelphia with first-degree murder (Hermann & Stein, 2016). The story points to common risk factors observed in cases of maltreatment in that the infant was inconsolably crying and fussy. The father innocently described a game of "bouncy thing" as if unaware that a father's rodeo knee can cause a fatal whiplash to a 1 month old.

The *Twin Cities Pioneer Press* featured the story of a St. Paul teenager facing murder charges after a five-month-old boy in her care died of injuries (Horner, 2017). The boy's eyes were dilated, and he was completely unresponsive. Doctors made the determination that the infant had suffered severe brain injury, among other injuries, such as bleeding in the lung. The Ramsey County medical examiner's office concluded that the boy died of traumatic head injuries

caused by "physical assault" that caused bleeding in the brain, reporting that such injuries are classic findings for abusive head trauma and child abuse. The baby-sitter admitted that she was frustrated at having to take care of the child because she wanted to go out and may have shaken him 3-5 seconds when she was in a "blacked out" state. Police found text messages on her cellphone expressing her frustration: "I'm getting irritated my baby keeps waking up. He being a big … crybaby … I am been dealing with (this) all day I just closed the door but I still hear him and it's irritating me I never let him cry" (Horner, 2017, para. 12). The medical examiner characterized shaking an infant as "physical assault," and it is worth emphasizing that baby sitters in cases such as these are now routinely charged with first- or second-degree murder, not neglect, child abuse, or some other lesser charge.

Shaken Baby Syndrome was the term used in the Woodward case. The case is still controversial, not only because of the judge's overriding the jury and absence of a typically corroborating witnesses, but because of doubts among some in the medical community (notably a lead medical witness at the trial) about the certainty of excluding alternate causes, e.g. prior injuries.

The 1997 trial generated enormous public and medical attention and marks the beginning of a semantic shift from Shaken Baby Syndrome toward Abusive Head Trauma that coincided with further moves into the arena of the social and legal justice system. The lexical implications are enormous. While the term *syndrome* avoids a direct cause-effect correlation, *abusive* does not. Court testimony by medical experts used to establish that the cause of harm or fatality is at the hands of the defendant relies primarily in the "diagnostic triad" of retinal hemorrhage,

sheering on the arachnoid or subarachnoid layers surrounding the brain leading to hematoma, and cerebral contusions (Albert, Blanchard, & Knox, 2012; Harding, Risdon, & Krous, 2004).

For many, this evolution of the lexicon from a language that implies accidents, unfortunate incidents, and syndromes to a language of culpability represents progress in the areas of applying established medical science to public policy in the protection of the most vulnerable, including the now-established practice of criminal prosecution, and Statute 144.574 reflects this position by mandating reporting of cases to law authorities. But this position is by no means universally embraced. In their documentary film, *The Syndrome*, Davidson and Davidson (2014) argued the position that the medical diagnosis of Inflicted Traumatic Brain Injury constitutes bad medicine, at best, and fraud, at worst. Goldsmith argued that the medical community and experts have perpetrated a cover-up while attempting to silence critics with an opposing view. The motive of such a cover-up is not explicitly explored in the film, beyond the implication that many professionals have built careers on inflicted Traumatic Brain Injury, and that they are willing to promote flawed science to protect these careers. But while the filmmakers raise questions of medical professionals' motives, we might equally raise questions about whether the filmmakers harbor motives for making the film beyond the seemingly altruistic pursuit of the truth for the sake of the public good.

By mandating reporting of caregivers, Statute 144.574 joins other legislation raising the polemic of governmental interference in the family, such as Canadian Senate Bill C-206 addressing the question of corporal punishment. For some who opposed this Statute, bringing parental treatment of children into the legal code constitutes an attack on the family itself by providing grounds for the gradual erosion of parental authority. This was precisely the position

argued in a letter written to Canadian senators by Harold Hoff, a spanking advocate who presented himself, without irony, as "Chair / *Child Protection* Advocate and Researcher." Hoff argued in response to Senate Bill C-206 sponsored by Senator Celine Hervieux-Payette to amend the Canadian criminal code by replacing Section 43, a vestigial clause from 1892 used to defend parents and educators who resort to corporal punishment as a corrective measure (Barnett & Raaflaub, 2008; 2016). In a background paper, Laura Barnett (2016) of the legal and Social Affairs Division of the Parliamentary Information and Research Service quoted Section 43:

> Every schoolteacher, parent or person standing in the place of a parent is justified in using force by the way of correction toward a pupil or child, as the case may be, who is under his care, if the force does not exceed what is reasonable under the circumstances (p. 1).

The judiciary weighed in on this polemic by affirming the equality of personhood for children. Barnett (2016) referenced the Supreme Court of Canada who upheld Section 43 under the logic of limitations in scope; that Section 43 “only extends to parents, teachers and persons who have assumed all of the obligations of parenthood” and restricts against the use of a ruler, strap, or paddle, or any other form of weapon (p. 2). However, Justice Marie Deschamps’ dissent argued that protections for child-rearing violence codified in Section 43 violates the security of the person (section 7) and ignores a child’s right to equality (section 15) of the Canadian Charter of Rights and Freedoms. Deschamps view is that Section 43 violated section 15 in that it “encourages a view of children as less worthy of protection and respect for their bodily integrity based on outdated notions of their inferior personhood” (Barnett, 2016, p. 3).

In his letter, Hoff (2016) raised alarm to Senator Hervieux-Payette revival of Bill C-206. Hoff argued that repeal of Section 43 "de-facto criminalizes 80% of Canadian Parents with preteen children" and a "draconian attack on family" (Hoff, 2016, p. 1). This line of reasoning appears to shift the frames from one of protecting children to one that is either in favor of families or criminalizing parenting.

Hoff's position appears to align with the Canadian Alliance Party, under which Stephen Harper campaigned on a platform to keep family central to the fabric of Canadian society. Harper's push mimics the rhetoric in the lower 48 states where a focus on the family is the foundation of society, and reels against any laws that might extend the reach of government into the private lives of citizens. Under such morality, a parent's rights to spank shall not be criminalized. This is where the debate has thus shifted from protection of children's rights to the protection of family against governmental interference. Andrea Mrozek, communications manager for the Institute of Marriage and Family Canada, told QMI Agency the law should be left alone, that government should not be allowed to act as a parent (Lilly, 2011).

This polemic raises complications for public health policy by asking for clarification about the point at which family violence should trigger government intervention, and at what level of response. While distinctions between the degree of violence when comparing inflicted Traumatic Brain Injuries to spanking may seem, to many, to discredit any blanket position against criminalizing parental behavior, such distinctions are culturally informed and by no means universally accepted. As a case in point, the State Duma of Russia recently voted overwhelmingly in favor of reinstating violent spousal abuse, currently a criminal offense, back into its traditional Russian place as private family business, with a legal amendment that would

end criminal liability for first-time battery of family members (Oliphant, 2017). The bill enjoys a degree of popularity in a country where it is reported by the Interior Ministry that in 2013 there were more than 9,000 fatalities from domestic violence (Associated Press - Moscow, 2017). Other reports estimate more than 14,000 women are killed each year at the hands of their current or former partner (Jäppinen & Johnson, 2016). Even if these statistics are inflated, other surveys suggest half of all married Russian women experienced physical violence at the hands of her husband. In such a country, a survey by VTsIOM, a state-run pollster, earlier this month found that 19% of Russians said, it can be acceptable to hit one's wife, husband or child in certain circumstances (Associated Press, 2017, para. 8). Only if a victim of domestic violence is severely harmed and needs to be hospitalized, the incident would fall under regular assault laws.

Two points are worthy of underscoring: (a) The inability to accurately assess incidence undermines public health and public policy, and (b) This is a bill pushed by *female* Russian lawmakers, Elena Batalina and Olga Mizulina, who argued that the law is designed as protection of Russian families. Batalina argued in front of Parliament that: "For us, it is extremely important to protect the family as an institution" (Rainsford, 2017, para. 11).

Historical Legal Authority of Statutes Protecting the Child

Precisely because public health policy requires clarification, consensus, a foundation in law, particularly when it enters traditional non-public realms such as behaviors within the family setting, it needs to be informed by authoritative historic literature. The literature is interdisciplinary, and ranges from social philosophy to religion to psychology to international law and human rights. The seminal document providing the formal foundation for legal/judicial considerations of iTBI and other forms of child abuse comes from the United Nations Office of

the High Commissioner. The *Declaration of the Rights of the Child*, ratification and proclamation by General Assembly Resolution 1386 (XIV) of 20 November 1959 enshrines the rights of children in international law (Yazarsiz, 1996). It articulates in its preamble that there are fundamental human rights, as well as dignity and worth. The Resolution asserts that children require special consideration as the most vulnerable class: "Whereas the child, by reason of his physical and mental immaturity, needs special safeguards and care, including appropriate legal protection, before as well as after birth" (Yazarsiz, 1996, p. 246). Furthermore, the preamble notes that the Geneva Declaration of the Rights of the Child (1924) among other Statutes and Covenants, set precedents for the special care extended to children.

It is significant to note that the 10 Principles of 1959 do not employ language that explicitly sets the rights of the child against a parental prerogative nor assumes that a principle threat to the child is the child's family itself. This is not only an ideological position; it is also a diplomatic concession to the cultural mores of nations that consider harsh physical punishment of children acceptable. Specifically, the U.N. General Assembly Convention on the Rights of the Child preamble (1989) includes family:

> Convinced that the family, as the fundamental group of society and the natural environment for the growth and well-being of all its members and particularly children, should be afforded the necessary protection and assistance so that it can fully assume its responsibilities within the community (p. 1).

In other words, the rights of the family are conflated with the rights of the child. The specter of parental abuse does not arise until Article 9:

> Parties shall ensure that a child shall not be separated from his or her parents against their will, except when competent authorities subject to judicial review determine, in accordance with applicable law and procedures, that such separation is necessary for the best interests of the child. Such determination may be necessary in a particular case such as one involving abuse or neglect of the child by the parents (p. 248).

And again, in Article 19:

> Parties shall take all appropriate legislative, administrative, social and educational measures to protect the child from all forms of physical or mental violence, injury or abuse, neglect or negligent treatment, maltreatment or exploitation, including sexual abuse, while in the care of parent(s), legal guardian(s) or any other person who has the care of the child (p. 252).

Article 27 (2) refers to the parent's obligations to provide for the child in accordance to their means (p. 255). Article 33 references legislative and administrative means to protect and ensure the welfare of a child (p. 258). Article 37 declares that: "no child shall be subjected to torture or other cruel, inhuman or degrading treatment or punishment" (p. 259). Article 39 mandates taking appropriate remedy in the case of neglect or exploitation, or cruelty (p. 260).

The 1989 Convention brings to the question of parental responsibility and accountability for criminal behavior toward a child the gravitas of international agreement and cooperation, and it has laid the groundwork for additional legal codification and social initiatives around the world. A full exploration of these developments is beyond the scope of this thesis, but a useful starting point for further reading is "A review of children's rights literature since the adoption of the United Nations Convention on the Rights of the Child" by Reynaert et al. (2009). This work

provides a commentary on the United Nations Convention on the Rights of the Child (UNCRC) listed above, and it offers an analysis of literature on the UNCRC from around the world. Of particular note, the work breaks the literature into three categories, where the second category explores the potential for opposition between the child's rights and the parental prerogative.

The argument for the necessity of the Convention as a *universal* legal position is that the position of parental sovereign control over children has deep universal and historical tenacity. Across cultures, we see the family as the *auctoritas principis* – the supreme moral authority, so much so that the imagery of the Divine and very language of the Judeo-Christian tradition incorporates the notion of the Father as ultimate Authority and Righteous (and Mother as Goodness and Grace). The authority and sanctity of the family is an area where government is reluctant to tread, and we have seen this in the reluctance of police to intervene in cases of spousal abuse to the difficulty passing legislation outlawing corporal punishment in the home. Much of this is seated in notions of the primacy of family as the basic institution upon which all society rests, and upon which it relies to perpetuate itself, through reproduction. The very lexicon of states around the globe, from Founding Fathers, to the Fatherland, to Mother Russia, articulates an assumption that the State, or society, is an extension of, or an expansion of, the family. This emotional concept seems to be intractably seated in the human psyche so powerfully as to figure, both in concept and in language, in the rallies for patriotic military conquest and defense (of the "Father/Motherland") throughout history.

In 1994, Dwyer challenged the foundation of parental prerogative in *Parents' religion and children's welfare: Debunking the doctrine of parents' rights* (1994). Dwyer comes at this from the perspective of law, and challenges not only traditional parental prerogatives/rights

relating to raising children, but he also challenges the very "assumptions" underlying these prerogatives/rights. He argues that such assumptions (as is the nature of assumptions) cannot sustain close scrutiny, and he challenges "parental rights in their entirety." Dwyer's line of attack targeted parental rights in religious contexts, "because it is in this arena that the notion of parental rights takes on its strongest form" (Dwyer, 1994, p. 1371). The author points out that notions of parental rights are at odds with other protected individual rights under our legal system, and that, furthermore, they are in violation of the very principles that underlie all other individual rights recognized in our society. He systematically deconstructs various justifications for parents' rights and makes the case for a fundamental "revision of the law governing child-rearing" (Dwyer, 1994, p. 1371). Specifically, Dwyer (1994) notes of children's human rights, often at odds with assumed parents' rights, must serve as the foundation for protecting children:

> The law should confer on parents only a child-rearing privilege, limited to actions that do not harm the child's interests. Such a privilege, coupled with a broader set of children's rights, satisfies parents' legitimate interests in child-rearing while providing children with a more appropriate level of protection than they receive under the current legal approach (p. 1372).

Five years later, Westman (1999) further argued for the necessity of the *Convention on the Rights of the Child* on the basis that because of the cultural assumptions privileging the natural parental prerogative, it does not require legal protection. It is the child's rights, on the other hand, that require legal protection, because the very "idea of individual rights springs from the vulnerability of human beings in the face of stronger forces" (p. 316). For this reason, Westman argues that human rights must begin with protections for children as the most

vulnerable individuals. At the same time, Westman argues that society has an obligation to support parenthood. By this, he does not mean protection against government intervention in questions of abuse; rather, he argues precisely *for* government intervention in the form of educational, economic, and wellness support that facilitate good parenting.

In the United States, the assumption of parental prerogative that Westman addresses lies entrenched in the value system of freedom unfettered by government intrusion that underlay the Revolutionary era. The banner of the time featured a rattlesnake—symbol of resistance—imposed on the U.S. Navy Jack with the motto *Don't Tread on Me.* This standard has been periodically resurrected to represent defiance of what is perceived by some groups as government interference, overreach, and intrusion. Most recently, the symbol and motto represent anti-governmental regulation venom among groups ranging from gun enthusiasts, to ranchers claiming the right to graze free of charge on public land, to the Tea Party. In 2010, on the eve of a House vote on legislation to overhaul health care, a group of Republican lawmakers hung a large "Don't Tread on Me" flag from a balcony of the Capitol building. This act conflated and confused the distinction between government intrusion and government protection of the common good as it related to providing for public health and security. Understanding how this political and ideological climate directly bears on public health policy provides insight into why the social contract provision was removed from Minnesota State Statute 144.574.

Legal Controversy

While the American Academy of Ophthalmology supports a conclusion that retinal hemorrhages are exclusively caused by “shaking” as a mechanism of injury “regardless of other circumstances,” there are exceptions (Lantz, Sinal, Stanton, & Weaver, 2004). The trial,

conviction of murder, and later having her sentence reduced to involuntary manslaughter of Au Pair Louise Woodward played out in the Boston courts in 1997 illustrates the polarizing of ideology and zeal where science is challenged (Silverglate, 1997).

Twelve years after the Louis Woodward trial, Dr. Deborah Tuerkheimer, a Professor of Law at DePaul University College of Law attacked the legal foundations for prosecuting Shaken Baby Syndrome (the term she uses) as "a prosecution paradigm without precedent" whereby the testimony of medical pathologists used to establish mechanisms of injury are thereby a crime; that shaking constitutes “depraved indifference to human life” (Tuerkheimer, 2009, p. 1). Tuerkheimer argued that an expert medical diagnosis of Shaken Baby Syndrome (SBS) predicated on a pathognomonic diagnosis: retinal bleeding, subarachnoid and subdural hematoma in the protective layers of the brain, and cerebral edema embraced unanimously by the scientific community, is wrongly the surrogate prosecution for murder. While Tuerkheimer’s focus is primarily judicial, not medical (note her privileging legal "precedent" even in an area of unprecedented medical science), she also raises the question of medical infallibility while examining the “intersection of science and law” (2009, p. 56). Tuerkheimer casts doubt on the forensic science while leaning on the governing principle of the judicial: innocent until proven guilty.

Overcoming the objections to forensic pathological science raised by Deborah Tuerkheimer (above) among others, that inflicted head injuries in infants and children cannot be reliably distinguished from accidental injuries, begins with an appreciation for the skull, brain, and spine in infants (Case, 2014). Impact or focal injuries typical of accidents are often characterized by a contusion or external laceration. The argument is then made by describing

dynamic impulsive loading forces when the head is free to move creating a difference between the inertial movement of the skull and the brain within where the bridging vasculature arising from the surface of the cerebrum and ascending through the dura is stretched and torn. By contrasts, the author systematically examines accidental head injuries, such as injuries sustained through crushing, falls, and blows, through an examination of the mechanism of epidural hemorrhage and focal subdural hemorrhage. Inflicted injuries to the brain are diffuse compared to accidental focal head injuries "that occur in and around the home" (Case, 2014, p. S632).

Bishop, Branigan, Leventhal, and Mittler (2015) also took issue with the stark premise of Tuerkheimer's argument. In *handling child abuse cases involving violent shaking and abusive head trauma,* the authors argued for a collaborative relationship amongst law enforcement, the medical community, public health, social services, and the broader community to drive down the incidence as well as prosecute cases of abuse. Unlike Tuerkheimer, the authors emphasize that trained medical professionals can offer early diagnosis of abuse, and the reliability of the medical science behind prosecution as “well supported in the medical literature” (Bishop, Branigan, Leventhal, & Mittler, 2015, para. 3). The authors make the case by examine an authoritative body of medical studies that highlight methods of distinguishing deliberate from accidental head trauma (Bishop et al., 2015).

Summary

The statute enacted by the State of Minnesota is grounded on the work of Dias with a focus on educating parents of neonates as a preventive strategy. In Dias’ study nearly 70% of the parents (65,205), 96% of birth mothers and 76% of birth fathers, voluntarily signed a commitment statement (2005). While the literature identifies an optimal age for intervention and

is supportive in policy and practice of education as a primary intervention under the theory of reasoned action, the literature does not appear to address the fundamental exclusion of the commitment statement in the statute the Minnesota Legislature enacted. Nor does the literature clearly address several other potential confounders including the difference between education provided by a pediatrician, i.e., Dr. Dias vs. a medical assistant dropping a video in a discharge bag along with samples of formula and baby wipes while reminding new parents they should take the time to view the video. One must note that in the Dias study the information was provided by medical professionals while the Minnesota Statutes merely require that a video tape be made available for viewing.

This study fills a major gap in the literature, by analyzing the effectiveness of a program of education for parents of newborn infants that leaves out the signed pledge that formed an integral part of the education and social contract upon which the previous literature drew its conclusions. That social contract explicitly acknowledged the risks of behaviors tantamount to abuse and pledge not to engage in such behavior, the enacted Statute did not include the signing of a social contract. It is the stated goal of public health officials in general to protect the public, and to reduce traumatic brain injuries in general, yet in this research, the purpose is evaluative much the way understanding if a seatbelt law or a reduction in speed limits has the desired effect of protecting the public from harm. This research seeks to understand if enacted statute has had the desired effect to reduce the overall incidence. The case definition is carefully and deliberately considered both conceptually as well as operationally such that statistical software can be written to extract the data from the archives of two registries in the State of Minnesota.

This study also looks beyond the medical research, and considers the contextualizing literature and discourse, ranging from social philosophy to religion to psychology to international law and human rights agreed upon by the community of nations. By considering the medical literature within its cultural and historical contexts, this study serves the interest of public policy and legislation on a practical level, by addressing and negotiating the public's perceptions, preconceptions, precedents, understanding and misunderstanding, and sensibilities surrounding the sensitive and polemical issues related to mandated health legislation.

In Chapter 3 the rational and research methodology of combining an event (E) code with a (D) diagnostic code is programmed into the Statistical Analysis Software to identify definitive cases of iTBI is introduced. Three specific databases are identified, and SAS is used to extract cases of iTBI. Four research questions guide this research project as the incidence, differences between rural and urban, possible associations with ethnicity, and a more nuanced ordinal shift in the severity of iTBI cases post enactment of statute 144.574 is explored.

Chapter 3: Research Methodology

Introduction

This is a quantitative research project on the incidence of traumatic brain injuries in children. The most compelling evidence for an intervention, or in support of a policy, comes from the rigor and purity of the research design (Hinkelmann & Kempthorne, 2012), yet rarely in practice is research purely qualitative or quantitative. While the specific purpose is of this research was evaluative—to learn if and to what extent there is a statistical effect—the purpose was also to further nudge the social dialogue away from a terminology that characterizes injury as syndromic and toward a terminology that identifies injuries that are intentional, and therefore preventable. In other words, someone *injures* a child; the child does not "catch" or "come down with" or "develop" this kind of brain trauma. The belief is that a state statute mandating delivery of education on the risks associated with behaviors tantamount to abuse would result in a decline in incidence. Prior to this research project, no one has compiled and analyzed the data with a view toward concluding whether or not the enacted statute has produced the desired result. This research project compared two cohorts that differed only in that one was comprised of those born before enactment of a statute in 2005, and the other cohort was comprised of those who were born after.

The first section of this chapter outlines the research design and rational, including its provenance, the data, and the evolving science. The following sections discuss the case definition and the ramifications of its lack of uniformity in research and validity. The third section looks at source data, research questions, and statistical methodology. The final section of this chapter lays

out potential threats to analysis validity, including socioeconomic and judicial pressures, and the complexity of the doctor's role in a community.

Research Design and Rationale

Three years after the Congressional Traumatic Brain Injury Act of 1996, the State of Minnesota began collecting case data specific to head and brain injuries among the citizens of Minnesota. As the initial data were compiled, public health officials found categorical associations between head and neck injuries. In winter for example, the risk of accidental falls on ice and slamming the occipital lobe in whiplash represented a concussive and potentially catastrophic scrambling of the brain. As the State of Hockey, Minnesotans' were already aware of inflicted injuries as a result of players being checked head-first into the boards (Stuart, & Smith, 2000). In response, the rules of youth hockey in Minnesota were changed, and an initiative was launched to educate all those involved in the game about the risks and injuries associated with checking from behind. The general logic was that education can be an effective intervention, as in this case, to change behavior and thus yield a lowering of incidence of injuries.

An evaluation of educational program success published in the *Journal of Clinical Sport Psychology* specific to concussive injuries in hockey concluded that while education is essential, "education alone is insufficient to cause a major reduction in the incidence" (Tator, 2012, p. 299). The parallel is not lost when implementing health policy designed for educated parents of newborn infants.

The data suggested a higher risk to infants and children from injuries generally understood to be shaken baby syndrome. In 2005 the State Legislature compelled by an

imperative to protect the most vulnerable enacted a statute mandating education be given to all parents of newborns within the state on the risks associated with behaviors tantamount to abuse at the time of discharge from hospital.

This quantitative research project is designed to compare the incidence of specifically iTBI; injuries to the contents of the skull in a cohort of subjects who were born before the enactment of state statute designed to educate new parents, to the incidence in a cohort born after the enactment of the statute. Data collected from 1998 to 2017 and archived by the State of Minnesota will be included in the analysis.

This research study is evaluative of the efficacy of healthcare policy mandating education. Because of this, the design choice is consistent with research designs needed to advance knowledge in the discipline. It is designed as a quantitative analysis the incidence of iTBI in a cohort of those born before enactment of the Statute 144.574 (1998-2005) and as such not exposed, with those born following passage (2006-2017); children born to parents who are in theory educated about the risks of maltreatment resulting in brain injury.

The year 2005 may have to be treated separately under the rational that the legislative debate may confound the results by creating social awareness.

Can education as an independent variable result in the desired effect? If there is a change in the incidence, because the research design casts a wide inclusion of all infants and children in the state over a number of years as a cohort, the effect is possibly or likely to be attributed to the enactment of policy designed to raise education and awareness at the time newborns are discharged from hospital as opposed to a single temperamental factor. On the other hand, if there is no appreciable difference in the incidence when comparing the two cohorts, that there is no

difference raises questions about the design and delivery of education as an effective means to change behavior and thus lower incidence.

Beyond a statistical comparison of the incidence in the two cohorts, the archived data may be robust such as to allow for an analysis of the incidence in urban areas vs. rural areas, comparisons among ethnic groups, and for an analysis of categorical shifts in incidence severity.

If there is found to be a difference in incidence between areas of differing population densities, the results would raise interesting questions beyond simply identifying a disparity. There may be differences in the way rural vs. urban hospitals have complied with state statutes in delivering education or may point toward differences in social networks or availability of social services. If there is found to be a relationship in the data between incidence of iTBI and an ethnic group, there may be questions about receptiveness or language barriers at the time when the education was offered or point to disparities in beliefs toward parental sovereignty associated with ethnicity. If there is found to be a categorical shift in the severity, even in if a change in incidence not observed, the shift may be attributed to education as an intervention and will point to the need for further research.

Any observable statistical effect is important in that it further informs public health officials and legislators about the State of Minnesota's investments in health policy as a tool to modify behavior. On the other hand, if there is no statistical effect, then an argument can be made for revision to the statute, or the adoption of a different strategy, to reduce the incidence of inflicted traumatic brain injuries.

Diagnostic (D) Codes

An evolved conceptual definition of TBI includes not only structural damage from an insult to the head, loss of or altered consciousness, the definition includes a diagnosis includes neurological and neuropsychological dysfunction (National Center for Injury Prevention and Control, 2003).

By combing through the International Classification of Diseases (ICD) the diagnostic definition can be translated to a specific code reference set labeled Diagnostic (D) Codes. Because the research spans the transition from ICD-9 to ICD-10, and because ICD-10 was used in cases of fatality, both ICD-9 and ICD-10 codes were identified (Chan, Thurairajah, & Colantonio, 2013). The ICD Diagnostic (D) code list is attached as an appendix to this research for subsequent review.

External Cause (E) Codes

The External Cause (E) Code 995.55 has been utilized as both a definitive diagnostic and to indicate the mechanism of injury (MOI). While code 995.55 is definitive, other cases where surface injuries may not be immediately evident, a history and physical examination may, for example, reveal less obvious fingertip bruising on the shoulder and arms where a child was grabbed, and suggest shaking (Kibayashi & Shojo, 2003).

A thorough review of the ICD-9 and ICD-10 external cause codes lead to a specific External Cause (E) code reference set that captures the nature and mechanisms of injury consistent with inflicted Traumatic Brain Injuries. Specific ICD External (E) Codes selected are attached as an appendix to this research for subsequent review.

Combining Cause and Effect

The International Classification of Diseases is a standard diagnostic tool of epidemiology and public health. This research project grounds the case definition of iTBI in both specific ICD diagnostic and event codes. With the exception of code 995.55, which may stand as either definitive of an event or cause of shaken baby syndrome, the case definition of inflicted Traumatic Brain Injury requires that the events leading to injury are consistent with maltreatment. Here the term "inflicted" is employed, as well as a diagnosis of injury to the brain. Thus, the iTBI case definition also pulls together a well understood scientific grounding in the logic of cause (event) and effect (diagnosis).

Methodology

Population Under Study

All children born in the state of Minnesota from 1998 through 2017 are to be included as a unique data point, regardless of race, ethnicity, religion, two- or single-parent family. With approximately 70,000 births per year in Minnesota, the study target population size was approximately 1.1 million. Given that incidence estimates range from approximately 20 to more than 40 cases of inflicted or abusive head trauma per 100,000 (Jayawant et al., 1998), the number of cases within the current study will likely fall within a range of between 250 and 500. Though it presents a logistical challenge to include children born in 2015 and follow them as a potential case until 5 years of age, the primary analysis is completed on neonates and infants up to 24 months, and children born in 2015 will be included. The rationale for this practical time constraint in the design is that the subjects need to be followed for a minimum of the first 2 years

of an infant's life—the period when the vast majority of the cases occur. Furthermore, there is a lag in the Minnesota data.

Sampling and Sampling Procedures

This research project examines the data in its entirety, rather than sample a limited number of cases with a view toward derivation. The strategy consists of an analysis of the Minnesota Hospital and Emergency Department Discharge Data. This data is tightly controlled and highly reliable. Statutorily compelled cases such as these are, by definition, inclusive and therefore eliminate the concerns and limitations of statistical deviation. Furthermore, the fact that the statute requires compiling data year over year allows the study to make meaningful analysis over time. Furthermore, because the parameters remain constant, cohorts before and after the implementation of the statute are likely to be mirror cohorts.

Permission to use the data for the purpose of this study was obtained through written proposal to the MDH). As a condition of access to the databases all access must be made while on site, must utilize specific computers, secure lines. MDH has an office and portal designated for such research.

Statistical Analytics Software (SAS) Code

Statistical Analytics Software (SAS) was chosen for this project because the MDH requires the data to be extracted with approved software, and, SAS is capable of bridging the multiple data sets where spine, head, and neck injuries are compiled.

The SAS program language in this project has been written to untangle imprecise language that conflates head and brain, or whiplash and coup contrecoup injuries, by employing specific ICD code sets. Moreover, that early cases were coded using ICD-9, cases of fatality

were recoded as ICD-10 beginning in 2010, and that by 2016 all cases were archived using ICD-10, required specific known capabilities of the SAS program. To bridge from 1998 to 2017 required a specific crosswalk from ICD-9 to ICD-10 and weeks of additional SAS programming.

Cases of inflicted Traumatic Brain Injuries were pulled and verified from registry data, emergency department and hospital discharge data, and records of vital statistics using SAS software. Each case was assigned a random ID so that where the data was incomplete, and as a random test of validity, case files were abstracted and reviewed.

Data Type

Hospital discharge data is compiled by the Minnesota Hospital Association, and although not statutorily mandated to be made to be available, discharge data is made available to the MDH for analysis through mutual agreement and contract.

Discharge data is primarily compiled from billing information and includes treating institution, admission (date and time), date of injury, patient demographics including date of birth, age and gender, zip code of the patient, type of injury coded as an ICD, mechanism of injury, treatment or procedure, and discharge date.

The MDH compiles a registry of all traumatic brain and spinal cord cases. Registry data is linked to the discharge data to ensure the data is comprehensive. Registry information comes from all hospitals in the state of Minnesota. Cases from larger hospitals are reviewed by a trauma registrar or trauma coordinator. As such the registry is believe do to be more sensitive; cases of iTBI are less likely to be unreported, or misdiagnosed, and less likely to include false positives. By combining discharge data to the registry, iTBI incidence data is cross checked.

Sources of Data

The Congressional Traumatic Brain Injury Act of 1996 authorized the state to collect brain injury data, and state statutes mandate hospital and other authorities to report cases, or suspected cases, of TBI to the MDH. Reporting is constrained by M.S. 144.665, 13.3805, 144.6581, and 13.02. Case records are archived in two specific data sets from which data will be extracted.

Database 1 – Traumatic Brain and Spinal Cord Injury Registry

Under State Statutes 144.661 through 144.665, hospitalized cases of traumatic brain and/or spinal cord injury must be reported to the MDH if the patient receives one of the following ICD-9-CM codes, either as a principal or secondary diagnosis (including the respective sub-coded rubrics) (Table 1):

Table 1
Minnesota Traumatic Brain Injury/Spinal Cord Injury Registry

ICD-9-CM Codes	Description
310.2	post-concussion syndrome
348.1	(when coded w/ 994.1 or 994.7) - anoxic brain damage
800.00-800.99	fracture of vault of skull
801.00-801.99	fracture of base of skull
803.00-803.99	other and unqualified skull fractures
804.00-804.99	multiple fractures involving skull or face with other bones
850.0-850.9	concussion
851.00-851.99	cerebral laceration and contusion
852.00-852.59	subarachnoid, subdural, and extradural hemorrhage, following injury
853.00-853.19	other and unspecified intracranial hemorrhage following injury
854.00-854.19	intracranial injury of other and unspecified nature
950.0-950.9	injury to optic nerve and pathways under Minnesota Rules
4643.002	Definitions subp. 10, Traumatic brain injury reportable cases.
995.55	shaken infant syndrome.

Table 1 was uniquely created for this research project.

The Minnesota Traumatic Brain and Spinal Cord Injury (TB/SCI) Registry is thus a compilation of all people who sustained a brain or spinal cord injury in the State of Minnesota regardless of external cause. Registry data includes demographic profiles, zip codes, ICD descriptive codes, and associated cause codes (Kinde & Roesler, 2003).

Database 2 – Emergency and Hospital Discharge Data

Hospital discharge data under Statute 144.05 which contains provision in the Statute language to ensure the data is accessible for research projects. Discharge data includes cause, diagnostic codes, and billing information. Cases are identified from hospital billing data with one or more of the following ICD-9-CM codes (Table 2):

Table 2
Emergency and Hospital Discharge Data

ICD-9-CM Codes	Description
N995.5x	child maltreatment syndrome
E967.x	child and adult battering and other maltreatment
V61.21	counseling for victim of child abuse
V71.81	observation for suspected abuse and neglect
E904.x	hunger, thirst, exposure and neglect

Table 2 was uniquely created for this research project.

Database 3 – Minnesota State Vital Records

Death recorded by certificate in State Vital Records in the case that a patient did not make it to an emergency department or hospital. Per Minnesota Statute 144.225 sub 1.: information contained in the vital records shall be public information.

Census Data

Zip Code Tabulation Area (ZTCA) Census Data were used to suggest social economics status by linking the zip code to the census data of median household income within the zip code. Where information about ethnicity could be found, it came either from the abstracted case history or from birth certificates accessed through vital records. Death certificates from Statewide Vital Statistics were used to verify fatalities that did not occur in hospital or emergency department.

Case Inclusion

A case of iTBI was included in this research project if the patient was admitted as an inpatient to an acute care hospital, or died in the emergency department prior to admission, or was declared dead on arrival, or was transferred from the emergency department to an out-of-state hospital.

The medical records must document cranio-cerebral trauma defined as either:

(1) an occurrence of injury to the head with one or more of the following conditions attributed to head injury: observed or self-reported decreased level of consciousness, amnesia, skull fracture, objective neurological or neuropsychological abnormality, or a diagnosed intracranial lesion, or

(2) an occurrence of death resulting from trauma, with head injury listed on the death certificate, autopsy report, or medical examiner's report in the sequence of conditions that resulted in death (Marr, & Coronado, 2004).

A case is determined by standard review to determine a preponderance of evidence in the clinical record as opposed to meeting a legal standard of evidence beyond a reasonable doubt.

Limitation of Age

While authoring State Statute, Legislators borrowed from Dias' 2005 study in which the incidence of 26 per 100,000 in the first year of life dropped to 3.4 per 100,000 in the second year (Dias, Smith, Mazur, & Shaffer, 2005). Because this research is evaluative, limiting the age to those under five years allows for better comparisons with previously published literature including Alexander's study on child maltreatment and references in child development on teething and colic when inconsolable crying is thought to be a trigger (Alexander, Levitt, & Smith, 2001). There appears to be a higher incidence during nonverbal infancy (Leventhal, Asnes, Pavlovic, & Moles, 2014). Infant and young children are less likely to have the level of physical development to inflict self injuries, and as such injuries are more likely to be attributable to abuse (Scannapieco, & Connell-Carrick, 2005). And, selecting age five years as a cut off better aligns with the CDC definitions (Parks, Annest, Hill, & Karch, 2012).

Legal Definition

Because this research project is grounded in medical science as well as statutory law, the legal definition of a case must be considered. U.S. Congress established the following definition for the CDC under Section 1261(h)(4) of the U.S. Public Health Service Act (42 U.S.C. 300d-61(h)(4)):

> The term "traumatic brain injury" means an acquired injury to the brain. Such term does not include brain dysfunction caused by congenital or degenerative disorders, nor birth trauma, but may include brain injuries caused by anoxia due to trauma.

Minnesota State statutes combine child abuse and traumatic brain injury under MS. 144.661 Definitions, Subd. 2 to define Traumatic Brian Injury as:

> a sudden insult or damage to the brain or its coverings caused by an external physical force which may produce a diminished or altered state of consciousness and which results in the following disabilities:
>
> (1) impairment of cognitive or mental abilities;
>
> (2) impairment of physical functioning; or
>
> (3) disturbance of behavioral or emotional functioning.
>
> These disabilities may be temporary or permanent and may result in partial or total loss of function. Traumatic brain injury does not include injuries of a degenerative or congenital nature (Minnesota Statutes, 2017).

Case Definition

This evolved term inflicted Traumatic Brain Injury, for the purposes of this research, combines elements of maltreatment with the trajectory of injury meeting specific diagnosis of trauma to the brain. All cases must be under the age of five years at the time of the injury. Cases must contain – at minimum - both a diagnostic (D) code as well as an external cause (E) code in the medical records documenting the injury to be inflicted. Cases where injuries result from neglect and/or specifically injuries from gunshot, stabbing, and penetrating trauma are excluded. Congenital or degenerative injury is excluded.

Operational Algorithm

The case definition of iTBI was translated into an operational algorithm for the purposes of programming the logic in SAS:

1 - The patient is a resident of Minnesota at the time of injury; and

2 - The patient is under five (5) years of age at the time of injury; and

3 - The patient was treated in the emergency department or in hospital, or died prior to admission; and

4 - The patient sustained a head injury with altered level of consciousness, amnesia, skull fracture, ocular or retinal damage, intracranial injury or lesion, or resultant neurological or neuropsychological abnormality consistent with brain injury, or the head and brain injury resulted in mortality with the injury specifically identified as the condition that resulted in death; contains one of the iTBI diagnostic codes, and

5 - There is documentation that the injury or health condition was due to: confirmed abuse (third party-witnessed or self-reported by victim or perpetrator); or suspected abuse (suspicious injury, suspicious pattern or injury inconsistent with history), contains one of the iTBI external cause (E) codes.

6 - Cases are of brain injuries reported from 1998 through 2017 in Minnesota and archived in the Minnesota Department of Health (MDH).

7 – Where the attending has documented an ICD-9-CM diagnostic and/or cause code of 995.55, the diagnosis is definitive.

Data Analysis

Quantitative Research Question 1

RQ1: Is there a statistically significant effect when comparing the incidence of inflicted Traumatic Brain Injuries (iTBI) in a cohort of infants and children born 1998 through 2005, and the incidence of same in a cohort born 2006 through 2017?

*Ho*1: There is no statistical difference between the two cohort groups: those born 1998 through 2005 and those born 2006 through 2017 in the incidence of inflicted Traumatic Brain Injury.

*Ha*1: There is a statistical difference between the incidence of inflicted Traumatic Brain Injuries in a cohort of those born 1998 through 2005 and a cohort of those born 2006 through 2017.

Research Question 1 sought to determine if there is a statistically significant size effect between two groups. While an ANOVA is useful in an analysis of a sampled data, it also implies a continuous dependent variable. In this analysis, we are counting all cases and seek a simple comparison of the incidence. A Poisson Univariate Regression was considered. It was determined that the most appropriate statistical test is the Z-test.

Quantitative Research Question 2

RQ2: Using Rural-Urban Commuting Area Codes (RUCA) data that tracks urbanization and population density, is there a difference in the incidence of inflicted Traumatic Brain Injuries (iTBI) in rural vs. urban areas (Duluth, Minneapolis, St. Paul, Rochester, East Grand Forks, Morehead, La Crescent) in infants and children born 1998 through 2005 vs. 2006 through 2017?

*Ho*2: There is no statistically significant difference between the incidence of inflicted Traumatic Brain Injury (iTBI) when comparing rural vs. urban cohorts of infants and children born 1998 through 2005 vs. 2006 through 2017.

*Ha*2: There is a statistically significant difference between the incidence of inflicted Traumatic Brain Injury (iTBI) when comparing rural vs. urban cohorts of infants and children born 1998 through 2005 vs. 2006 through 2017.

Research Question 2 seeks to learn if there is a disparity between rural and urban populations, in both groups before and after enactment of State Statute. A Poisson multivariate regression as a generalized linear model used to analyze data that is counted and expresses the probability of a subsequent event occurring given a fixed interval when the frequency is known, when there is more than one variable, is appropriate. However, because the data is not a ratio, the data is in fact a census count of real cases, the Z-test is most appropriate.

Quantitative Research Question 3

RQ3: Is the incidence of inflicted Traumatic Brain Injury (iTBI) in infants and children proportional to the differences among ethnic groups such that no one ethnic group is observed to have a disproportionately higher – or lower – incidence in cohorts born either before enactment of statute 144.475 or those born after the enactment?

*Ho*3: There is no statistically significant difference found in the incidence of iTBI when comparing ethnic cohorts of infants and children born 1998 through 2005 and cohorts of same born 2006 through 2017.

*Ha*3: There is a statistically significant difference found in the incidence of iTBI when comparing ethnic cohorts of infants and children born 1998 through 2005 and cohorts of same born 2006 through 2017.

Research question 3 seeks to understand if there is a proportional difference in incidence related to ethnicity. The model is specifically designed around ethnicity vs. race. The logic is that

while race is frequently associated with somatic health concerns, for example diabetes (Mitin et al., 2011), or sickle cell anemia (Wailoo, 2014), ethnicity is associated with a variety of social constructs and behaviors that affect health. Research question 3 also requires a consideration and the ability to control for social economic status in the analysis. A Poisson Multivariate Regression would have been applied as a statistical model to answer this question. However, because the data is incomplete a statistical analysis is not possible.

Quantitative Research Question 4

RQ4: Is there a categorical shift using registry variable data in the severity of inflicted Traumatic Brain Injury (iTBI) cases defined as:

i. Without sequelae – modified Glasgow Outcome Scores of "good recovery"; cases where the victim is believed to have a good prognosis of recovery with age appropriate levels of functioning and without the need for special assistance or educational services,
ii. With sequelae – modified Glasgow Outcome Scores representing "Moderate or Severe Disability"; cases with sequelae where there are noticeable reductions in cognitive functioning and/or motor deficits requiring accommodation(s),
iii. Vegetative or fatal – modified Glasgow Outcome Scores indicating "Persistent Vegetative state" or fatality; cases where the injuries result in a vegetative state or fatality in a cohort of infants and children born before enactment of statute 144.475 (those born 1998 through 2005) compared to cases after enactment (those born 2006 through 2017)?

*Ho*4: There is no apparent statistically significant categorical shift in the severity of injury when comparing a cohort of infants and children born 1998 through 2005 with same born 2006 through 2017.

*Ha*4: There is a statistically significant categorical shift in the severity of injury when comparing a cohort of infants and children born 1998 through 2005 with same born 2006 through 2017.

Research question four is an analysis of categorical shifts. It is important to learn if there is a shift in severity that can be associated with the benchmark in time when Statute 144.574 was enacted. Categories can be operationalized as:

i. documented trauma without sequelae that can be identified as those taken to the emergency department but are not admitted as an in-patient.

ii. inflicted trauma where there the victim is admitted as an in-patient, and/or there is data to support additional care is required, and

iii. trauma that results in a vegetative condition or fatality.

The analysis is predicated on a summary of the cases within the two groups, while apportioning the cases as a percentage, then comparing the weight of each category; the categorical weight those born before vs. the categorical weight of those born after legislative enactment.

Statistical Analysis Software (SAS) Code

SAS version 9.4 underlying module TS level 1M2 was used to pull incidence allows researchers to preserve and analyze disparities related to rural vs. urban health safety nets, and

the potential to examine an association with patient volume or in hospitals that describe their service to the community as a birthing center (Cromartie, & Bucholtz, 2008).

Care was taken to preserve links to the year of birth, age in days, gender, zip code for an analysis of urban vs rural, ethnicity and race, as well as discharge data to use as a proxy for severity. The data was pulled multiple times and each successive iteration tested for validity. Including ages from birth up to the fifth birthday, not including the fifth birthday, the SAS program pulled 1,061 "valid" cases from 1998 through 2017.

After multiple test runs pulling data and reiterations of SAS program language, it was determined that greater than 95% of the cases are accurately identified and more than 95% of the cases are correctly true. This sensitivity and validity test reduced uncertainty and supported the operational definition for inflicted Traumatic Brain Injury (iTBI) as an event code combined with a diagnostic code.

Threats to Validity

A study published in the Journal of Neurosurgery challenged the thinking that a child with a skull fracture should be admitted to hospital (Arrey, Kerr, Fletcher, Cox, & Sandberg, 2015). The exception that a linear non-displaced fracture will do no worse, and thus a trip to hospital is needless runs counter current to idea that brain injuries may result even in the absence of apparent skull fracture. And, in the absence of clarity, when the public learns that it is a child or infant who suffered a skull fracture and potential brain injury does no better taken to hospital undermines public health. This confusion, where there are already barriers to healthcare, combined with the potential of self-incrimination by walking through the doors of an emergency department carrying the victim, leads to inaction.

Economic stress worsens the inaction by people who simply seek to avoid the cost of care. In an environment where the cost of healthcare beyond the co-pay, arguable a mechanism in place to change behavior as opposed to making any significant offset in the costs, families weigh the costs against a believe that kids bounce and if there is no loss of consciousness the event does not rise to the level of needing attention (Langlois, Rutland-Brown, & Wald, 2006).

If the victim is taken to hospital, injuries may not be coded properly. A case review of death certificates of 384 pre-school children by the Missouri Division of Family Services where the death certificate contained a cause code found 121 (31.5%) cases of definitive maltreatment, fewer than half were coded as maltreatment (Ewigman, Kivlahan, & Land, 1993). Four in five of the identified fatalities were in families where there was definite determination of abuse and/or neglect, yet only two in five were reported and found in the Uniform Crime Database as homicides. One cannot conclude complicity or negligence, or even that there is a conscious decision to not code as abuse or child maltreatment. At the same time, there appears to be reticence, or avoidance of, documentation that may point to criminal behavior of injuries that mandate the intervention of child protective services and/or the county sheriff. Or, the data suggests that medical professionals may not fully appreciate the imperative of mandatory reporting (Lynne, Gifford, Evans, & Rosch, 2015).

When treating a victim, understanding the mechanism of injury; determining the cause is knotted to treatment. Yet another primary threat to validity comes from inconsistency in the way emergency attending and/or other physicians triage, diagnose, and employ assign code. This research project is largely predicated on a comprehensive review of hospitalized cases as

identified and extracted by SAS software. The project employs a case specific definition based on assumptions of the proper use by emergency departments of ICD cause codes.

A 2006 chart audit suggests that one out of three hospitalization records was not associated with a cause code (Coben, Steiner, Barrett, Merrill, & Adamson, 2006). When external (E) cause codes are used, they are inconsistent and confounding. There appears to be an inherent bias depending on medical specialty. For example, if a patient is taken to hospital and diagnosed with a cerebral hemorrhage, was that as a result of a fall, or was the fall as a result of a cerebral hemorrhage? The etiological dilemma is one of chicken and egg. Moreover, a review of the quality of medical records and use of cause codes concluded that even when cause codes are used, there are major deficiencies in the medical documentation leading to a failure to support the code (Cunningham et al., 2014).

Yet another undermining issue is that a medical doctor, who's responsibility it is to code, often views coding as an extension of billing and eschews the chore as outside the practice of medicine. This tacit dismissal of coding as the business of medicine leads to only doing what is required to remain in compliance. Such failure to properly code, and equally troublesome failure to seeking medical attention, is beyond a threat to validity. Both lead to large numbers of under reported and undiagnosed traumatic brain injuries regardless of cause.

As a strategy to reduce threats to validity, 1 in every 20 cases identified by SAS was randomly pulled from the archives and the entire medical record reviewed for consistency in the application of both diagnostic and cause codes, to ensure RUCA data is not corrupted, to verify residence and other demographic data is correct.

Ethical Considerations

The research adheres to considerations of confidentiality and protections of privacy as a grounding tradition of epidemiological research (Gold, 1996). It is acknowledged that the case definition is specific to children, classically a protected group who cannot offer an informed consent. However, an informed consent is not required because the data is statutorily made available to research.

Additional training and compliance specific to the review and handling of private and protected health information (PHI) under the direction of the MDH will be completed.

Specific PHI is only linked through medical record numbers which, in the event that a specific patient chart needs to be accessed, requires combining the record number with specific hospital records.

Caution will be taken to preserve the anonymity of victims as well as parents, attending physicians, and others involved in the case through SAS coding and assignment of case identifiers.

As a researcher, I will not be paid for or benefit in any way from uncovering additional cases, a threat to validity as much as being unethical.

The study will be under the guidance and supervision of Jon Roesler, Director of the Department of Injury and Violence at the Minnesota Department of Health, as well as under the specific guidance of Walden University Institutional Review Board (IRB approval 05-23-18-0080525).

Summary

It is the stated goal of public health officials in general to protect the public, and to reduce traumatic brain injuries in general, yet in this research the purpose is evaluative much the way understanding if a seatbelt law or a reduction in speed limits has the desired effect of protecting the public from harm. This research seeks to understand if enacted statute has had the desired effect to reduce the overall incidence.

The case definition is carefully and deliberately considered both conceptually as well as in operationally such that statistical software can be written to extract the data from the archives of three registries in the State of Minnesota.

In Chapter 4 the results of the statistical analysis are presented using a series of Tables and Figures created specifically for this project. The analysis begins with summarizing the overall population as a denominator, and presenting rational for narrowing the analysis to infants under the age of 1 year old. Plotting the incidence over time highlights 2005, a trough when the statute was authored, debated, and enacted, and 2009 as the peak incidence. The question of including or excluding data from 2005 is addressed through a statistical analysis. Each of the research questions requires cutting the data and incidence in unique ways to answer if null hypothesis should be adopted, or if the alternative hypothesis should be adopted.

Chapter 4: Results

Introduction

The State of Minnesota began collecting data on head, neck, and brain injuries in 1998 and continue to collect data under mandated case reporting. An ad hoc review of the first 5 years of reported cases, and the publication by a pediatric neurologist in 2005, buttressed the hypothesis that education may operate as preventive intervention. By authoring and enacting Minnesota State Statute 144.574 in 2005, health officials and state legislators anticipated similar results: a statistically significant reduction in the incidence of iTBI.

Using quantitative and evaluative research models, this project sought to answer the fundamental question of whether the statute resulted in a statistically significant effect. The null hypothesis was that there is no statistically significant effect in incidence when comparing a cohort of those born before to a cohort born after enactment. The second research question asked whether the statute would show similar results in urban and rural communities. Because of Minnesota's many traditional rural farming communities and its large, concentrated urban areas, it is important to know how the statute affects the state's geographic diversity; the hypothesis was that there is a similar effect in both rural and urban communities. The third research question was written with the understanding that culture and ethnicity, as they relate to learned behaviors, may produce differing results. The null hypothesis was that incidence is proportionally distributed across all ethno-cultural populations, and that there would be no statistically observed difference in incidence. The fourth research question was predicated on the hypothesis that the effect of the statute might be to shift the distribution of case severity. That is, in the event that the overall incidence remained unchanged, the statute might have result in a modifying effect where

events previously resulting in a severe trauma or fatality would, instead, be survivable or less permanently debilitating.

Population Data

To calculate the incidence of iTBI in a population of infants and children under 5 years old in Minnesota, it was first necessary to know the total number of infants and children as a denominator (Table 3).

Table 3

Population of Minnesota (0-<5 years of age)

	Males			Females			**Total**
Year	0-<1	1-<5	0-<5 y.o.	0-<1	1-<5	0-<5 y.o.	0-<5 y.o.
1998	33,201	128,755	161,956	32,005	123,420	155,425	317,381
1999	34,035	130,067	164,102	31,916	125,605	157,521	321,623
2000	34,512	134,317	168,829	32,938	127,827	160,765	329,594
2001	32,337	132,557	164,894	30,717	126,415	157,132	322,026
2002	32,096	131,370	163,466	30,390	125,139	155,529	318,995
2003	33,566	133,485	167,051	31,873	127,102	158,975	326,026
2004	35,325	135,119	170,444	33,468	128,112	161,580	332,024
2005	36,339	135,922	172,261	34,581	128,735	163,316	335,577
2006	37,490	138,670	176,160	36,025	133,065	169,090	345,250
2007	37,469	143,696	181,165	36,206	136,530	172,736	353,901
2008	37,031	146,179	183,210	35,346	139,915	175,261	358,471
2009	36,306	149,289	185,595	34,309	144,071	178,380	363,975
2010	34,950	146,392	181,342	33,456	140,706	174,162	355,504
2011	35,048	144,734	179,782	33,368	139,110	172,478	352,260
2012	35,189	142,784	177,973	33,589	136,776	170,365	348,338
2013	35,435	142,645	178,080	33,743	135,744	169,487	347,567
2014	35,526	142,908	178,434	34,381	135,828	170,209	348,643
2015	35,929	143,472	179,401	33,902	127,231	161,133	340,534
2016	35,625	144,548	180,173	34,116	138,215	172,331	352,504
2017	35,072	146,720	181,792	33,531	139,908	173,439	355,231

SAS was used to extract live birth data, then combined with census data to create a table of the population. Table 3 as well as all other tables and figures presented in this research project were uniquely created for this project using SAS-extracted data and analysis of the data.

It was then possible to break down the population data by male and female, and to further break out the number of infants who had not yet reached their first birthday (0-<1).

Cases of iTBI

Cases of iTBI were pulled and verified using SAS from registry data, from emergency department and hospital discharge data, and from records of vital statistics. SAS was chosen for this project because the (MDH) requires the data to be extracted with approved software, and because it is known that SAS is capable of bridging multiple databases to extract discrete data while preserving mapped data. Each case was assigned a random ID so that where the data was incomplete, and as a random test of validity, the medical chart could be abstracted.

Each successive data pull, review, and edit of the SAS program language resulted in a data set where cases were determined to be greater than 95% accurately identified, and where more than 95% of the identified cases are true. This sensitivity and validity test reduced uncertainty and supported the operational definition for iTBI as an event code combined with a diagnostic code.

Links to the year of birth, age in days, gender, zip code (for an analysis of urban vs rural), ethnicity and race, as well as discharge data (to use as a proxy for severity) were preserved. Including ages from birth up to the fifth birthday, but not including the fifth birthday, the SAS program pulled 1,061 “valid” cases from 1998 through 2017.

Incidence of iTBI

Overall incidence of iTBI, defined as cases of iTBI per 100,000 in infants and children younger than age 5, was calculated by dividing the number of valid cases in any given year by total population younger than 5 years old in that same year. The annual incidence of iTBI in a population of children younger than age 5, and an overall incidence from 1998 through 2017 in Minnesota was compiled (Table 4).

Table 4

Annual Incidence of iTBI in Infants and Children in Minnesota Younger Than 5 Years Old

	0-<5 y.o.	Cases	Incidence
1998	317,381	43	13.55
1999	321,623	50	15.55
2000	329,594	41	12.44
2001	322,026	51	15.84
2002	318,995	55	17.24
2003	326,026	58	17.79
2004	332,024	51	15.36
2005	335,577	45	13.41
2006	345,250	58	16.80
2007	353,901	68	19.21
2008	358,471	67	18.69
2009	363,975	77	21.16
2010	355,504	61	17.16
2011	352,260	44	12.49
2012	348,338	56	16.08
2013	347,567	59	16.98
2014	348,643	40	11.47
2015	340,543	51	14.98
2016	352,504	36	10.21
2017	355,231	50	14.08
Total	**6,825,433**	**1,061**	**15.54**

There were 1,061 cases of iTBI and a population of 6,825,433 over the duration of the study. The overall incidence was 15.54 cases of iTBI per 100,000 infants and children under the age of 5 years old.

Table 5 is a presentation of the annual and overall incidence of iTBI in Minnesota from 1998 through 2005 in a cohort (B), before the intervention and is, analogous to Dias' control period wherein the incidence-inclusive of children up to 60 months-is calculated to be 15.13 cases of iTBI per 100,000 live births.

Table 5

Annual Incidence of iTBI From 1998 to 2005

	0-<5 y.o.	Cases	Incidence
1998	317,381	43	13.55
1999	321,623	50	15.55
2000	329,594	41	12.44
2001	322,026	51	15.84
2002	318,995	55	17.24
2003	326,026	58	17.79
2004	332,024	51	15.36
2005	335,577	45	13.41
Total	**2,603,246**	**394**	**15.13**

The annual and overall incidence of iTBI in a cohort of validated cases 2006 through 2017, defined as cohort A: after introduction of statute 144.574, calculated to be 15.80 cases of iTBI per 100,000 live births (Table 6). These results, when compared to cohort B indicate that the incidence overall has increased.

Table 6

Annual Incidence of iTBI From 2006 to 2017

	0-<5 y.o.	Cases	Incidence
2006	345,250	58	16.80
2007	353,901	68	19.21
2008	358,471	67	18.69
2009	363,975	77	21.16
2010	355,504	61	17.16
2011	352,260	44	12.49
2012	348,338	56	16.08
2013	347,567	59	16.98
2014	348,643	40	11.47
2015	340,543	51	14.98
2016	352,504	36	10.21
2017	355,231	50	14.08
Total	**4,222,187**	**667**	**15.80**

To further explore how age of the victim might affect the analysis, each validated case was mapped to a value of days from birth to incident. Validated cases of iTBI were broken down by age of the victim (Table 7). 63.43% of all cases occur in the first year of life.

Table 7

Percentage of Cases By Age of Victim

Age	Number	Percent
0-<1	673	63.43%
1-<2	172	16.21%
2-<3	100	9.43%
3-<4	66	6.22%
4-<5	50	4.71%
Total	1061	

An analysis of the time from birth to incidence performed by averaging the number of days in each successive year. The analysis reveals the average age that an infant suffers an iTBI is 152.2 days (Table 8). The results presented in Table 6 are weighted by adding each successive

year to arrive at an average of those years. When including children up to 48 months the average number of days to incident is still under a year (362 days).

Table 8

Average Number of Days From Birth to Incident

0 - <1	0 - <2	0 - <3	0 - <4	0 - <5
152	228	300	362	420

Note: Calculation of year two (0-<2) is a combined average across both years. Year three (0-<3), year 4 (0-<4), and year five (0-<5) are similarly combined.

Annual incidence of iTBI in infants under 1 year old was calculated (Table 9).

Table 9

Annual Incidence of iTBI in Infants (0-<1 y.o.)

	Live Births	Cases	Incidence
1998	65,206	28	42.94
1999	65,951	34	51.55
2000	67,450	29	42.99
2001	63,054	31	49.16
2002	62,486	26	41.61
2003	65,439	28	42.79
2004	68,793	34	49.42
2005	70,920	22	31.02
2006	73,515	34	46.25
2007	73,675	48	65.15
2008	72,377	43	59.41
2009	70,615	55	77.89
2010	68,406	45	65.78
2011	68,416	26	38.00
2012	68,778	34	49.43
2013	69,178	43	62.16
2014	69,907	24	34.33
2015	69,831	33	47.26
2016	69,741	25	35.85
2017	68,603	31	45.19
		673	

The results overall, and, specifically, analysis showing that the majority of cases (63.43%) occur in the first year of life, lead to the decision to restrict subsequent analysis to cases were the victim has not yet reached the age of 1 year old.

Questioning Data From 2005

A plot was made (Figure 1) of the year-over-year incidence in infants (0-<1). A conspicuous dip in the plot of calculated incidence found in 2005 that appears to coincide with the legislative debates, authoring, and enactment of Statute 144.574. There also appears to be a peak in incidence in 2009 coincidental to the height of the unemployment during the recession.

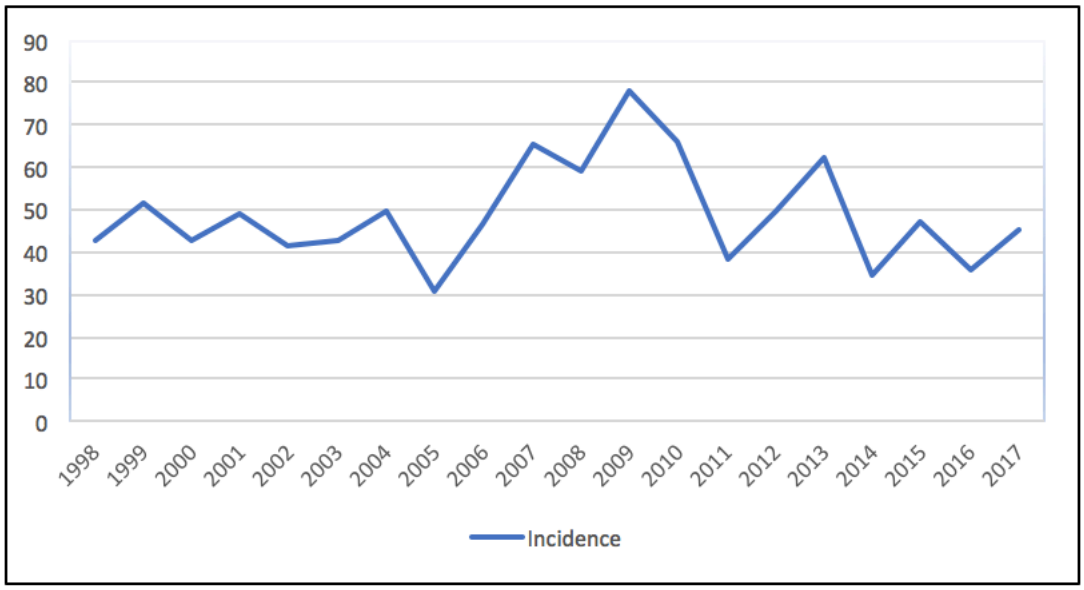

Figure 1. Annual Incidence (per 100,000 births) of Inflicted Traumatic Brain Injury Injury in Minnesota from 1998-2017 in infants younger than one year old (0-<1 y.o.).

If a statistically significant difference were found when comparing the incidence in years 1998-2004 to the incidence in 2005, then data from 2005, the year of enactment, would have been excluded.

From 1998-2004 there were 210 cases of iTBI in infants. In that same time period, there were 458,379 live births. The calculated incidence from 1998 through 2004 in infants (0-<1 year old [y.o.]) is 45.81 cases of iTBI per 100,000 live births (Table 10).

Table 10
Incidence of iTBI (0-<1) 1998-2004

Cases	210
Births	458,379
Incidence	**45.81**

The incidence from the year 2005 was 31.02 (22 cases of iTBI in 70,920 live births). The Z-Score is -1.7512 with a p-value is 0.08012. The Z-test leads to a conclusion that there is *not* a significant difference between years 1998 through 2004 and the year 2005 where p is less than 0.05. The decision was made to retain data from 2005 during the legislative debates and enactment of statute 144.574 in cohort B data.

When 2005 is included, there are 232 validated cases of iTBI in infants (0-<1 y.o.) and 529,299 live births. The annual and overall incidence in Cohort B, is calculated (Table 11).

Table 11
Annual Incidence of iTBI in Infants (0-<1) in Cohort B

	0 - <1 y.o.	Cases	Incidence
1998	65,206	28	42.94
1999	65,951	34	51.55
2000	67,450	29	42.99
2001	63,054	31	49.16
2002	62,486	26	41.61
2003	65,439	28	42.79
2004	68,793	34	49.42
2005	70,920	22	31.02
	529,299	**232**	**43.83**

In Cohort A there are (441) validated cases of iTBI in infants (0-<1 y.o.) and 843,042 live births from 2006 through 2017. The annual number of live births, number of validated iTBI cases, and incidence, as well as overall incidence in cohort A is calculated (Table 12).

Table 12

Annual Incidence of iTBI in Infants (0-<1) in Cohort A

	0 - <1 y.o.	Cases	Incidence
2006	73,515	34	46.25
2007	73,675	48	65.15
2008	72,377	43	59.41
2009	70,615	55	77.89
2010	68,406	45	65.78
2011	68,416	26	38.00
2012	68,778	34	49.43
2013	69,178	43	62.16
2014	69,907	24	34.33
2015	69,831	33	47.26
2016	69,741	25	35.85
2017	68,603	31	45.19
	843,042	**441**	**52.31**

Gender

It is noted that of the 1,061 cases inclusive of birth through 60 months of age, males are disproportionately more represented (62%) compared to females (38%) (Table 13).

It is important to know if there is a redistribution when restricting the analysis to those under 1 year old. A side by side comparison of gender when age is restricted to infants under 1 year old (0-<1) shows a similar disproportion (Table 14).

Table 13
Gender Disparity (0-<5)

Male	658	62.02%
Female	403	37.98%

Table 14
Gender Disparity (0-<1)

Male	419	62.26%
Female	254	37.74%

This research project was not designed to explore how gender might affect incidence. Nor is it known if, or to what extent, the proportion of males to females may weigh on, or into, the results. However, because the proportions are similar when comparing children under 60 months to infants under 12 months, gender is not thought to confound this analysis.

Research Question 1

Research Question 1 sought to learn if there is a statistical difference in the incidence of inflicted Traumatic Brain Injuries in a cohort B: children born to parents in Minnesota before enactment of State Statute 144.574, when compared to those born after enactment: cohort A.

From 1998-2005, restricting to infants less than 1 year old, there were 232 cases of iTBI. During the same time, there were 529,299 live births in the state of Minnesota. The calculated incidence is 43.83 cases of iTBI per 100,000 live births (Table 15):

Table 15
Incidence of iTBI (0-<1) 1998-2005

Cases	232
Births	529,299
Incidence	**43.83**

Similar methodology was used to calculate the incidence in cohort A. Restricting the data to infants who have not yet reached the first birthday, the total number of valid cases from 2006 through 2017 in infants under 12 months was divided by total live births to calculate incidence, and normalized to cases of iTBI per 100,000 (Table 16).

Table 16

Incidence of iTBI (0-<1) 2006-2017

Cases	441
Births	843,042
Incidence	**52.31**

On face value these results indicate that in cohort A the incidence of iTBI in infants, when compared to cohort B, is higher rather than lower.

Statistical Test of Cohort B and Cohort A

A statistical test for two population proportions in which the distribution of the dependent variable under the null hypothesis can be approximated by a normal distribution provided that the sample size, in this case the population variance, is known. An ANOVA and/or Poisson Regression were considered to test the statistical significance. A two-tailed Z-test is preferred.

Results of the Z-test are -2.1841 where p is equal to 0.02926. The Z-test is significant where $p < 0.05$, and leads us to reject the null hypothesis in lieu of the alternative; there is a statistically significant difference between the incidence in a cohort B and cohort A.

Research Question 2

Research Question 2 is framed to learn if there is a difference in the incidence of iTBI in communities in Minnesota that are rural vs urban. The analysis employs Rural and Urban Commuting Area (RUCA) data. RUCA data compiled by Zip Codes was collapsed to county data to allows an alignment data from the Census and Vital Statistics. Several counties in Minnesota are geographically large enough to contain both rural as well as urban zip codes. Where there are both, the county definition takes priority. The exception is St. Louis County which under the Federal Information Processing Standardization (FIPS), a collection of associated hardware and software used as a crosswalk cryptography between RUCA and County

Census contains both city of Duluth and Boundary Waters Wilderness Canoe area (BWCA) which is thousands of square miles of Federally protected wilderness that boarders the United States and Canada.

A side-by-side comparison of the of iTBI cases in infants younger than 1 year old in cohort B (Table 17) vs. cohort A (Table 18) suggests there is a shift in the percentages as a proportional increase in incidence in rural communities.

Table 17

1998-2005 *Rural vs Urban Cases*

	Cases	Percent
Rural	45	19.40%
Urban	187	80.60%
Total	232	

Table 18

2006-2017 *Rural vs Urban Cases*

	Cases	Percent
Rural	151	34.24%
Urban	290	65.76%
Total	441	

To further explore the data requires a calculation of the incidence in rural vs urban communities. Cohort B (Table 17) shows the incidence in rural from 1998-2005 to be 30.88 cases of iTBI per 100,000 live births in infants (0-<1 y.o.), whereas the incidence of urban cases of iTBI in same is 48.75 per 100,000 live births.

A side-by-side comparison of incidence in Cohort B (Table 19) to Cohort A (Table 20) suggests there is a marginal decrease in incidence in urban communities while the incidence of iTBI in rural communities appears to more than double in the time period 2006-2017.

Table 19

1998-2005 *Incidence Cohort B*

	Cases	Population	Incidence
Rural	45	145,709	30.88
Urban	187	383,590	48.75

Table 20

2006-2017 *Incidence Cohort A*

	Cases	Population	Incidence
Rural	151	236,032	63.97
Urban	290	608,013	47.70

Charting the dynamic changes in the two groups (Figure 2) visually draws attention to the rather dramatic increase in rural communities as compared to the relatively small reduction in the incidence of iTBI in the urban communities in Minnesota.

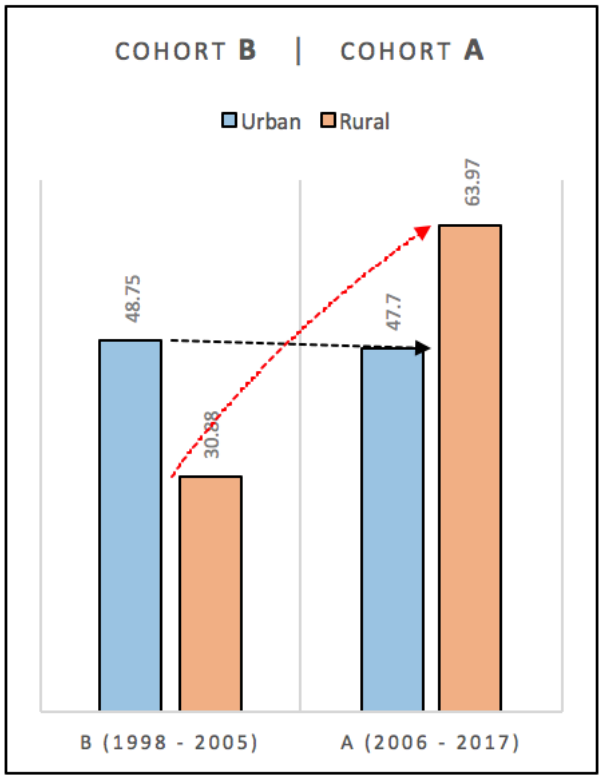

Figure 2. A comparison of the Incidence (cases per 100,000 live births) of Inflicted Traumatic Brain Injury in Rural vs. Urban Communities Before and After Passeage of Statute 144.574

Statistical Test of Increase in Rural iTBI

The Z-test is employed to explore the significance in the changes observed within the urban and rural communities over time. The result of the Z-test when incidence in urban communities is compared is 0.2322 where p equals 0.8181. The result of the Z-test is *not* significant at $p < 0.05$ leading to a conclusion that although there is a decrease in incidence, the

decrease is not statistically significant. The null hypothesis is accepted when comparing urban communities.

A Z-test is also employed to explore observed increase in rural communities between cohort B and cohort A. The result of the Z-test is -4.3846 where p is equal to 0.0. The Z-test is significant at $p < 0.05$ and confirms a statistically significant increase in the incidence of iTBI in the rural populations in Minnesota following the enactment of Statute 144.574. The null hypothesis is rejected in favor of the alternative hypothesis when comparing rural communities.

Research Question 3

Research Question 3 was written to explore any differences in the incidence of inflicted Traumatic Brain Injury (iTBI) proportional to the differences among ethnic groups. SAS was coded to extract data for both race and ethnicity with the intention of comparing both, and with the possibility to use race as a proxy when ethnicity was not recorded.

A random review of iTBI cases reveals blurring of race and ethnicity that confounds an analysis. Moreover, of the 1,061 identified cases in infants, toddlers, and children younger than 60 months, fewer than half (468) are mapped to either "race" or an "ethnicity" value. And, where there is a value, the value is frequently mapped to "unknown." Specifically, when restricted to the 673 cases of infants yet to reach their first birthday, no record is found in 334 of the cases. In the 339 records containing data, 165 of the cases are mapped to "unknown."

Distribution was explored by first dividing the data into cohorts B and A. In cohort B more than half, 135 of the 232 cases (58.2%), are mapped to "unknown" and/or there is "no record" (Table 21). In cohort A more than four in five, 364 of the 441 cases (82.5%), are mapped to either "unknown" or have "no record" mapped to either race or ethnicity (Table 22).

Table 21

Ethnicity (0-<1 y.o.) 1998 through 2005

	Cases	Percent
1. White	74	31.90%
2. Black	9	3.88%
3. Native American	0	0.00%
4. Asian	7	3.02%
5. Pacific Islander	0	0.00%
8. Other	7	3.02%
9. Unknown	68	29.31%
No Record	67	28.88%
Total	232	

Table 22

Ethnicity (0-<1 y.o.) 2006 through 2017

	Cases	Percent
1. White	48	10.88%
2. Black	10	2.27%
3. Native Ame	3	0.68%
4. Asian	3	0.68%
5. Pacific Islan	0	0.00%
8. Other	13	2.95%
9. Unknown	97	22.00%
No Record	267	60.54%
Total	441	

Regardless, the lack of complete data neither supports the null hypothesis, nor leads to the adoption of the alternative hypothesis.

Research Question 4

Research Question 4 sought to learn if there is an ordinal shift in the distribution of case severity over time. A side-by-side comparison of the distribution of coded discharge data mapped to severity codes in those under five years old (0-<5 y.o.) from 1998-2017 (Table 23) was made when restricting cases to infants under 1 year old (0-<1 y.o.) (Table 24):

Table 23

Severity of iTBI (0-<5) 1998-2017

Severity	Discharge	Percent
1	817	77.00%
2	82	7.73%
3	1	0.09%
4	11	1.04%
5	14	1.32%
6	13	1.23%
7	68	6.41%
No Record	55	5.18%
Total	1061	

Table 24

Severity of iTBI (0-<1) 1998-2017

Severity	Discharge	Percent
1	530	78.75%
2	59	8.77%
3	1	0.15%
4	7	1.04%
5	5	0.74%
6	10	1.49%
7	30	4.46%
No Record	31	4.61%
Total	673	

Visual inspection suggests there was not a remarkable difference when the data was restricted to infants under 1 year old. Coded discharge data for infants was then divided to cohort B (1998-2005) (Table 25) and cohort A (2006-2017) (Table 26) for side-by-side comparison:

Table 25

Severity of iTBI (0-<1) 1998-2005

Severity	Discharge	Percent
1	186	80.17%
2	26	11.21%
3	0	0.00%
4	0	0.00%
5	1	0.43%
6	5	2.16%
7	11	4.74%
No Record	3	1.29%
Total	232	

Table 26

Severity of iTBI (0-<1) 2006-2017

Severity	Discharge	Percent
1	344	78.00%
2	33	7.48%
3	1	0.23%
4	7	1.59%
5	4	0.91%
6	5	1.13%
7	19	4.31%
No Record	28	6.35%
Total	441	

Severity codes were then collapsed into ordinal categories of Mild, Moderate, or Severe (Table 27):

Table 27

Severity of iTBI (0-<1) 1998-2005

Mild	1. Home - Self Care
Moderate	2. Home - with Assistance 3. Discharged Against Medical Advice
Severe:	4. Long Term Care 5. In-Patient Rehabilitation 6. Other 7. Vegatative or Fatal

A review of coding algorithms indicates that cases coded as “6” include transfer to surgical or specialty hospitals including St. Paul Children’s, Regions level one trauma, or the

Mayo Clinic. For the purposes of this research analysis, transferred (code 6) they were assigned to be severe.

Where there is "No Record" of severity the initial assumption was that the patient was discharged without further treatment or sequelae. Under this assumption, no record cases are added to category "Mild 1. Home - Self Care."

Three cases without records were added to Mild in Cohort B (Table 28), and 28 cases without records were added to Mild in Cohort A (Table 29) and incidence calculated.

Table 28

Severity of iTBI (0-<1 y.o.) 1998-2005

Severity	Discharge	Percent	Incidence
Mild	189	81.47%	35.71
Moderate	26	11.21%	4.91
Severe	17	7.33%	3.21
Total	232		

Table 29

Severity of iTBI (0-<1 y.o.) 2006-2017

Severity	Discharge	Percent	Incidence
Mild	372	84.35%	44.13
Moderate	34	7.71%	4.03
Severe	35	7.94%	4.15
Total	441		

The side-by-side comparison of cohorts shows a shift in percentages of cases and indicates there is a change. Because the data is an epidemiologic census of all cases, any observation of difference is real and statistical. The two-tailed Z-test is used to answer if there is a statistically significant shift between cases in Cohort B vs same in Cohort A when comparing incidence, and applied to each ordinal separately.

The result of the Z-test on Mild cases is -2.375 where p is equal to 0.01778. The Z-test is significant at $p < 0.05$ and leads us to adopt the alternative hypothesis that there is a statistical increase in the incidence of Mild cases in cohort A compared to the incidence of Mild in cohort B wherein the stated assumption is that cases of "No Record" were added to "Mild."

A two-tailed Z-test was employed looking at the difference between incidence of Moderate cases between cohorts. The result of the Z-test on Moderate cases is 0.7591 where p is equal to 0.44726. The result of the Z-test is *not* significant at $p < 0.05$ leading to the conclusion that there is *not* a statistical difference in the incidence over time between cohort B and cohort A in "Moderate" cases, and supports adopting the null hypothesis.

A two-tailed Z-test was also employed to test for a statistical difference in incidence in the category of severe between cohort B and cohort A. The result of the Z-test is -0.8709 where p is equal to 0.3843. Again, the result of the Z-test is *not* significant at $p < 0.05$ leading to a conclusion that there is *not* a statistical difference in the incidence over time between cohort B and cohort A in "Severe" cases, and supports the null hypothesis.

While trying to confirm the validity the initial assumption, discharge coding, and adding cases of "No Record" to the ordinal of mild, it was learned that the coding definitions in the database changed over time, and that a discharge code of "6" for "other" includes not only surgical centers, but psychiatric hospitals and/or jail. Moreover, in the first 55 cases abstracted as to test validity where there were no records, no final data could be found on 23 cases while 22 cases were found to have been transferred to in-patient care.

It is unlikely that an infant would be transferred to adult psychiatry or to jail, yet code 6 might include foster care. Any further analysis down this thread requires crossing into legal documents and is beyond the IRB authority granted in this research project. Regardless, when those same cases are added to severe under the rational that they were transferred to another institution the results change. In fact, it is possible to steer the results based on the assumptions

of where to allocate code 6 and/or cases where there is no record. As such, both the initial assumption(s) and initial results were rejected.

Alternative Methodology

Alternative methodology considered for managing data where there were no records were to exclude the data, to randomly assign the data, or to impute calculated values. Each alternative methodology was rejected on the basis on introducing bias and/or confounding.

Yet another alternative method was to use SAS to extract all cases with the map institution in-patient discharge as a proxy for severity. Under the rational that patients who are admitted to an in-patient unit have at minimum suffered a moderately intense trauma, any patient admitted to, or discharged from an in-patient unit, moderate cases can be separated from mild cases. All cases discharged from emergency departments without sequela are assigned to Mild. Case data from the Minnesota Vital Statistics was used to identify fatalities. Using this methodology all 673 cases were linked successfully to a discharge data as Mild, Moderate, or Severe (Table 30).

Table 30
Discharge Data

Mild	Emergency Department Discharge
Moderate	Admitted to, and discharged from, a hospital in-patient unit
Severe	Fatality

The data was then separated into cohorts before (B) and after (A) the statute was enacted. Both percentage of cases and incidence was calculated. Table 31 is a summary of the discharge

data from 1998 through 2005 (Cohort B), and Table 32 is a summary of discharge data from 2006 through 2017 (Cohort A).

Table 31
Severity of iTBI (0-<1 y.o.) 1998-2005

Severity	Discharge	Percent	Incidence
Mild	25	10.78%	4.72
Moderate	196	84.48%	37.03
Severe	11	4.74%	2.08
Total	232		

Table 32
Severity of iTBI (0-<1 y.o.) 2006-2017

Severity	Discharge	Percent	Incidence
Mild	111	25.17%	13.17
Moderate	311	70.52%	36.89
Severe	19	4.31%	2.25
Total	441		

A side-by-side inspection of the data shows that there is a shift in the percentage of patients from moderate to mild over time as well as an increase in the incidence of less severe (mild) brain injuries from 4.72 cases of iTBI per 100,000 live births in cohort B to an incidence of 13.17 in cohort A.

Statistical Test of Shift in Severity

A two-tailed statistical Z-test was employed to test for significance in the change from cohort B to cohort A in the incidence of mild brain injuries. The Z-test result of -4.8402 where p is equal to 0.0 shows a statistically significant change. The result of the Z-test leads to a conclusion that there is a statistical increase in the incidence of mild cases in cohort A. This methodology leads to re-adoption of the alternative hypothesis.

A two-tailed Z-test was employed to test for a statistical difference in moderate brain injuries over time. The result of the Z-test is 0.415 where p is equal to 0.9681. The Z-test is *not* significant at $p < 0.05$ leading to the conclusion that there is *not* a statistical difference in moderate cases between cohort B and cohort A. The null hypothesis is adopted in the incidence of mild iTBI cases.

And, a two-tailed Z-test was employed to explore the difference in the incidence of severe brain injuries between Cohort B and Cohort A. In severe cases the result of the Z-test is -0.2074 where p is equal to 0.83366. The Z-test does *not* show significance at $p < 0.05$. Here as well, the null hypothesis is adopted, that there is no apparent shift or increase in severe cases.

Because there is not the same proportional distribution of mild, moderate and severe cases when comparing cohort B with cohort A, question 4 is answered by adoption of the alternative: there is a statistically significant categorical shift in the severity of injury when comparing a cohort of infants and children born 1998 through 2005 with same born 2006 through 2017.

Conclusion

The critical and tedious step-once the research questions where formulated was to write SAS program language where ICD-9 and ICD-10 are integrated in operational logic. The SAS program required multiple tests for validity and edits prior to pulling cases from data archived in the registry of brain and spinal injuries, from hospital and emergency department discharges, and from the state of Minnesota Census and Vital Statistics.

The analysis of the age of inflicted trauma shows three of five cases occur in the first year of life. An alarming finding is that there were three cases of inflicted Traumatic Brain Injury, one female in 2000, one male in 2003, and one male in 2013, where the age of the victim at the time of incident is recorded as 0 days old, and the average of birth to trauma in infants in the first year is 152 days. Overall, analysis shows that restricting the data to infants who have not yet reached their first birthday is valid.

For each of the research questions, the incidence of iTBI in cohort B, those born before State Stature 144.574 was enacted, was compared to cohort A, those born after enactment. Multiple statistical tests were considered before employing a two-tailed Z-test.

Results of the Z-tests show a statistically significant increase in the incidence of iTBI when comparing data before and after enactment of Minnesota Statute 144.574, yet a statistically significant shift over time toward cases which are less severe. It was not possible to analyze the proportion or change related to ethnicity due to the lack of data. It was unanticipated that the incidence would be higher overall, and that the increase is found in rural communities.

Possible explanations for the peak incidence in 2009 as an association to the economy and unemployment, as well as an unexpected increase overall, a difference between rural and urban, and an ordinal shift in severity follow in Chapter 5. The results are discussed in the context of additional research and opportunities social change.

Chapter 5: Discussion

Introduction

This quantitative research project evolved from an observation that head injuries were a primary risk to infants to an alarm raised about injuries and perpetrated violence, the societal imperatives to protect the most vulnerable, and the role that public health policy plays through influencing behavior. Minnesota Statute 144.574 was enacted in 2005 on the premise that public health policy can indeed shape behavior, based on the evidence presented through the research of Dias (2005). Despite ambiguities in the authoring of the statute, there was no dissent among public health officials in Minnesota, nor among medical professionals who shaped the discussion, that there was a compelling interest in lowering the incidence of head injuries in infants.

I raised the question of if injuries to the brain should be a more precise focus. As such, this research did not seek to learn if there is a lower incidence of shaking or whiplash as a surrogate analysis, but, rather, it sought to learn if there were fewer brain injuries. The research evolved from general descriptions of maltreatment to identifying axonal shearing and retinal detachment as definitive diagnosis. The use of precise language and the operational definitions translated to event and diagnostic codes in the analysis, where the use of the word *inflicted* implied an intentional act, and a focus on *traumatic* injuries to the *brain,* are intended to focus professional and public attention on the specific acts and their consequences to the brain.

This research is not simply a quantitative analysis, it is a consideration to what extent the statute, and, especially the education component of the statute, may impact positive social change in other ways, beyond the potential reduction in the incidence of iTBI. Might the statute

influence the political arena of public discourse and policy generally? It is acknowledged that epistemological considerations ground assumptions, biases, and conceptual contexts that come into play as the data is interpreted. Analysis of the results may provide the impetus for improvements in public health while proposing fruitful avenues of future studies.

General Comparison

The calculated overall incidence in this research project was 15.54 iTBI cases per 100,000 infants and children under 5 years old. For comparison, Wirtz and Trent (2008) reported an incidence of 14.0 cases per 100,000 in a population under 2 years old, in a study of what they called at the time "Shaken Baby Syndrome," using hospital inpatient data.

Dias (2005) reported a much higher overall incidence of 41.5 cases per 100,000 in a study of what he called Abusive Head Trauma in infants and toddlers under 36 months. There was no similar reduction in incidence in Pennsylvania over the 6-year control period. The calculated incidence in this study, when cases were restricted to those who had not yet turned 1 year old, was 45.81 cases of ITBI per 100,000 live births.

The comparable incidences build confidence in the methodology and analysis of the current study, yet understanding the discrepancies requires caveats. First, it is known that incidences of abuse and neglect predominantly occur in the first or second year of life; naturally, the inclusion of toddlers and children up to 60 months results in a lowered calculated incidence. Second, the broad definition of AHT employed by Dias is, in this research project, narrowed to *brain* injuries, making any direct comparison difficult.

Research Question 1

Research Question 1 leads us to conclude that State Statute 144.574 has not achieved the intended result of reducing the incidence of iTBI. This question looked at the difference between the incidence of iTBI in a cohort (B) of children born to parents in Minnesota before enactment of State Statute 144.574, and the incidence in a cohort (A) born after enactment. The incidence of iTBI in Minnesota before the enactment of the statute was similar to the incidence of AHT among the New York population included in Dias' study before the measures he implemented. In his study, Dias implemented an educational program and social contract that resulted in halving the incidence of AHT among his population. Inversely, the recorded incidence of iTBI in Minnesota *rose* after the enactment of State Statute 144.574. Analysis of the data shows the statute has not had the intended positive effect.

These unanticipated results run counter to initial assumptions made about the directional change in incidence grounded in the theoretical model of Reasoned Action whereby behavior modified through educating parents of newborns will result in a decrease the incidence over time, and lead to tedious review of case definitions, the ICD 9 and 10 code sets, tedious review of SAS programming logic, and case validation prior to accepting the result.

We cannot conclude that the incidence rose *because* of the statute, in that the rise may reflect better reporting. Even though Minnesota began the mandatory reporting and collection of data surrounding cases of "head and spinal cord injuries" in 1998—seven years before the enactment of the statute—it is possible that compliance to this mandate may have required a period of education and adjustment. Similarly, where the language of "head and spinal cord injuries" used in the 1998 is more general and casts a broader net, we cannot discount the

possibility that a peripheral benefit of the statute has been a boost in reporting compliance through raising general awareness of the problem, and providing additional education and administrative conduits for reporting.

It is not believed the results can be explained by an increase in reporting that off-sets an actual reduction in cases. That the incidence in baseline cohorts in Dias' study and in this study, prior to the implementation of an intervention—despite the differences in measuring head vs. brain injuries—are comparable independently validates the methodology and analysis as correct. Further, the very nature of the severity of brain injuries, as opposed to more generally head injuries, and that cases are defined by specific event and diagnostic codes in the operational definition removes bias. The nature of medical science employed in this research to confirm diagnosis through MRI or other diagnostic imaging also removes confounding.

Research Question 2

Research question 2 asks whether there was difference in the trend of incidence in urban vs rural areas, with a view toward understanding whether public health initiatives—specifically, education as intervention—produce different results in urban areas vs rural areas. This is particularly relevant in Minnesota, where most of the land mass remains agrarian and the largest industries are farming and other extraction. Almost half (2.5 million) of Minnesota's population of an estimated 5.5 million live outside the seven-county metropolitan area.

The data reveals that while in urban areas the incidence remained nearly constant, in rural Minnesota the incidence of iTBI doubled in the period after the enactment of Statute 144.574, accounting for the net increase state-wide. This revealing statistic adds particular urgency to understanding the dynamics at play.

One possible explanation points to the stress of economic instability, which, historically, disproportionately affects rural areas. Rural areas tend to have an approximately 5% higher proportion of people who have not completed high school, and the difference between rural and urban college degree-earners is even more striking (Gilbert, Coussens, & Merchant, 2006). The following graph (Figure 3) displays the familiar trend line of incidence of iTBI, and overlays the dotted annual rates of unemployment (Minnesota Department of Employment and Economic Development, 2018).

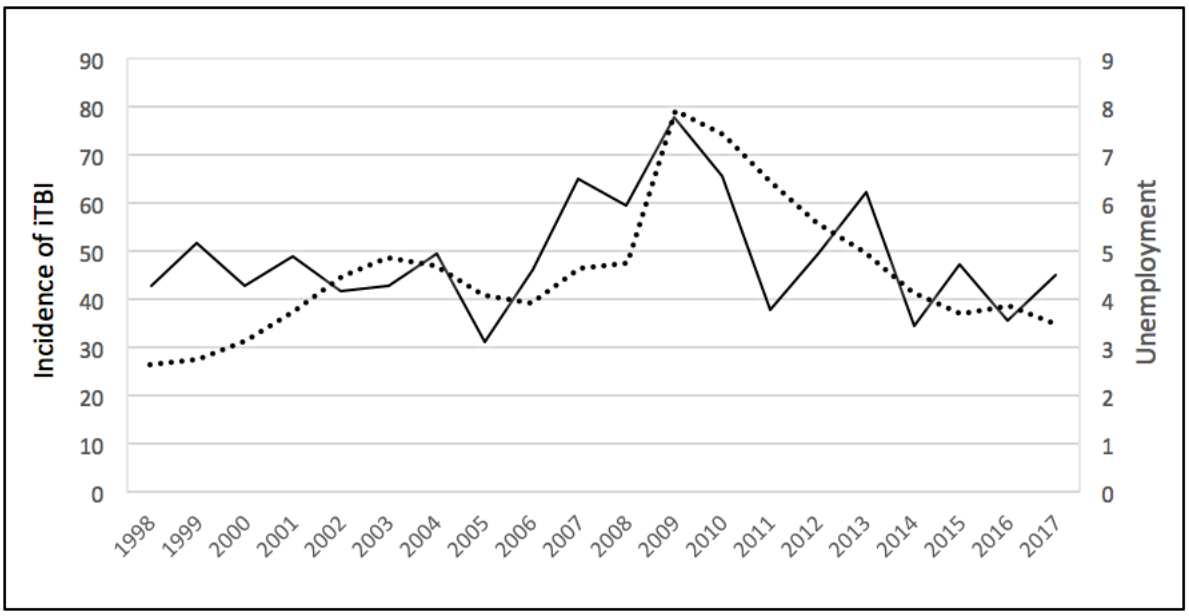

Figure 3. **The solid line represents a trend of annual incidence and is compared to annual percent unemployment (the dotted line) in the same time period.**

The remarkable correlation between incidence and unemployment during the recession of 2009 for example, strengthens the case that economic stress and home environment associated with job loss may contribute to iTBI. At the same time, those differences in education levels that underlie economic disparities may themselves account for behavioral differences that include

more violent reactions to stressors, or the ability to fully understand the medical consequences of violent reactions when it comes to the treatment of infants.

Questions of access to healthcare also weighs into the rural equation. In chapter four, we looked at rural data as defined by RUCAs, Rural-Urban Commuting Area Codes that by definition incorporate commuting distances to work and other facilities, including, most relevantly to this analysis, distances to medical facilities. The fastest growing population in rural areas is Hispanic, where cultural differences and lack of English can add another obstacle to healthcare access. Of relevance to this study, the average age of Latinos in Minnesota is 23 years, a prime reproductive age (Ramirez, & De La Cruz, 2003). If lowered access to healthcare is indeed a factor in the rural iTBI statistics, the question of why that would be the case is not readily apparent. The data does not chart frequency of patient-provider contact in iTBI cases, but if reduced access to healthcare results in less frequent contact with a provider, and this, in turn, results in more frequent iTBI incidents, it would suggest that providers' guidance to the care-givers is useful, or that providers are intervening when observing warning signs, or that the mere interaction between patients and providers in itself constitutes an inhibitory effect on caregiver violence toward infants.

Research Question 3

There are compelling arguments against conflating race with ethnicity, especially when the grounding theory in this research project of Reasoned Action is one of learned behavior as opposed to inherited genetics. Research Question 3 asks if the incidence of inflicted Traumatic Brain Injury (iTBI) in infants and children is proportional to the differences among ethnic groups such that no one ethnic group is observed to have a disproportionately higher – or lower –

incidence in cohorts born either before enactment of statute 144.475 or those born after the enactment?

The question in terms of public health and policy speaks both to established minority populations in Minnesota as well as new Minnesotans, especially those who speak little or no English. International migration to Minnesota has increased steadily from roughly 5,000 annually in 1990 to nearly 15,000 annually in 2015 as Minnesota has become one of the most sought-after destinations for immigrants (Minnesota State Demographic Center, 2015). Yet numbers do not tell the entire story as some immigrant groups tend to maintain stronger cultural identities through subsequent generations than other groups. The result is that one in ten Minnesotans speak a primary language other than English in the home. Benefits of analyses along the lines ethnicity has implications for positive social change—that is, are certain populations underserved by the statute, and, specifically, is the linguistic and cultural-effectiveness of the content and delivery of the educational material, and messaging in healthcare generally, equally effective across all ethnicities. As noted in chapter 4, the lack of ethnicity data in the case history undermines any reasonable analysis–on the basis ethnicity-as a risk factor associated with iTBI. It is neither possible to reject nor accept the null hypothesis.

Research Question 4

The fourth research question seeks to answer whether the iTBI education component of the statute has had the effect of lessening the severity of injuries by modifying caregivers' behavior. As in research questions 2 and 3, research question 4 takes as its premise that while the statute has not lowered iTBI incidences statewide, it may nevertheless result in benefits not evident at first glance. Restricting the data to infants not yet one-year-old suggests a distribution

shifting toward less severe cases. Yet there is no way of knowing, short of interrogating caregivers who commit the violence, whether their understanding of iTBI checked or mitigated the severity of their action.

At the same time, it is possible that the growing societal opprobrium of corporal punishment (CP) of children, rather than education material provided to caregivers by a hospital, mitigates the violent act. The Theory of Planned Behavior suggests that one's perceived injunctive and descriptive social norms and expectations influence not only attitudes, but also behavior. To wit, in 1968, 94% of adults in the U.S. approved of spanking a child; this strong consensus represented a cultural norm that expected parents to physically discipline their children. By 1994, national surveys showed a decrease in the approval of CP to 68%, and this trend has continued since (Straus, & Mathur, 1996). Changing societal attitudes such as these could account for a decrease in iTBI severity, even where the incidence itself has not declined.

Limitations

It was not known at the time when Minnesota began mandatory reporting of "head and spinal cord injuries" how the data would be analyzed. As well as important demographic data not collected, data on the number of parents and/or children in the home, merged parenthood, age of the caregiver, level of education, employment status at the time of incident, and other useful data was not collected. As a result, it is not possible to mapping cases to factors thought to modify risks without some broad assumptions. This lack of data limits efforts to draw conclusions from economic and social contexts.

Limitation in Delivery of Intervention

This analysis specifically relies on an assumption that each birthing center complied with the statute by delivering education. Yet compliance with Statute 144.574 simply mandates a licensed hospital must make a video on the dangers of shaking infants "available for viewing." When only one parent receives the educational material, or statute compliance is achieved by merely dropping a video into a take home bag, the assumption breaks down. In a study conducted by Leslie Seymour, MD on behalf of the Minnesota Department of Health in 2015 on compliance to Minnesota Statute 144.574, 92% of hospital and birthing centers report offering education on the risks associated with shaking an infant (MDH internal compliance data, 2016). The study included a survey of mothers who delivered at same institutions in which 68% of the mother acknowledge receipt education on shaken baby syndrome (MDH internal compliance data, 2016). Anecdotal and ironic evidence from one of the people working for the Minnesota Department of Health is that she herself was discouraged by a nurse at a birthing center from watching the video because the material presented in the video "is disturbing." The reliability of the intervention, in this case variability in compliance and delivery of education, undermines the basic scientific methodology, resulting in a scattered distribution of dependent variables.

Limitation in Coding

Through legislative language, the State of Minnesota requires injury coding at the level of the emergency department and hospital discharge. This research and analysis relies on the proper employment of ICD event and diagnostic codes, yet coding is an imprecise science and its accuracy depends on the level of training of the person assigning the codes. Further, many of the iTBI cases were attended to by emergency department personnel where the imperative is to

triage, stabilize, then admit or street the patient. In such a pressure-cooked environment, the necessity of speed introduces limitations and error, as much as incomplete case history.

Limitations to Ethnicity

Statistical Analytics Software (SAS) was programmed to link cases to ethnic and racial categories, occasionally with only slight variations, that have become the standard set in the U.S. Census Bureau, government contract application, college applications, grants and other financial aid applications, hospitals and clinics, and many other areas. As in education, employment, healthcare, civic participation, and other fields wherein the collection of data concerning race and ethnicity have become common, an examination of ethnicity carries implications for social justice. For the purposes of this study, data concerning ethnicity informs the question of whether the statute serves all ethnic groups equally, and, if it does not, whether to recommend remediation to effect positive social change.

The analysis in this study along the lines of ethnicity (research question three exploring differences in incidence related to ethnicity) faced two principal limitations. The first limitation was methodological, in that data was not collected at the time of injury. The second limitation was theoretical and foundational, and concerns the formulation of the categories themselves: whereas genetics and phylogeny define race, ethnicity, on the other hand, is defined by culture, that is, collective beliefs, values, and traditions. Because understanding the impact of cultural characteristics might help inform the design of future interventions to be culturally appropriate and responsive, ethnicity is a more useful and actionable category than race. By contrast, classifications wherein race and ethnicity are conflated, or wherein race is merely substituted as a proxy for ethnicity, are of limited value in designing programs of remediation for positive social

change. For instance, the category "Black" conflates U.S.-born and foreign-born (African, Caribbean, etc.) cultures that may hold significant differences in child-rearing, attitudes toward authority, the effects of language barriers, and stress triggers. These differences, in turn, might suggest that radically different approaches to remediation are necessary on the part of health providers and health policy makers. For this reason, clearer, more granular classifications of ethnicity-as-culture will better serve the collection of data where cultural contexts are an important consideration in the future.

Structural Limitation

There is a structural limitation related to conducting a study within a population, in this case the population of Minnesotans younger than age five, whereby a comparator population was not identified. In Dias's study of infants in Western New York, results were compared to the trends of Abusive Head Injuries in the Commonwealth of Pennsylvania over a time period that bracketed Dias' study (2005). The lack of a comparator population bracketing the time, specifically for inflicted Traumatic Brain Injuries, limits the confidence that observed effects are truly a function of the intervention, and does not allow for calibration. It might be that the incidence in a comparator population where the statute was not in effect would show a dramatic rise in incidence, leading to speculation that the statute had the modifying effect of putting brakes on the increase.

While Minnesota began collecting surveillance data under the 1996 congressional authorization, other states did not initiate mandatory reporting of head and spinal injuries. Lack of similar surveillance data limits this study to Minnesota and limited generalizability. At the

same time, the hope is that this research project and analysis will more broadly provide insights into the ability of public policy to shape public health by offering a model.

Recommendations for Legislation and Policy

On a foundational level, the more precise language that comes of a deeper understanding of the medicine and behavior associated with iTBI constitutes progress by promoting a more precise understanding among the public and more productive public policy. I recommend that the term *inflicted Traumatic Brain Injury* adopted by healthcare professionals, researchers, and public health officials, rather than interchangeably with the variety of terms in the past. The background literature review for this research noted prior to the passage of the Traumatic Brain Injury Act of 1996, injury inflicted as a result of shaking an infant was described as "syndromic," a term that is neither attached to medicine nor science. The review traced terminology that evolved from syndromic through maltreatment. Even as the understanding of the mechanisms of injury evolved, a standard case definition did not, making critical analysis difficult. In fact, the Statute Minnesota enacted contains a vestigial reference to "shaken baby." This argues for standardizing the terminology by avoiding the misleading term "shaken baby syndrome" in favor of the current "inflicted Traumatic Brain Injury." Implications for employing precise language includes facilitating further research while demystifying cause and diagnosis.

Delivery of the Education Component

The recommend change to Minnesota State Statute 144.574 is in specifying that the required iTBI educational materials be taught face-to-face by an authorized (trained) medical provider of the institution to the new parent(s).

The absence of personal education delivery constitutes a critical departure from the Dias model upon which the statute was based, whereas there is little difference in the contents and quality of the educational artifacts provided to parents in the Dias study and the video prescribed by the Minnesota statute. The video "obtained from the commissioner or approved by the commissioner" in accordance with the Minnesota statute contains relevant information about infant anatomy and the consequences of shaking a baby. The video begins by explaining that crying, even many hours of crying every day, is normal for infants, and that this can cause stress, even rage, to the caregiver. The video presents animated graphics of what happens to the infant's brain when shaken, including depictions of neurological damage. It explains that "all it takes is a moment (as short as 5-20 seconds) of lost control" to result in blindness, mental Retardation, seizures, cerebral palsy, hearing loss, paralysis, broken bones, speech or learning disabilities, severe developmental delays, and death. The video unequivocally equates shaking to abuse, then offers a checklist for parents on what to do when a baby cries, both in order to accommodate the infant and in order to calm down. In short, there is nothing insufficiently informative, instructional, or persuasive in the video presentation that would point to the educational artifact itself as the reason for the failure of the Minnesota statute to reduce TBI. Rather, discrepancy between the Minnesota statute and the Dias model lies in the method of delivery.

What we know about the political context surrounding the elimination of the Social Contract as originally designed into State Statute 144.574, based on the model of Dias' study, is that it had nothing to do with doubts about the validity and thoroughness of the Dias model, nor doubts about best that prescribe methods of education delivery and assessment. Rather, the hospital lobby persuaded the legislature to eliminate this component because it required

administration on the part of the hospital, and, as such, a burden on the institution. The degree of administration was to be relatively minor by healthcare industry standards, given the high level of compliance, filing, and record-keeping that figures into the modern hospital's bureaucracy.

Much is, and will be, made about fidelity to the statute, and/or quality control when the statute vaguely prescribes measures of compliance. In the delivery of educational materials lies a significant variable. Whereas in Dias' study, parents were educated in the materials face-to-face, the Minnesota statute requires no such personal instruction. In practice, there is likely a difference of impact between a video and a pediatric neurologist or other expert authority sitting down with parents and impressing upon them the seriousness. Furthermore, the statute does not contain any language *requiring* that parents watch the video, much less demonstrate understanding of the material through some form of assessment. The statute merely asks the hospital to urge parents to view the video. It is conceivable that new parents, sleepless and overwhelmed and distracted by the baby and the countless responsibilities and radical changes in their lives, may not give the video sufficient focus, or see the video at all. This lack of verified compliance and accountability in the Minnesota statute constitutes a critical departure from Dias' model.

This laissez-faire approach to the delivery of critical information is antithetical to modern medical and pharmaceutical practices, wherein patients are increasingly given agency for their health and wellness through face-to-face information. Modern medical practice has moved from a treatment of patients as passive consumers who merely follow doctor's orders to a consideration of patients as informed partners in healthcare, with emphasis on patients' active engagement in healthy practices and lifestyles.

Current Procedural Terminology (CPT) code

To meet anticipated institutional objections over the additional layer of administration required for in-person education delivery, I recommend the creation of a Current Procedural Terminology (CPT) code funded by state appropriation as a reimbursement for nursing time during the delivery (teaching) of the educational material. Likewise, I recommend a funded CPT code for a home healthcare worker to visit the home of the new family any time between the third or sixth month for a check-up, when parents would be given additional information and support. (See the section on Nursing or Social Worker Follow-up below.)

Limited Liability Provision

During the legislative drafting of the statute in 2005, there was resistance to the accountability and potential liability on the part of the administering institution implied by face-to-face education and assessment delivery, compared to the more limited accountability in the case of merely dropping a pamphlet and/or video in the take-home bag of a parent. In the latter case (the current practice, the extent to which a parent understands the material, or perpetrates an act of violence, is out of the hospital's jurisdiction, and, by implication, its responsibility.

To meet institutional concerns about liability, I further recommend the inclusion of a provision in the statute granting the institution administering the educational service limited immunity under Good Samaritan laws.

Restoration of the Social Contract

For lack of evidence, we do not know the extent to which the inclusion or exclusion of a parent's signed pledge accounts for the difference in success between the Dias study and the Minnesota statute. Nor do we know whether a signed pledge carry the same level of seriousness

today on the part of the signatory as it did during the period of the Dias study, given the rapidly changing culture in the computer age. Does putting one's signature to paper continue to carry historical implications of personal accountability in a modern culture where we are routinely required to click an "I Agree" button to pages of inscrutable and mostly unread fine print in order to perform basic functions online or on our iPhone? How do recent revelations about how requiring us to click "I Agree" and/or submit our telephone number and other data constitute corporate deceit, allowing institutions to spy on us, collect and use our personal data, and subject us to marketing spam and intrusive phone calls? Does such a rapidly evolving culture not only corrode the sanctity of a signature, but even cultivate suspicion and a sense of violation toward agencies that request our signature?

Given such trends, it is unclear if a personal pledge still weighs on the human conscience as a matter of honor and obligation, as it has historically, and to what extent conscience influences behavior. Specifically, does it influence behavior in a moment of the kind of extreme frustration and vexation that drives a caregiver to shake or throw an infant? To some extent, these questions speak to what we commonly refer to as a person's *character*. Traditionally, one's word has been one's honor. Now, however, we live in what some describe as a post-truth era that greatly complicates, perhaps impugns, the word-honor relationship. What is the value of a person's word, a person's pledge, within a culture where the president himself models and normalizes lying, for which not only is he held unaccountable by the bodies of government, but that solidifies his popularity among his base? This is a culture where science is widely impugned and attacked, not only by the faith-based groups, holocaust deniers, and flat-earthers of the past,

but now by the very agencies and officials of our government, those agencies charged with overseeing industrial policy, land use, and environmental protection.

Despite these complications, we return to the fact that the personal pledge was a key component of the Dias study, and that without it, the Minnesota statute has not been successful. The current Statute reads:

144.574 DANGERS OF SHAKING INFANTS AND YOUNG CHILDREN.

Subdivision 1. **Education by hospitals.** (a) A hospital licensed under sections 144.50 to 144.56 shall make available for viewing by the parents of each newborn baby delivered in the hospital a video presentation on the dangers associated with shaking infants and young children.

(b) A hospital shall use a video obtained from the commissioner or approved by the commissioner. The commissioner shall provide to a hospital and any interested individuals, at cost, copies of an approved video. The commissioner shall review other video presentations for possible approval upon the request of a hospital. The commissioner shall not require a hospital to use videos that would require the hospital to pay royalties for use of the video, restrict viewing in order to comply with public viewing or other restrictions, or be subject to other costs or restrictions associated with copyrights.

(c) A hospital shall, whenever possible, request both parents to view the video.

(d) The showing or distribution of the video shall not subject any person or facility to any action for damages or other relief provided the person or facility acted in good faith.

Additions to subdivision 1 might read:

(e) Parents of new born shall attest that they have been provided education specific to the risks and consequences, and sufficient opportunity to discuss, abusive behavior resulting in inflicted Traumatic Brain Injury by voluntarily signing of the Social Contract pledging the signatory to abstain under any and all circumstances from shaking, throwing, or striking of an infant.

(f) Related to non-parent caregivers, the education, training, and certification of non-parental caregivers, and wards of infants and children, attesting to the competence and employability of such caregivers, shall whenever possible, require the signing of the Social Contract pledging the signatory to abstain under any and all circumstances from shaking, throwing, or striking of an infant.

Standardization of Childcare Curricula and Certification

I recommend that the education component of the Minnesota Statute 144.574 be uniformly used in other contexts and facilities of infant care. Under the current statute:

Subd. 2. Education by health care providers. The commissioner shall establish a protocol for health care providers to educate parents and primary caregivers about the dangers associated with shaking infants and young children. The commissioner shall request family practice physicians, pediatricians, and other pediatric health care providers to review these dangers with the parents and primary caregivers of infants and young children up to the age of three at each well-baby visit.

However, there is no standardization of childcare curricula and certification among the many training programs, including American Red Cross, Safe Sitter, high and junior high schools, and community organizations. Safe Sitter, for example, explicitly places self-control front and center, as the second of its four main teaching points (Safe Sitter, Inc., 2018). Despite the fact that pediatrician Patricia Keener launched Safe Sitter in response to the death of a child while under a baby sitter's care, and Safe Sitter's otherwise-thorough emphasis on safety including the information that injuries are the leading cause of death in children up to age 5, neither its Instructor Manual nor Student Handbook mention abusive behaviors leading to inflicted brain trauma, or shaken baby beyond avoiding "physical punishment like shaking, slapping, spanking, pinching, poking, or hitting."

Nursing or Social Worker Follow-up

The analysis that the average days to the incident is 152 (chapter 4), that 63% of all cases occur in the first year (chapter 4), and that colicky behavior is a trigger, and/or inconsolable crying related to teething occurs in the fifth or sixth month (Markman, 2009) all combine to make a compelling argument for mandated and code-able follow-up in the form of a nurse or social worker visit in the family's home, funded by the creation of a CPT code. (See the section above under Current Procedural Terminology (CPT) code.) This preventative policy would be aligned with precedents and current best practices in healthcare that emphasize *prevention* of accident and disease, in the form of vaccinations and other prophylaxis.

This visit should be informed by the coincidence of additional stressors experienced by the family, and training of the nurse or social worker should be predicated on understanding triggers of stress and best practices in modifying response. Data already points to a correlation between economic stress and the incidence of iTBI, strengthening the argument that economic

stress or poverty should be classified as high-risk conditions. Recommendations for further research outlined in the following section may reveal scientific evidence for additional high-risk conditions that would inform prevention measures.

Recommendations for Further Research

Method of Education Delivery

To fill gaps in this and similar future research projects, a recommendation is made for a qualitative study to examine the methods and agents of education delivery. Because there is a significant difference in the incidence in rural vs. urban post enactment of the statute, such a study would compare the delivery of education from institution to institution whereby compliance with current state statutes may differ significantly.

Ethnicity and Socio-Dynamics

I recommend a more thorough and precise examination of iTBI incidence across the ethnic and socio-dynamic spectra, using more limited and precise definitions and delineations of ethnicity, with a view toward remedying the current ambiguities outlined above in the discussion of limitations. Additionally, I recommend introducing a number of new categories that identify conditions as risk factors. Doing so would entail an examination of personal and household data that may challenge some notions of privacy and long-held assumptions about parental sovereignty. Nevertheless, personal and household data collection and analysis finds precedent not only in the field of healthcare, but also in education. In both healthcare and education, the collection and analysis of personal and family data have as their goal the elimination of disparities. In fact, in the field of education, population-targeted remediation has not only become an industry standard, but it is also federally-mandated.

Home Environment

Despite research showing that life patterns are largely established in, or influenced by, early childhood experience, investigations into the home environment are often off-limits, with the notable exception of investigations of physical or sexual abuse of the child. Politically, there is fear that such probing, or even introducing the topic of related public policy is viewed as an intrusion and violation of one's rights. This political position often takes partisan sides, as in the case where Gov. Rick Scott made it illegal for a doctor, even a mental health professional, to ask patients if they owned guns. Such a political environment may lead to healthcare officials and policy makers absolving themselves of responsibility while pointing to traditions of autonomy.

Healthcare, however, must move beyond these limitations and political taboos, with the understanding that a broad array of conditions influence mental and physical health. There is precedent as physicians routinely ask patients, including children, about their sense of safety: whether there is a gun in the home, whether they use seatbelts and bicycle helmets, whether they smoke and alcohol consumption, whether they feel stress in their job and personal lives, and whether they ever have thoughts of self-harm or suicide. With this purpose, there are a number of categories contextualizing iTBI worthy of further research.

History of Family and Community Violence

Research shows there is an overlap in attitudes and intergenerational cycles of violence within families (Taylor, Hamvas, Rice, Newman, & DeJong, 2011). Child maltreatment is more common in homes where intimate partner aggression and violence occur (Taylor, Guterman, Lee, & Rathouz, 2009). Furthermore, there is evidence that community violence similarly indicates higher levels of risk for child and infant abuse (Molnar, Buka, Brennan, Holton, &

Earls, 2003). Community measures are similarly linked to abusive parenting where there is a concentrated disadvantage of poverty and violent crimes (Pinderhughes, Nix, Foster, Jones, & Conduct Problems Prevention Research Group, 2001). Findings such as these opens the door to additional research on associated family violence and increased risks of iTBI. From the perspective of education and intervention, these findings suggest that new parents coming from a history of family violence require particular attention.

Attitudes About Corporal Punishment

The premise for looking at links between iTBI incidence and spanking or corporal punishment (CP) is that CP presents a predictive risk to escalate from punishment to child maltreatment (Taylor, Fleckman, & Lee, 2017). By the time American children reach their early teens, 85% have been physically punished by their parents, a particularly alarming statistic given that we know individuals who have suffered family violence as children are more likely to enter into an inter-generational cycle of violence (Regalado, Sareen, Inkelas, Wissow, & Halfon, 2004). Research suggests that African American parents, for example, spank their children more frequently than parents of other ethnic groups (McLoyd & Smith, 2002; Richardson, 2012; Straus & Stewart 1999), suggesting a need for culturally-appropriate education. Additional research centered on attitudes and the practice of corporal punishment may provide additional insights useful in breaking the cycle.

Age of Parents

This research question would examine data about the age of parents involved in iTBI and ask whether parents of any particular age are more likely to assault an infant. While no study has been conducted examining the relationship between the age of parents and the incidence of iTBI,

research into the link to child maltreatment reveal that risk factors do include (but are not limited to) younger, single parents (US Preventive Services Task Force, 2015). Teenage parents who have not finished high school and/or who have not established a career, particularly, may experience stressors due to a number of factors such as low income potential, a lack of emotional maturity and/or preparedness to take on the responsibilities and lifestyle of parenting, living with parents and/or otherwise dealing with instable housing, a sense of failure and incompleteness if dropping out of school to raise a child, and many other challenges related to their age and station in life.

Family Composition and Planned Parenting

This research question would examine data about the number of children, the presence of extended family members in the household, the presence of non-biological partners, and marital status to determine whether any of these factors increase the risk specifically of iTBI. While no study of these factors has yet been conducted in the area of iTBI research, research in the area of child abuse generally suggests that there is good reason to pursue this line of inquiry. An article published by the National Institutes of Health presented findings that larger families and unplanned parenthood raises the risk of both abuse and neglect (Zuravin, 1991).

Healthcare Economics

Avenues of further research should focus on gaining a better understanding of more complete contexts coded in the case history, and dynamics among populations in Minnesota that may impede the reduction or total elimination of iTBI related to economics. Research project might abstract the narrative of cases as health economics research based on the associated cost of care over time.

Implications

The results of this research study, together with recommendations for legislation and policy and further research, suggest a number of implications for positive social change. Standardized terminology among medical personnel, researchers, and public health policy makers anchors discourse and research in medical science and improves understanding. Expanded reach of public policy as it pertains to protections afforded to infants as well as toddlers, and improvements to current legislation, along with standardized training, assessment, and certification for daycare employees, baby sitters, nannies, home nurses, and other non-parental child caregivers, all improve the quality of care for the state's most vulnerable population.

Conclusion

The State of Minnesota has a compelling interest in the protection of infants and children from annihilative brain injuries. In 2005 Minnesota legislators authored and enacted legislation as an intervention to address brain injuries not as a result of playground falls, or vehicular accidents, but from inflicted trauma; assault. The grounding logic comes of research aligned with the Theory of Reasoned Action (Hale, Householder, & Greene, 2002), affirming that behavioral modification predicated on education and learning a function as an intervention to change behavior as the subject of education is capacitated with tools to understand and align with societal constructs and normative behavior. Thus, education can serve to preempt and intervene in violence with the goal of lowering the incidence of inflicted trauma among infants and children.

Armed with theory, this quantitative research project set out to evaluate if there was a statistical effect of lowering the incidence of inflicted Traumatic Brain Injuries when comparing a cohort of those born before, to those born after, enactment of the statute. The first challenge was that there was no standard case definition used by public health officials, researchers, or in the legislature. However, a review of the literature did reveal an evolution in the language from syndromic diagnosis to the CDC's adoption of Abusive Head Trauma as a subset of Pediatric Maltreatment. To create a case definition this research disambiguates and untangles the language conflating of injuries to the head with those to the brain as a specific case definition. While injuries to the head and skull include abrasions and skull fracture, this research considered retinal hemorrhage, axonal sheering below the subarachnoid layers surrounding the brain, cerebral hematoma and contusion as definitive diagnosis. Rather than shaking and whiplash, coup contrecoup injuries specifically to the brain are diagnostic.

The case definition was operationalized by combining ICD cause (event) and ICD diagnostic codes, and programmed into SAS statistical software to specifically identify inflicted Traumatic Brain Injury cases. From 1998 through 2017, more than 1,000 (1,061) cases of inflicted Traumatic Brain Injuries were identified in children under five years old, and tested for validity. Nearly two thirds of the cases (673) were found to have occurred in the first year of life, and the decision made to narrow the analysis to those under 1 year old.

There is an overwhelming and emotional desire when reviewing case after case of inflicted brain injuries to go beyond reporting to social services by co-opting the legal system. To criminalize may in fact prove counterproductive. Rather, the goal is to better understand effective public health policy and, where syndromic terminology undermines interventions, to

further change the social dialogue away from syndromic to acknowledge inflicted, and therefore preventable, injury.

Although the statute did not have the intended statistical effect of lowering the incidence of iTBI, there were some important findings. Nearly two-thirds of all cases occur in the first year of life. The average time from birth to incident in those who had not yet reached their first birthday was 152 days. A plotted trend of the incidence over the length of the study found an irregularity in the incident data during the legislative debates, and pointed to a correlation with the economic recession suggestive of social and economic triggers that need to be explored. The incidence in urban areas remained statistically unchanged, while there was a statistical rise in the incidence in rural areas. There was a statistically significant shift in the cohort of those born after implementation of Statute 144.574 in favor of less severity. And, although it is beyond the scope of this research to analyze fidelity of implementation, this research found nothing to contradict the grounding that public policy designed education leads to a change in behavior.

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Appendix A: Minnesota Statute 144.574, The Dangers of Shaking Infants and Young Children

Subdivision 1. **Education by hospitals.** (a) A hospital licensed under sections 144.50 to 144.56 shall make available for viewing by the parents of each newborn baby delivered in the hospital a video presentation on the dangers associated with shaking infants and young children.

(b) A hospital shall use a video obtained from the commissioner or approved by the commissioner. The commissioner shall provide to a hospital and any interested individuals, at cost, copies of an approved video. The commissioner shall review other video presentations for possible approval upon the request of a hospital. The commissioner shall not require a hospital to use videos that would require the hospital to pay royalties for use of the video, restrict viewing in order to comply with public viewing or other restrictions, or be subject to other costs or restrictions associated with copyrights.

(c) A hospital shall, whenever possible, request both parents to view the video.

(d) The showing or distribution of the video shall not subject any person or facility to any action for damages or other relief provided the person or facility acted in good faith.

Subdivision. 2. **Education by health care providers.** The commissioner shall establish a protocol for health care providers to educate parents and primary caregivers about the dangers associated with shaking infants and young children. The commissioner shall request family practice physicians, pediatricians, and other pediatric health care providers to review these dangers with the parents and primary caregivers of infants and young children up to the age of three at each well-baby visit.

Appendix B: Non-Fatal Case ICD-9 Clinical Diagnostic (D) Case Codes

310.2 Post Concussive syndrome

348.1 Anoxic Brain Damage. * when coded with 994.1 or 994.7

362.81 Retinal hemorrhage

781.0 – 781.4 Abnormal Involuntary Movement, Disturbances of smell/taste, poor coordination or gait, or transient paralysis

781.8 Neurologic neglect syndrome

800 Fracture of vault of skill

800.x Fracture of vault of skull w or w/o intracranial injuries

800.01 - with no loss of consciousness

800.2 - with meningeal hemorrhage

800.21 - with subarachnoid, subdural, and extradural hemorrhage, no loss of consciousness

800.22 - with subarachnoid, subdural, and extradural hemorrhage, with (fewer than 60 minutes) loss of consciousness

801 Fracture to base of skull - closed without mention of intracranial injury

801.x Fracture to base of skull

801.4 - with brain injury

803.x other/unqualified skull fracture

804.x Multiple fractures involving the skull and/or face with other bones - cerebral laceration and contusion; intracranial injury

804.1 – 804.4 Multiple fractures involving skull and/or - cerebral laceration and contusion

804.6 – 804.9 Intracranial lacerations, hemorrhage - concussion, or unspecified (loss of) consciousness

850 Concussion

850.x Concussion c/ …

851 Cerebral; laceration and contusion - cortex (cerebral) contusion without mention of open intracranial wound

851.x Cerebral Laceration and contusion - with, or without, loss of consciousness, with or without, wound

852.0 – 852.59 Subarachnoid, subdural, and extradural hemorrhage following injury with, or without, intracranial wound

852.2 Cerebral hemorrhage following injury without mention of open intracranial wound – unspecified consciousness

852.21 - no loss of consciousness

852.25 - prolonged loss of consciousness

853 Other and unspecified intracranial hemorrhage

853 – 853.19 unspecified intracranial hemorrhage following injury

853.1 Other/unspecified intracranial hemorrhage following injury - with open intracranial wound

854 – 854.19 Intracranial injury

854 Intracranial injury or other unspecified nature - w/out mention of open intracranial wound

854.1 Intracranial injury or other unspecified nature - with open intracranial wound

905 Late effect of fracture of skull and face

907 Late effect of intracranial injury w/o skull fracture

925.1 Crushing injury of/to face and scalp.

950 – 950.9 Injury to optic nerve and pathways

950 – 950.3 Optic nerve and/or visual cortex 959.01 Head injury, unspecified.

959.01 Head Injury, unspecified.

Appendix C: Non-Fatal Case ICD-9 External Cause (E) Codes

E960 Unarmed fight or brawl

E967.x Perpetrator of child or adult abuse

E967.2 Abuse by mother or stepmother

E967.3 Abuse by spouse or partner

E967.6 Abuse by grandparent

E967.7 Abuse by relative

E967.9 Child abuse

E968.1 Pushing from a high place

E968.2 Striking by a blunt or thrown object

E968.8 Assault - specified – means

E968.9 Assault - unspecified – means

E969 Late effects of injury purposely inflicted by other person

E987 Falling from a high place - undetermined whether accidentally or purposeful (probable)

E987.9 Falling from unspecified site - undetermined whether accidental or purposely inflicted

E988.8 Injury by other and unspecified means, undetermined whether accidentally or purposely inflicted (probable)

E988.9 Injury by other and unspecified means, undetermined whether accidentally or purposely inflicted.

995.5 Child abuse (maltreatment). Unspecified.

* Case Excluded if a “fall” or “accident” code is present

995.54 Child physical abuse

995.55 Shaken Infant Syndrome.

*** Case is definitive; does not require a cause code.**

995.59 Other child abuse and neglect

V71.6 Observation following other Inflicted Injury

V71.81 Abuse and Neglect

Appendix D: Fatal Case ICD-10 Clinical Diagnostic (D) Codes

S02 Fracture of Skull and facial bones

S02.0 Fracture of vault of skull

S02.1 Fracture of base of skull

S02.7 Multiple fractures involving skull and facial bones

S02.8 Fractures of other skull and facial bones

S02.9 Fracture of skull and facial bones, part unspecified

S04.0 Injury of optic nerve and pathways

S06.0 Concussion

S06.1 Traumatic cerebral edema

S06.2 Diffuse brain injury

S06.3 Focal brain injury

S06.4 Epidural hemorrhage

S06.5 Traumatic subdural hemorrhage

S06.6 Traumatic subarachnoid hemorrhage

S06.7 Intracranial injury with prolonged coma

S06.8 Other intracranial injuries

S06.9 Intracranial injury, unspecified

S07.1 Crushing injury of skull

S07.8 Crushing injury of other parts of head

S07.9 Crushing injury of head, part unspecified

S09.7 Multiple injuries of head

S09.8 Other specified injuries of head

T90.2 Sequelae of fracture of skull and facial bones

T90.5 Sequelae of intracranial injury

T90.8 Sequelae of other specified injuries of head

T90.9 Sequelae of unspecified injury of head

Appendix E: Fatal Case ICD-10 External Cause (E) Codes

Y00	Assault by blunt object
Y01	Assault by pushing from high place
Y04	Assault by bodily force
Y07	Other maltreatment syndromes
Y07.1	By parent
Y07.2	By acquaintance or friend
Y07.3	By official authorities
Y07.8	By other specified persons
Y07.9	By unspecified person
Y08	Assault by other specified means
Y09	Assault by unspecified means
Y29	Contact with blunt object, undetermined intent (probable)
Y30	Falling, lying or running before or into moving object, undetermined intent (probable)
Y33	Other specified events, undetermined intent (probable)
Y34	Unspecified event, undetermined intent (probable)
T74.1	Physical abuse
T74.2	Sexual abuse *pending case review
T74.8	Other maltreatment syndromes
T74.9	Maltreatment syndrome, unspecified
Y87.1	Sequelae of assault
Y87.2	Sequelae of events of undetermined intent (probable) ICD-10 External Cause Codes

Appendix F: Non-Fatal Case ICD-10 Clinical Diagnostic (D) Case Codes

F0781 Post Concussive syndrome

G931 Anoxic Brain Damage. * when coded with 994.1 or 994.7

H3560 Retinal hemorrhage

R250 – R253, R259, R430 – R432 Abnormal Involuntary Movement, Disturbances of smell/taste,

R260, R261, R2689, R269 Ataxic, Paralytic Gait, Abnormalities of Gait and Mobility

R270, R278, R279 Lack of Coordination

R295 Transient Paralysis

R414 Neurologic neglect syndrome

S020XXA Fracture of vault of skill

S06330A Contusion and Laceration of Cerebrum, Unspecified, w/o Loss of Consciousness (LOC)
S06331A Contusion and Laceration of Cerebrum, LOC for Less than 30 minutes
S06332A Contusion and Laceration of Cerebrum, LOC for 31-59 minutes
S06333A Contusion and Laceration of Cerebrum, LOC for 1 hour to 5 hours 59 minutes
S06334A Contusion and Laceration of Cerebrum, LOC for 6 hours to 24 hours
S06335A Contusion and Laceration of Cerebrum, LOC greater than 24 hours w/ return to Pre-Existing Conscious Levels
S06336A Contusion and Laceration of Cerebrum, LOC greater than 24 hours w/o return to Pre-Existing Conscious Levels
S06337A Contusion and Laceration of Cerebrum, LOC for any duration with Fatality due to Brain Injury prior to Regaining Consciousness
S06338A Contusion and Laceration of Cerebrum, LOC for any duration with Fatality Due to Other causes prior to Regaining Consciousness
S06339A Contusion and Laceration of Cerebrum, LOC for any duration

S064X0A Epidural Hemorrhage without Loss of Consciousness
S064X1A Epidural Hemorrhage with LOC for Less than 30 minutes
S064X2A Epidural Hemorrhage with LOC for 31-59 minutes
S064X3A Epidural Hemorrhage with LOC for LOC for 1 hour to 5 hours 59 minutes
S064X4A Epidural Hemorrhage with LOC for LOC for 6 hours to 24 hours
S064X5A Epidural Hemorrhage with LOC greater than 24 hours with return to Pre-Existing LOC
S064X6A Epidural Hemorrhage with LOC greater than 24 hours with return to Pre-Existing LOC
S064X7A Epidural Hemorrhage with LOC of any duration with fatality due to brain injury prior to regaining consciousness
S064X8A Epidural Hemorrhage with LOC of any duration with fatality due to other causes prior to regaining consciousness
S064X9A Epidural Hemorrhage with LOC of unspecified duration

S065X0A	Traumatic Subdural Hemorrhage without Loss of Consciousness
S065X1A	Traumatic Subdural Hemorrhage with LOC for Less than 30 minutes
S065X2A	Traumatic Subdural Hemorrhage with LOC for 31-59 minutes
S065X3A	Traumatic Subdural Hemorrhage with LOC for LOC for 1 hour to 5 hours 59 minutes
S065X4A	Traumatic Subdural Hemorrhage with LOC for LOC for 6 hours to 24 hours
S065X5A	Traumatic Subdural Hemorrhage with LOC greater than 24 hours with return to Pre-LOC
S065X6A	Traumatic Subdural Hemorrhage with LOC greater than 24 hours without return to Pre-Existing Conscious Levels
S065X7A	Traumatic Subdural Hemorrhage with LOC of any duration with fatality due to brain injury prior to regaining consciousness
S065X8A	Traumatic Subdural Hemorrhage with LOC of any duration with fatality due to other causes prior to regaining consciousness
S065X9A	Traumatic Subdural Hemorrhage with LOC of unspecified duration
S066X0A	Traumatic Subarachnoid Hemorrhage without Loss of Consciousness
S066X1A	Traumatic Subarachnoid Hemorrhage with LOC for Less than 30 minutes
S065X2A	Traumatic Subarachnoid Hemorrhage with LOC for 31-59 minutes
S066X3A	Traumatic Subarachnoid Hemorrhage with LOC for 1 hour to 5 hours 59 minutes
S066X4A	Traumatic Subarachnoid Hemorrhage with LOC for 6 hours to 24 hours
S066X5A	Traumatic Subarachnoid Hemorrhage with LOC greater than 24 hours with return to Pre-Existing Conscious Levels
S066X6A	Traumatic Subarachnoid Hemorrhage with LOC greater than 24 hours without return to Pre-Existing Conscious Levels
S066X7A	Traumatic Subarachnoid Hemorrhage with LOC of any duration with fatality due to brain injury prior to regaining Consciousness
S066X8A	Traumatic Subarachnoid Hemorrhage with LOC of any duration with fatality due to other causes prior to regaining Consciousness
S066X9A	Traumatic Subarachnoid Hemorrhage with LOC of unspecified duration
S06360A	Traumatic Hemorrhage of Cerebrum without Loss of Consciousness
S06361A	Traumatic Hemorrhage of Cerebrum with LOC for Less than 30 minutes
S06362A	Traumatic Hemorrhage of Cerebrum with LOC for 31-59 minutes
S06363A	Traumatic Hemorrhage of Cerebrum with LOC for 1 hour to 5 hours 59 minutes
S06364A	Traumatic Hemorrhage of Cerebrum with LOC for 6 hours to 24 hours
S06365A	Traumatic Hemorrhage of Cerebrum with LOC greater than 24 hours with return to Pre-Existing Conscious Levels
S06366A	Traumatic Hemorrhage of Cerebrum with LOC greater than 24 hours without return to Pre-Existing Conscious Levels
S06367A	Traumatic Hemorrhage of Cerebrum with LOC of any duration with fatality due to brain injury prior to regaining Consciousness
S06368A	Traumatic Hemorrhage of Cerebrum with LOC of any duration with fatality due to other cause prior to regaining Consciousness
S06369A	Traumatic Hemorrhage of Cerebrum with LOC of unspecified duration
S06890A	Intracranial Injury (Specified) without Loss of Consciousness
S06891A	Intracranial Injury with LOC for Less than 30 minutes
S06892A	Intracranial Injury with LOC for 31-59 minutes
S06893A	Intracranial Injury with LOC for 1 hour to 5 hours 59 minutes
S06894A	Intracranial Injury with LOC for 6 hours to 24 hours
S06895A	Intracranial Injury with LOC greater than 24 hours with return to Pre-Existing LOC
S06896A	Intracranial Injury with LOC greater than 24 hours without return to Pre-Existing LOC
S06897A	Intracranial Injury with LOC of any duration with fatality due to brain injury prior to regaining Consciousness

S06898A Intracranial Injury with LOC of any duration with fatality due to other causes prior to regaining Consciousness
S06899A Intracranial Injury with LOC of unspecified duration

S069X0A Intracranial Injury (Unspecified) without Loss of Consciousness
S069X1A Intracranial Injury with LOC for Less than 30 minutes
S069X2A Intracranial Injury with LOC for 31-59 minutes
S069X3A Intracranial Injury with LOC for 1 hour to 5 hours 59 minutes
S069X4A Intracranial Injury with LOC for 6 hours to 24 hours
S069X5A Intracranial Injury with LOC greater than 24 hours with return to Pre-Existing Conscious Levels
S069X6A Intracranial Injury with LOC greater than 24 hours without return to Pre-Existing Conscious Levels
S069X7A Intracranial Injury with LOC of any duration with fatality due to brain injury prior to regaining consciousness
S069X8A Intracranial Injury with LOC of any duration with fatality due to other causes prior to regaining consciousness
S069X9A Intracranial Injury with LOC of unspecified duration

S0210XA Unspecified Fracture of Base of Skull for closed fracture

S0210XB Unspecified Fracture of Base of Skull for open fracture

S0190XA Unspecified Open Wound of the Head

S0291XA Unspecified Fracture of the skull

S0291XB Unspecified Fracture of the skull

S060X0A Concussion without Loss of Consciousness
S060X1A Concussion with LOC for Less than 30 minutes
S060X2A Concussion with LOC for 31-59 minutes
S060X3A Concussion with LOC for 1 hour to 5 hours 59 minutes
S060X4A Concussion with LOC for 6 hours to 24 hours
S060X5A Concussion with LOC greater than 24 hours with return to Pre-Existing Conscious Levels
S060X6A Concussion with LOC greater than 24 hours without return to Pre-Existing Conscious Levels
S060X7A Concussion with LOC of any duration with fatality due to brain injury prior to regaining consciousness
S060X8A Concussion with LOC of any duration with fatality due to other causes prior to regaining consciousness
S060X9A Concussion with LOC of unspecified duration

S06370A Contusion, Laceration, and Cerebellum of Brainstem without Loss of Consciousness
S06371A Contusion, Laceration, and Cerebellum of Brainstem with LOC for Less than 30 minutes
S06372A Contusion, Laceration, and Cerebellum of Brainstem with LOC for 31-59 minutes
S06373A Contusion, Laceration, and Cerebellum of Brainstem with LOC for 1 hr to 5 hrs 59 minutes
S06374A Contusion, Laceration, and Cerebellum of Brainstem with LOC for 6 hours to 24 hours
S06375A Contusion, Laceration, and Cerebellum of Brainstem with LOC greater than 24 hours with return to Pre-Existing Conscious Levels
S06376A Contusion, Laceration, and Cerebellum of Brainstem with LOC greater than 24 hours without return to Pre-Existing Conscious Levels
S06377A Contusion, Laceration, and Cerebellum of Brainstem with LOC of any duration with fatality due to brain injury prior to regaining consciousness

S06378A	Contusion, Laceration, and Cerebellum of Brainstem with LOC of any duration with fatality due to other causes prior to regaining consciousness
S06399A	Contusion, Laceration, and Cerebellum of Brainstem with LOC of unspecified duration
S06380A	Contusion, Laceration, and Hemorrhage of Brainstem without Loss of Consciousness
S06381A	Contusion, Laceration, and Hemorrhage of Brainstem with LOC under 30 minutes
S06382A	Contusion, Laceration, and Hemorrhage of Brainstem with LOC 31-59 minutes
S06383A	Contusion, Laceration, and Hemorrhage of Brainstem with LOC of 1 hr to 5 hrs 59 minutes
S06384A	Contusion, Laceration, and Hemorrhage of Brainstem with LOC for 6 hours to 24 hours
S06385A	Contusion, Laceration, and Hemorrhage of Brainstem with LOC greater than 24 hours with return to Pre-Existing Conscious Levels
S06386A	Contusion, Laceration, and Hemorrhage of Brainstem with LOC greater than 24 hours without return to Pre-Existing Conscious Levels
S06387A	Contusion, Laceration, and Hemorrhage of Brainstem with LOC of any duration with fatality due to brain injury prior to regaining consciousness
S06388A	Contusion, Laceration, and Hemorrhage of Brainstem with LOC of any duration with fatality due to other causes prior to regaining consciousness
S06389A	Contusion, Laceration, and Hemorrhage of Brainstem with LOC of unspecified duration
S061X0A	Cerebral Edema without Loss of Consciousness
S061X1A	Cerebral Edema with LOC under 30 minutes
S061X2A	Cerebral Edema with LOC 31-59 minutes
S061X3A	Cerebral Edema with LOC of 1 hour to 5 hours 59 minutes
S061X4A	Cerebral Edema with LOC for 6 hours to 24 hours
S061X5A	Cerebral Edema with LOC greater than 24 hours with return to Pre-Existing Conscious Levels
S061X6A	Cerebral Edema with LOC greater than 24 hours without return to Pre-Existing LOC
S061X7A	Cerebral Edema with LOC of any duration with fatality due to brain injury prior to regaining Consciousness
S061X8A	Cerebral Edema with LOC of any duration with fatality due to other causes prior to regaining Consciousness
S061X9A	Cerebral Edema with LOC of unspecified duration
S020XXS	Fracture of the Vault of the Skull with Sequela
S0210XS	Unspecified Fracture of the Vault of the Skull with Sequela
S02110S	Type I Occipital Condyle Fracture with Sequela
S02111S	Type II Occipital Condyle Fracture with Sequela
S02112S	Type III Occipital Condyle Fracture with Sequela
S02113S	Unspecified Occipital Condyle Fracture with Sequela
S02118S	Fracture of Occiput with Sequela
S02119S	Unspecified Fracture of Occiput with Sequela
S022XXS	Fracture of Nasal Bones with Sequela
S023XXS	Fracture of Orbital Floor with Sequela
S02400S	Malar Fracture Unspecified with Sequela
S02401S	Maxillary Fracture Unspecified with Sequela

S02402S	Zygomatic Fracture Unspecified with Sequela
S02411S	Lefort I Fracture with Sequela
S02412S	Lefort II Fracture with Sequela
S02413S	Lefort III Fracture with Sequela
S0242XS	Fracture Alveolus of Maxilla with Sequela
S025XXS	Fracture of Tooth (Traumatic) with Sequela
S02600S	Fracture of Unspecified Part of the Body of Mandible with Sequela
S02609S	Unspecified Fracture of Mandible with Sequela
S0261XS	Fracture of Condylar Process of Mandible with Sequela
S0262XS	Fracture of Sub-Condylar Process of Mandible with Sequela
S0263XS	Fracture of Coronoid Process of Mandible with Sequela
S0264XS	Fracture of Ramus of Mandible with Sequela
S0265XS	Fracture of Angle of Mandible with Sequela
S0266XS	Fracture of Symphysis of Mandible with Sequela
S0267XS	Fracture of Alveolus of Mandible with Sequela
S0269XS	Fracture of Mandible with other Specified site and Sequela
S0291XS	Unspecified Fracture of the Skull with Sequela
S0292XS	Unspecified Fracture of the Facial Bones with Sequela

S069X9S	Intracranial Injury with Loss of Consciousness Unspecified Duration and Sequela
S049XXS	Unspecified Injury of Cranial Nerve and Sequela
S070XXA	Crushing Injury of the Face
S078XXA	Crushing Injury of the Head
S04019A	Injury of Optic Nerve, Unspecified Eye Injury
S0402XA	Injury of Optic Chiasm
S04039A	Injury or Visual Cortex, Unspecified Eye
S04019A	Injury of Optic Nerve, Unspecified Eye
S0990XA	Unspecified Injuries to the Head.

Appendix G: Non-Fatal Case ICD-10 External Cause (E) Codes

Y040XXA	Assault by Unarmed Brawl or Fight
Y048XXA	Assault by Other Bodily Force
Y0711	Biological Father, Perpetrator of Maltreatment and Neglect
Y0701	Husband, Perpetrator of Maltreatment and Neglect
Y0712	Biological Mother, Perpetrator of Maltreatment and Neglect
Y07410	Brother, Perpetrator of Maltreatment and Neglect
Y07499	Other Family Member, Perpetrator of Maltreatment and Neglect
Y0759	Other Non-Family Member, Perpetrator of Maltreatment and Neglect
Y0750	Unspecified Non-Family Member, Perpetrator of Maltreatment and Neglect
Y079	Unspecified Perpetrator, Perpetrator of Maltreatment and Neglect
Y01XXXA	Pushing from a high place
Y01XXXS	Assault by Pushing from a high place
Y00XXXA	Striking by a blunt or thrown object
Y0889XA	Assault - specified – means
Y09	Assault - unspecified – means
Y00XXXS	Assault by Blunt Object with Sequela
Y0889XA	Assault by Other Specified Means
Y30XXXA	Falling from a high place - undetermined whether accidentally or purposeful (probable)
Y33XXXA	Injury by other and unspecified means, accidentally or purposely inflicted (probable)
T7492XA	Child abuse Maltreatment (Confirmed). Unspecified.
T7692XA	Child abuse Maltreatment (Suspected). Unspecified.
T744XXA	**Shaken Infant Syndrome. * Case is definitive; does not require a diagnostic code.**