**Abusive Head Trauma Scoping Review**

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**Introduction**

Abusive Head Trauma (AHT) is the most common cause of death due to child abuse and is also the most common cause of death in children less than one year old (Bechtel, K., Stoessel, K., Leventhal, J. M., Ogle, E., Teague, B., Lavietes, S., & Duncan, C., 2004). It is defined as “an injury to the skull or intracranial regions of a child under the age of five due to blunt trauma or violent shaking” and the incidence of such may actually be an underestimation (Center for Disease Control, 2012; Kelly, P., Thompson, J. M., Koh, J., Ameratunga, S., Jelleyman, T., Percival, T. M., & Mitchell, E. A., 2017). Indeed, some scholars indicate that the reported rates of child abuse homicide may even be underreported by 50-60% (Albert, D. M., Blanchard, J. W., & Knox, B. L., 2012). Survivors frequently suffer physical disabilities, neurological impairments and behavioral difficulties (Niederkrotenthaler, T., Xu, L., Parks, S. E., & Sugerman, D. E., 2013). Mortality rate estimates for AHT have been estimated at between 15%-38% and neurological morbidity for survivors is severely high (Keenan, H. T., Runyan, D. K., Marshall, S. W., Nocera, M. A., Merten, D. F., & Sinal, S. H., 2003). Often, AHT results in head trauma including intracranial hemorrhage, parenchymal injury, retinal hemorrhages and sometimes fractures of the long bones and ribs (Barr, R. G., Trent, R. B., & Cross, J., 2006).

AHT includes what was described by Caffey in the 1970s as the Whiplash Shaken Infant Syndrome, later referred to simply as the Shaken Baby Syndrome, which at that time described situations where intracranial injury was present in the absence of external signs of head trauma (Byard, 2014). Infants were thought to be most vulnerable to shaking given their physiology: a large head, soft neck, unmyelinated axons and a flat skull base (Byard, 2014). More likely than not, the perpetrator is aware that the shaking is harmful given the nature of the act (American Academy of Pediatrics, 2001). Other patterns of presentations include hyper-acute encephalopathy, acute encephalopathy, subdural and retinal hemorrhages, rib fracture, chronic extra-cerebral presentation and raised intra-cranial pressure (Minns, R. A., & Busuttil, A., 2004).

Lazoritz & Bier (2001) in the book “The Shaken Baby Syndrome” by Lazoritz & Palusci (2001) outline a history of the Shaken Baby Syndrome concept from its earliest historical incantation to its development into the modern syndrome known today. SBS can be traced back to 1559 with King Henri the II of France who died after receiving a blow to the head during a joust. His personal physician wrote that “because of such common or shaking of the head” he died 11 days later (Lazoritz & Bier, 2001).

 In 1946, Caffey published his landmark article “Multiple fractures in the long bones of infants suffering from chronic subdural hematoma” where he concluded that when physicians see signs of one (i.e. Subdural Hematoma) they should look for signs of the other (i.e. bone fractures) which effectively developed the concept of the medical evaluation of trauma (Lazoritz & Bier, 2001). In 1968, Ommaya, a neurosurgeon showed using rhesus monkeys that Subdural Hematoma by whiplash could be produced without impact. Caffey then built upon this assertion and also the work of Guthkelch to show the effects of rotational acceleration and deceleration as the etiology of Subdural Hematomas (Lazoritz & Bier, 2001) which led to Caffey’s 1972 characterization of the Whiplash Shaken Infant Syndrome.

The Whiplash Shaken Infant Syndrome became known as Shaken Baby Syndrome, and SBS reflects a subset of injuries caused by Abusive Head Trauma which is part of Kempe’s (1962) “Battered Child Syndrome” (Lazortiz & Palusci, 2001). Additionally in 1972, Caffey and Kempe introduced the concept of the Parent-Infant Traumatic Stress Syndrome (Caffey, 1972; Reece & Nicholson, 2003) which was a medical definition including non-accidental physical injury inflicted by distraught children that could include subdural hematoma and cerebral contusions (Caffey, 1972). The syndrome also included language describing the acceleration and deceleration sharing forces which produce repetitive whiplash which in turn compress the intracranial blood vessels of the brain (Caffey, 1972). In 2009, the American Academy of Pediatrics recommended the use of the term “Abusive Head Trauma” with the rationale:

“Although shaking an infant has the potential to cause neurologic injury, blunt impact or a combination of shaking and blunt impact cause injury as well. Spinal cord injury and secondary hypoxic ischemic injury can contribute to poor outcomes of victims. The use of broad medical terminology that is inclusive of all mechanisms of injury, including shaking, is required.” (Christian & Block, 2009)

Abusive Head trauma therefore is the most current nomenclature being utilized with the intent of broadening the medical terminology to account for all forms of injury that may occur exclusive of or including shaking.

 Differentiating between AHT and Non-Abusive Head Trauma (NAHT) can be difficult; despite some clear differences in patient presentation and case history between the two, and therefore requires specialized training or even a Child Advocacy and Protection Team (Jenny, C., Hymel, K. P., Ritzen, A., Reinert, S. E., & Hay, T. C., 1999; Niederkrotenthaler et al., 2013). A large proportion of AHT patients may be initially misdiagnosed, underdiagnosed or diagnosed too late to prevent injury (Niederkrotenthaler et al., 2013). 31.2% of AHT cases were found in the Jenny et al. (1999) study to be missed and 28% of children were later re-injured (Niederkrotenthaler et al., 2013) indicating a clear need for improved recognition of signs for AHT.

 There are some forensic and legal disagreements in the literature regarding AHT. In the court system, approximately 1,500 people per year are involved in some form of AHT or Shaken Baby Syndrome and approximately 200 people per year are prosecuted and convicted (Findley, K., & Barnes, P., 2013). Some legal and medical scholars refute the AHT or Shaken Baby diagnosis as more of an unproven hypothesis (Findley, K., & Barnes, P., 2013). As recognized by Slovis, et al., some child abuse denialists have even falsely claimed that the diagnosis of AHT or child abuse is “the creation of a non-disease” (Slovis, T. L., Strouse, P. J., Coley, B. D., & Rigsby, C. K., 2012). Defense-biased law professors and law students have published deeply flawed legal articles claiming, for instance, that the issue of AHT is the “Next Innocence Project” and indicating that the diagnosis of AHT is equivalent to the “medical diagnosis of murder” thereby circumventing the traditional legal processes in determining levels of intent (Tuerkheimer, D., 2009). Others have argued simply that there is scant “evidence based medical or empirical medical evidence on that issue and that some of the scientific literature does not meet admissibility frameworks in national and international courts (Henneberg, M. L., 2014).

 Overall, about 40% of AHT cases result in criminal prosecution with a conviction rate of 88% (Albert et al., 2012). Legal defenders often believe that many individual charged and convicted of AHT are actually innocent, while prosecutors often believe that many guilty perpetrators go free thus “compromising society’s responsibility to protect infants from abuse” (Albert et al., 2012). What is of considerable concern is that different AHT cases with similar findings have led to disparate verdicts, often with inconsistent sentencing ranging from going free to probation to life in prison (Albert et al., 2012). Much of what drives these differences may be due to expert medical witnesses, some of whom have “variable credentials”, and may use unique interpretations of medical evidence to make the jury feel that there is enough confusion to create “reasonable doubt” (Albert et al., 2012).

Overall, ethical citizens on either the prosecution or defense side of the coin would not want to see an innocent person go to jail nor would they want to see a guilty person go free. Furthermore, it appears that despite the 40 years of evidence in the field and the more than 1,000 peer-reviewed articles supporting the AHT diagnosis there continue to be inconsistencies within the judicial system suggesting some form of science-application breakdown. Ultimately, it is impossible to randomly sort infants into abuse and non-abuse groups in order to conduct controlled experiments to determine causation of childhood head injuries, and therefore the closest proxies (whether they be bio-mechanical models or scaling of pigs or woodpeckers) are sometimes inappropriately claimed to be biofidelic indicators of the thresholds for human child head injury.. Additionally, the lifetime cost of AHT based on one single year (2010) is 13.5 billion dollars with an estimated breakdown of $257 million for medical care, $552 million for special education and $322 million for child protective services and criminal justice costs. (Miller, T. R., Steinbeigle, R., Lawrence, B. A., Peterson, C., Florence, C., Barr, M., & Barr, R. G., 2017).

The goals of this literature review/scoping review will be:

(1) Differentiating between Abusive Head Trauma and Non-Abusive Head Trauma (NAHT); (2) addressing the effects of legal controversies in the court system; (3) what are the best methods for prevention; (4) Given gaps in our knowledge about epidemiology and outcomes, what research is needed in AHT?

The review will then move to claimed controversies in the field including a discussion of possible alternate hypotheses to AHT, alternate theories that seek to explain a differential pathogenesis of AHT as well as methodological queries in AHT to discuss the point related to admissibility as scientific evidence. Finally the review will conclude with a section discussing the claim that a medical diagnosis of AHT is a “medical diagnosis of murder.” The hope is that this review provides ample fodder in an unbiased and objective manner to drive policy discussions regarding the implications of AHT.

**Key Elements in the Identification of AHT**

 As previously noted AHT is a difficult area of study and presents several methodological concerns. Generally, the scholars and scientists in the extant literature tend to follow two general methods (Spivak, 2001). Outcomes may be analyzed through observation of incidents of AHT and researchers can extrapolate from variables noted in clinical reports to identify patterns (Spivak, 2001). Otherwise, researchers can develop experimental models of different types of traumas and then scale to AHT with regard to infants (Spivak, 2001). One other method would be the use of meta-analysis of the extant literature, which then would probably fall into one or the other category just highlighted.

 We begin with the bio-mechanics of head trauma. The first breakthrough in this area came from Holbourn (1943), a British physiologist who began to identify and analyze the forces required for cerebral injury. He made five assumptions about the brain: that it had uniform density, that it was about as incompressible as water, that it could change shape easily in response to an applied force, that the skull was more rigid than the brain and that the shape of the brain and the size of the head mattered when it came to cerebral injury (Holbourn, 1943). Holborun (1943) noted that rotational shearing forces were critical in producing concussion symptoms and significant brain injury.

Caffey (1972) found that the subdural hematoma and cortical injury found in infants was similar to the shear strain hypothesis identified by Holbourn (1943) and that it also represented what looked to be a whiplash phenomenon. During this period in medical history, the postulation from such scholars was that rotational acceleration was critical in the pathogenesis of brain injury in abused infants in comparison to those seen in short falls (Spivek, 2001). Ommaya, Faas & Yarnell (1968) added to this body of literature in an experimental study examining adult monkeys and chimpanzees. Ommaya and colleagues proposed critical tolerances based on shearing forces for concussion, subdural hematoma and diffuse axonal injury in humans (Spivek, 2001).

Work by Gennarelli et al. (1982) found that the development of diffuse axonal injury was due to the duration of trauma in addition to the axis of rotation, with more prolonged and coronal rotation likely to lead to subdural hematomas. He and his colleagues have identified the metabolic changes in axonal membranes and micro-glia after rotational trauma (Spivek, 2001).

Several other descriptive factors have been found in infants with AHT. Imagawa, Hamilton, Ceschin, Tokar, Pham, Bluml, & Panigrahy (2014) compared 17 infants with a diagnosis of AHT with a control sample. Results indicated that reduced axonal diffusivity was shown in widespread white matter regions in the AHT infants and that these findings related to a worse prognosis and clinical outcomes (Imagawa et al., 2014). Work by Narang & Clarke (2014) identified subdural and retinal hemorrhages as most common findings in AHT. The authors define subdural hemorrhage as a traumatic hemorrhage developed from torn veins between the brain and the dural sinus (Narang & Clarke, 2014) as opposed to other theories which historically believed they emerged from illnesses. Narang & Clarke (2014) further posit that infants with AHT suffer from an array of symptoms which can range from non-specific (i.e. irritability, poor feeding and vomit) to delayed development to life threatening conditions such as respiratory compromise and seizures.

Cervical spine injury may also be an underreported aspect of AHT; initial studies indicated a low detection rate in children with confirmed inflicted trauma (35%) however more recent studies have shown the rate to be as high as 44% (Narang & Clarke, 2014). Some other manifestations may include spinal cord injury with ligament injury, fractures or spinal cord injury without radiologic abnormality (Narang & Clarke, 2014). In the cases where an infant survived AHT, they often sustained epilepsy, severe neurological impairment, motor and visual deficits, sleep disorders, language abnormalities and attention and behavioral disorders (Lind, Toure, Brugel, Meyer, Laurent-Vannier & Chevignard, 2016).

Piteau, Ward, Barrowman, & Plint (2012) conducted a meta-analysis of 24 studies from 2000-2009 to determine statistically the differences between clinical and radiological variables of AHT as opposed to nAHT (non-Abusive Head Trauma). Their results indicated that “subdural hemorrhages, cerebral ischemia, retinal hemorrhages, skull fractures, metaphyseal fracture(s), long bone fracture(s), rib fracture(s), seizure(s), apnea, and no adequate history given” were significantly associated with AHT (Piteau et al., 2012). In comparison, epidural hemorrhage(s), scalp swelling, and isolated skull fracture(s) were significantly associated with nAHT (Piteau et al., 2012).

Subdural hemorrhages have been reported in 77%-90% of patients with abusive head trauma and retinal hemorrhages have been reported in 74%-82% of AHT cases (Narang & Clarke, 2014). Specifically, multiple subdural hemorrhages and those within the interhemispheric fissure and over the convexities were related to AHT in a statistically significant way. Shein, Bell, Kochanek, Tyler-Kabara, Wisniewski, Feldman, & Berger (2012) conducted a quasi-experimental study on risk factors that then predicted mortality in infants with AHT. Their analysis included 386 children with AHT and their findings indicated that a low score on the Glasgow Coma Scale, Retinal Hemorrhage, Intraparenchymal Hemorrhage and Cerebral Edema were independently associated with mortality.

In children with intracranial injuries, along with rib fractures Retinal Hemorrhages (RH) are the physical findings predictive of AHT (Agarwal, Peters, Adams, & Pierce, 2012; Coats, Binenbaum, Peiffer, Forbes, & Margulies, 2010; Levin, Luyet & Knox, 2016; Maguire, Watts, Shaw, Holden, Taylor, Watkins, & Kemp, 2013). Much of this literature also borrows from experimental methods utilized with piglets which were shown to have ocular hemorrhage in 73% of the animals including in the anterior chamber, vitreous and optic nerve (Coats et al., 2010).

Retinal Hemorrhages are the most common ophthalmological finding in child physical abuse and are estimated at 85% prevalence in AHT cases (Levin et al., 2012). RH tend to occur more frequently in children who died than those who are survivors and have a low incidence in child abuse by blunt trauma only or short falls (Levin et al., 2012). In cases of severe accidental head trauma, the incidence is usually between 0-3% (Levin et al., 2012). Maguire et al., (2013) found that RH were found in 78% of AHT versus 5% of nAHT and that in a child with head trauma and RH, the probability for abuse is 91%.

Highly numerous and multi-layered RH are highly specific for AHT (Levin et al., 2012). They are not likely to be explained by the differential diagnosis of hypoxia alone since they do not occur in other disorders with cerebral hypoxia (Levin et al., 2012). Retinal folds and traumatic retinoschisis is also highly specific for AHT; indeed in one meta-analysis no studies documented retinal folds or retinoschisis in conditions other than AHT (Bhadwaj et al., 2010; Levin et al., 2012). Other studies have shown that RH were bilateral in 83% of AHT cases in comparison to 8.3% in nAHT cases with few RH located in the posterior pole and only 10% extending to the periphery in nAHT (Maguire et al., 2013). A different study found that severe, multi-layered RH were only seen in 3.7% of patients without AHT (i.e. leukemia and sepsis, illness during birth) (Agarwal, 2010).

Various scientists, medical practitioners and researchers over the past sixty years have contributed to the knowledge base of AHT. The knowledge base has moved forward to best understand the symptoms and radiologic factors associated with AHT in an effort to correctly, and effectively identify the diagnosis As with all medical diagnoses, the collective experience of those who regularly diagnose the cause, timing and mechanism of childhood head injuries enhanced by research findings has resulted in significant advancements since the hypothesis was originally advanced in the 1970’s. For survivors, the prognosis is not good and several negative behavioral and cognitive concerns may be prevalent through the lifespan. Only a few survivors will have minimal or no consequences of their inflicted head trauma. Authors made various recommendations for practice and moving the field forward. In a synthesis of these recommendations, four emerge with the potential to influence policy at the intersection of practice and research. They are as follows:

1. Seek immediate ophthalmological consultation if a child is being assessed for head trauma.
2. Develop more prospective, controlled studies with a common definition of terms.
3. Utilize a multi-disciplinary team to focus on symptoms with high specificity and predictive validity as determined by the literature in order to make diagnoses with confidence.
4. Work to enhance bio-mechanical models to most appropriately reflect the physiology of a human infant.

**Prevention of AHT**

These section overviews descriptive factors of the abused and their abusers, general epidemiological statistics related to AHT and various ways of preventing it from happening. As stated before, the lifetime cost of one case of AHT amounts to 5.7 million dollars with a total lifetime cost for one year of AHT cases of $13.5 billion dollars (Miller et al., 2017). Existing prevention programming would exceed costs if it prevents 2% of cases (Millet et al., 2017) suggesting the need to further examine the efficacy of prevention efforts and the potential to create new prevention efforts.

**Descriptive factors for Abusive Head Trauma.**

 A study by Peterson, C., Xu, L., Florence, C., & Parks, S. E. (2015) estimated the medical costs of AHT among patients 0-4 over a 5 year period. The average total annual nationwide medical cost of AHT hospital visits was US$69.6 million over the study period. Niederkrotenthaler et al. (2013) conducted a descriptive study on the socio-demographic data of children who had been diagnosed with AHT. In this four year study, rates of AHT per 100,000 were higher in children under 1 years old, males and Blacks; more of the AHT cases were fatal (6.7%) as opposed to fatal cases in the NAHT group (1.8%).

Cases that were covered by Medicaid or those uninsured had increased odds of being diagnosed with AHT; given that insurance status is a great predictor of socio-economic status, the risk of AHT is associated with socio-economic disadvantage making them more at risk (Niederkrotenthaler et al., 2013). Similarly, AHT and its relationship to economic hardship was explored by Berger et al. (2011) in an investigation of the link between the recession and AHT. Authors found that the rate of AHT increased from 8.9/100,000 before the recession to 14.7/100,000 during the recession providing further evidence for the relationship between parental stress and violence.

 Scribano, Makoroff, Feldman, & Berger (2013) studied the characteristics of perpetrators of AHT over a five year period. Alleged perpetrators were most likely to be fathers (53%), parent partner (22%), mother (8%), babysitter (8%) and other adult caregiver (5%). Non-parental perpetrators were more likely to cause head injury to a child over the age of 1 suggesting that some interventions need to focus as well on the post infancy age. Gender differences between male and female perpetrators have also been explored (Esernio-Jenssen, Tai, & Kodsi, 2011) and have shown significant perpetrator differences. The median age for female perpetrators (34) was higher than for males (27) and male perpetrator gender was associated with worse clinical outcomes, surgical intervention, perpetrator confession, and conviction. Children who had a male perpetrator were much more likely to suffer worse outcomes, even death. Parental risk factors for abuse include substance abuse, domestic violence, criminal history, unrealistic expectations and attachment problems (Ricci, Giantris, Merriam, Hodge, & Doyle, 2003).

 Perpetrator confessions have also been examined to see if they correlate with mechanisms of injury (Adamsbaum, Grabar, Mejean & Rey- Salmon, 2010). Shaking was described as extremely violent in 100% of the cases, and was repeated in 55% of the cases with the mean amount of times shaken being 10. The majority of confessions indicated that shaking was done to stop infant crying (62.5%) and in the majority, impact was not used (24%). Another study of perpetrator confessions by Biron & Shelton (2005) indicate that perpetrator accounts described an immediate neurological response from the victim suggesting that the symptoms of head injury presented immediately.

 Perpetrators may lack the sufficient knowledge, relationship skills and/or impulse control to manage infant behaviors. Barr (2012) examined the role of crying as a trigger for AHT. Prolonged unsootheable crying in the early months has been interpreted in various ways including pathology with the infant, pathology with the caregiver or a pathological interaction between the two (Barr, 2012). Barr (2012) interprets the increase in the proclivity for violence during infant crying as a breakdown in the normative dynamics of the infant-caregiver relationship; he recommends prevention methods aimed at educating adults regarding the normative development curves of infants and how to respond appropriately. This articulates the need for interventions that target a specific window of risk.

**Prevention efforts and efficacy of evidenced based and informed models.**

 There have been several attempts at prevention programs on AHT which focus on education, maternal education, education within the context of medical settings and prevention programs which focus on crying as a trigger. A search of Abusive Head Trauma prevention on PsychINFO returns 32 articles over the past 10 years. For the purposes of this scoping/literature review, I will focus on some variables that predict the need for early screening; some screening methods and overview (scope) various select prevention efforts and their effectiveness.

***Screening tools for AHT.***

A study conducted by Letson, Cooper, Deans, Scribano, Makoroff, Feldman & Berger (2016) examined over a four year period the amount of opportunities medical or child protective staff had of identifying and referring a child with symptoms consistent with abuse. Authors found that 31% of the patients surveyed had a prior opportunity of having their abuse identified, and 25% had one prior opportunity in a medical setting. Authors found no differences between age, gender, race or insurance status. The most common prior opportunities within the medical setting included chronic subdural hemorrhage and healing fractures in addition to vomiting, prior CPS contact and bruising (Letson et al., 2016).

 Other concerns include “sentinel injuries” defined as a previous injury in a medical history which was suspicious for abuse, with explanations that appeared implausible (Sheets, Leach, Koszewski, Lessmeier, Nugent & Simpson 2013). Sheets et al. (2013) found that in a sample of 200 abused infant, 27.5% had previously had a sentinel injury as opposed to 0 of the 101 non-abused infants. The most common form of sentinel injury in the abused cohort was bruising at 80%; sentinel injuries tended to occur early in infancy with 95% occurring before the age of 7 months (Sheets et al., 2013).

Early screening therefore is a recommended proposal and the rationale for primary prevention programs of AHT is clear. One concern with prevention programming is the potential impact on the reduction of AHT through screening. Bailhache, Bénard, & Salmi (2016) studied the impact of screening with the potential side effects being that parents could be wrongfully accused of being an abuser. Their research indicated that after a two year period, the median number of deaths avoided ranged from 6 to 28 per 100,000 newborns (Bailhache et al., 2016). The overall impact of the screening process was determined as uncertain, but brings up the need for potential benefits and rigorous evaluation of promising prevention programs.

Other screening tools have shown more empirical promise. Hymel, Herman, Narang, Graf, Frazier, Stoiko & Wang (2015) developed a valid screening tool for the identification of AHT. Their results suggest that the AHT screening guide could increase AHT detection in PICU setting from 87% to 96% and increase the overall diagnostic yield of completed evaluations from 49%-56% while targeting less children for evaluation (Hymel et al., 2015). Another screening tool developed by Cowley, Morris, Maguire, Farewell & Kemp (2015) known as the PredAHT (Predict AHT) also showed promise in novel data with a sensitivity of 72.3% and a specificity of 85.7% with an estimation probability of AHT at 81.5%. Sensitivity is the measure of correctly identifying the proportion of people who have said condition and Specificity is the ability to correctly identify the proportion of people who do not have the said condition. Six features were recorded in the scale including retinal hemorrhage, rib and long bone fractures, apnea, seizures and head and neck bruising (Cowley et al., 2015).

 ***Evidenced Informed and Evidence Based Programs.***

As noted previously, there have been varied prevention programs that have shown various levels of empirical evidence of effectiveness. Often, some parents are not aware of AHT or the dangers associated with it (Simonnet, Laurent-Vannier, Yuan, Hully, Valimahomed, Bourennane, & Chevignard (2014). According to a study conducted by Simonnet et al. (2014) 27% of mothers and 36% of fathers had never heard of AHT; parents found a brief talk by medical staff useful in increasing their knowledge regarding AHT. Going one step further, Altman, Canter, Patrick, Daley, Butt, & Brand (2011) evaluated the effectiveness of a leaflet and 8 minute video explaining AHT. Pre-Post analysis indicated that there was a 75% reduction in injuries in the years after the training program was introduced.

Some of these programs have been evaluated in an international context. For example, in Turkey an educational film was utilized as a prevention program and outcomes suggested that the average levels of knowledge increased over time with the most effective learning time occurring prior to birth and three to seven days after birth (Taşar, Bilge, Şahin, Çamurdan, Beyazova, Polat, & İlhan, 2015). Many programs that were developed in the United States used international replication studies for further empirical cross cultural validation.

Dias, Smith, deGuehery, Mazur, Li & Shaffer (2005) utilized a hospital based prevention program where hospitals were asked to provide mothers and fathers information describing the dangers of infant shaking including providing alternative parenting strategies. Both parents were asked to sign a voluntary “commitment statement” to never shake their child. The methods included a quasi-experimental, retrospective longitudinal design which showed that incidences of child maltreatment after the introduction of the prevention program decreased 47% (p=.0168). Limitations of the study include that it was not a randomized control trial and that the results did not follow a dose response pattern. Kelly, Wilson, Mowjood & Reed (2016) did an independent cross-cultural replication of Dias et al.’s (2005) prevention method in New Zealand on a sample of 2,592 caregivers also using a quasi-experimental design. Results indicated that 85% of respondents remembered one key message from the intervention and that 92% made a plan of what to do when frustrated. Interestingly, there results were found to be statistically significant despite the lack of commitment statements which were hypothesized to be a key determinant of success in the original study.

As also noted previously, crying has been widely regarded as a trigger for abuse. Morrill, McElaney, Peixotto, VanVleet, & Sege (2015) implemented and evaluated a media based program called ABC (All Babies Cry) which focused on reducing parental stress and soothing infants. Results indicated that after 17 weeks, the stress management group of parents used a wider variety of skills than the control group and reported using stress reduction strategies depicted in the program (Morill et al., 2015). Another program which educated caregivers about crying was the Period of PURPLE Crying program which was evaluated and showed that new mothers found the program useful in teaching them about normal infant crying and soothing and coping strategies (Reese, Heiden, Kim, & Yang 2014).

People of Purple Crying is considered an evidence based model and has been subject to a randomized control trial in addition to an independent replication (Barr, Barr, Fujiwara, Conway, Catherine & Brant, 2009: Fujiwara, Yamanda, Okuyama, Kamimaki, Shikoro & Barr, 2012). The letter PURPLE each stand for a property of the types of crying that frustrates caregivers: P for Peak, U for unexpected, R for resistance, P for pain like look, L for long bouts and E for evening (Barr et al., 2009). The materials along with the packet also suggest ways to soothe the child and ways to calm you as a parent (Barr et al., 2009).

A randomized control trial of 1279 mothers showed statistically significant differences in knowledge (p<.001) as well as self-reports of walking away (p<.001) when the child is inconsolable (Barr et al., 2009). A cross cultural replication study in Japan showed knowledge scores which were significantly higher in the intervention group (p<.005) and self-reported walking away behavior that was significantly higher in the intervention group (p<.1) (Fujiwara, et al., 2012).

Other physicians and researchers have focused on the education of primary healthcare professionals. One such model is the SEEK program which also meets the criteria for evidenced-based. The SEEK model includes the training of child health care primary care professionals, a parent questionnaire which screens for potential problems, and a Reflect-Empathize-Assess-Plan approach to address the problems identified in the screening (Dubowitz, 2014). Two large randomized control trials were conducted on SEEK – one in a resident training clinic serving low income African American families and the other in 18 suburban pediatric private practices serving middle income, mostly White families (Dubowitz, 2014; Dubowitz, Lane, Semiatin & Magder, 2012). In the first study, SEEK children were significantly less likely to be maltreated including fewer CPS reports, fewer documented incidences of medical neglect and fewer instances of severe physical assault reported by parents (Dubowitz, 2014). In the second study, SEEK mothers reported fewer Minor Physical Assaults (p=.019, ES=.16) than controls at 6 months and 12 months follow up. It is worth noting that the effect size for this sample was low (Cohen’s D<.2).

Other programs have utilized partnerships between healthcare providers in the home setting. McCall, Eckenrode & Olds (2009) assert that over the past twenty years, one of the most effective means of preventing child maltreatment has come from health services and parenting education within the home setting. Several of these programs have shown empirical promise. The Nurse Family Partnership Program begum in Elmira, NY was tested in an Randomized Control Trial and showed 80% fewer cases of abuse in the experimental group (p=.07) (McCall et al., 2009). NFP was also replicated in Memphis, TN in a Randomized Control Trial which showed that children in the control group were 4.5 times more likely to have died from child maltreatment than their counterparts in the nurse visited group (p<.08).

Healthy Families America, another home based nursing program was evaluated using four randomized control trials. No effects were found across the trials which led to the conclusion that the program was not cost effective and that in fact, investment in the program may produce a net loss of $1,830 per family (McCall et al., 2009). Another program, Parents as Teachers was subjected to four randomized control trials and results show few statistically significant effects on child maltreatment, although some effects were found on educational outcomes.

 One particularly promising form of prevention is the community based Strong Communities for Children (McDonnel, Ben-Arieh & Melton, 2014). SCC is a comprehensive community-wide initiative that promotes a narrative change in the perceptions, beliefs and behavior of community members (Melton & Melton, 2015). Implementation includes the phases of Spreading the Word, Mobilizing the Community, Increasing Resources for Families and Institutionalizing Resources (Melton & Melton, 2015). Three related studies using random sampling were compared to a comparison sample; results indicate moderate effect sizes for both coded child injuries and founded cases of abuse and neglect (ES=.32, ES=.57 respectively) (Melton & Melton, 2015). These studies are promising on two fronts: one, the measure the actual outcome of child abuse rather than scaling from self-reports or intentions for harm and two, they present effective sizes which are in the moderate range which is unique to the articles reviewed thus far which all include statistically significant results, no evidence of harm, but small to modest effect sizes.

 Strategies for effective implementation have also been found in the literature. A study of the RE-AIM (Reach, Adoption, Implementation and Maintenance) framework has been used to evaluate statewide implementation of an AHT prevention program (Shanahan, Fleming, Nocera, Sullivan, Murphy & Zolotor, 2014). 86 state hospitals were able to implement the program with high fidelity and the majority were able to incorporate the program into unit procedures and employee training – a majority of hospitals indicated their desire to continue the program into the future (Shanahan et al., 2014).

 Various empirically validated screening measures and various prevention efforts with positive empirical possibilities have been implemented nationally and some internationally to effectively identify ways to diagnose AHT and to prevent AHT both generally and during critical periods (i.e before birth, before 7 months). Education programming is particularly relevant given that a large minority of both men and women do not understand what AHT is, and a small reduction in AHT during one given year could lead to multi-million dollars in reduction of funds and save lives. In addition, one-sided media coverage has often focused on the flawed claims of a very small number of physicians and others that the shaken baby syndrome is no longer accepted by mainstream diagnosticians, that it is not dangerous to shake infants and toddlers, or that many caretakers have been falsely accused of abusing their children based on a faulty diagnosis. The success of future prevention efforts may have to begin with neutralizing public misperceptions caused by such biased and flawed media coverage of the topic. Some questions for consideration in this section which may influence policy and practice include:

1. What is the closest we can come to determining evidence based prevention while still being ethical (i.e. we cannot randomize parents into a prevention and non-prevention group)?
2. Should certain conditions immediately be followed by prevention as protocol in hospitals? (i.e. children found with sentinel wounds immediately have caregiver referred to AHT prevention)
3. Given that the science behind the screening tools is pretty strong, should we begin to train medical and para-medical professionals on the way to use these tools?
4. Should prevention efforts start with a collective multi-disciplinary focus on exposing flawed media coverage of the topic of AHT and refuting the misconceptions created among some members of the public through exposure to such unscientific treatment of the problem?

**Controversies –Real or Fabricated?**

According to Gabaeff (2016), there is a controversy in child abuse pediatrics between “an established corps of child abuse pediatricians aligned with hospital colleagues and law enforcement, and a multi-specialty challenger group of doctors and other medical professionals working with public interest lawyers”. He goes on to state that “as the ability to convict based on this unproven prime hypothesis, that Subdural Hemorrhage plus Retinal Hemorrhage equals abuse some defense attorneys were professionally compelled … to seek second opinions (Gabaeff, 2016). Gabaeff is one of a very small group of physicians who deny the existence or prevalence of child abuse, testify in courtrooms as to unproven alternative explanations for inflicted childhood head injuries, and who regularly try to confuse the triers of fact in child abuse litigation. Some claimed controversies in the area focus on issues related to lucid intervals, rebleed of chronic subdural hematomas, alternate theories of explanation including hypoxia and short falls causing death and a claim that the shaken baby syndrome has been abandoned by mainstream medical diagnosticians. (Krous & Byard, 2005). Unfortunately, there are “unethical and unqualified” physicians whose testimony may be described as irresponsible according to legal and medical rules of ethics, who nevertheless continue to propagate unfounded and scientifically uproven claims which represent unusual interpretations of medical findings, but which have led to hung juries and acquittals and even to appellate court reversals of prior convictions or granting of new trials based on the claim of “new science” not available at the time of trials.. (Krous & Byard, 2005).

 Those who believe the “unproven hypothesis” notion state that the scientific proof boils down to three essential features known as the “triad” which include subdural hematoma, retinal hemorrhages, and acute encephalopathy (Findley et al, 2012). Tuerkheimer (2009) also discusses the triadd as now being undermined by current research, and that the triadd can no longer be seen as “pathogonomic of AHT”. This claim that a triad of findings automatically results in a diagnosis of abusive head trauma has never been accurate, yet is accepted uncritically by those who desire to deny the existence of child abuse. It was originally coined by child abuse denialists as a “straw man” foil for their arguments, but is akin to the specious claim of legal writers that a diagnosis of AHT is a legal “diagnosis of murder”. Henneberg (2015) indicates that the “triad … is not reliable” and that courts ought to pay more attention to the advances in scientific thinking and that much of the evidence on AHT is “not admissible in court”. In my current analysis of 101 articles on PSYCHINFO under the search term “Abusive Head Trauma” two included the term “triad” in their papers. Nevertheless, the concept of the triad continues to be a popular term with use in legal journals such as Washington University Law Review as well as the Oklahoma City University Law Review.

 It is beyond the scope of this literature/scoping review to outline every single alleged controversy present in the field of AHT. However, in my analysis of 16 articles pertinent to the topic (from 1999-current) three themes emerge as critical towards the controversy of AHT. First, this includes whether the studies which have provided the empirical basis for AHT are scientific enough, or whether they even meet the criteria for admissibility in the U.S. court systems. Geddes & Plunkett (2004) in an editorial response stated “Shaken Baby Syndrome/Inflicted Head Injury is based on imprecise and ill-defined criteria, biased selection, circular reasoning, inappropriate controls, and conclusions that overstep the data”. That article, however, is based on several logical fallacies, including the straw man claim that the diagnosis of SBS is solely based on the “triad.”

 Another key argument is that there are alternate theories that better explain the injuries a child suffered which range from paroxysmal coughing, vomiting, to the “unified hypothesis” of hypoxia and raised venous pressure (Geddes et al., 2000; Geddess et al., 2003; Geddes & Plunkett, 2004). Furthermore, these other conditions potentially “mimic” the symptoms seen in AHT however share a much different pathophysiology. Finally, there is a legal argument that leads to real life legal implications which is that AHT is essentially “medical diagnosis of murder” in that all three components of who, when and did they know are answered through one diagnosis and one expert witness, allegedly circumventing the legal process (Findley et al. 2000; Turkheimer, 2009). The goal herein, is to provide the literature on each critique and end with some questions which may influence policy and practice.

**Are these studies scientific enough?**

Geddes & Whitwell (2004) indicate that in their study of the literature “there have been no systematic formal neuropathological studies of infant head injury” and that the “evidence base for Diffuse Axonal Injury being a common finding in infant head injury is poor.” Gabaeff (2016) indicates that the theory on AHT essentially follows the same pattern of thought – that “a caregiver snapped under stress”, they then shook a child in an abusive manner, and was then assumed to be guilty. Gabaeff (2016) goes on to indicate that studies indicate the improbability of the “snapping” hypothesis and that the probability of a previously caring caregiver “snapping” is less than 1/10,000. Gabaeff (2016) continues to make some other arguments critical of the “shaking hypothesis” including that current biomechanical testing indicates that humans could not produce shearing forces strong enough to cause brain damage (without also causing neck injury), that observational methods have been used in most studies which is not an evidence based methodology, that researchers use a circular logic in these observational studies and that multi-disciplinary teams in hospitals are prone to groupthink which thereby derides their ability to operate as objective scientists.

 Findley et al. (2012) also claim that when doctors began applying “evidence based medicine” standards, which required “biostatistical significance” and the scientific method, most of the research on AHT did not meet the “quality under evidence based medicine standards”. Furthermore, Findley et al. (2012) allege that the majority of the AHT cases fall to the bias of the Prosecutors Fallacy, the notion that the researchers “ignored the base rate”, that is to say that the researchers did not look at the rate at which abuse is present compared to all of the cases of infant death. Finally, Findley et al. (2012) posit that research for AHT suffer from selection bias, observer bias or both in that the validity of the research depends on whether researchers are accurately identifying which cases reflect abuse and which do not; often “the very diagnostic signs that are used to sort the cases into these two categories are the same signs that the studies are purporting to measure.”

 Researchers who support the generally accepted diagnosis of AHT assert on the contrary that much of the alternate research is also based on case reports and circular logic; some even go as far as to say that omissions and misrepresentations are made regarding “mimics” of AHT (Edwards, 2014). Indeed, sometimes case reports are not made by the clinician treating the child, and are often out of sync with sworn testimonies (Edwards, 2014). Jenny (2014) also indicates that “the evidence base supporting many of the explanations offered to disprove abusive head trauma is often quite weak” and that in the case of suspected accidental trauma, a thorough workup is required. Hymel et al. (2002) outlined a 10 step process in ruling out differential diagnoses in order to make the appropriate diagnosis of AHT; some of these steps include paying close attention to the clinical presentation of the child in addition to consultation with radiologists and appropriate radiological exams.

**Alternate Theories and their Shortcomings.**

In Geddes et al. (2001), 53 cases of non-accidental head injury were subjected to detailed neuro-pathological study. Results indicated that the most usual cause of death was raised intracranial pressure secondary to brain swelling in 82% of the cases and that hypoxic brain damage was present in 77% of the cases. Furthermore, diffuse axonal injury was present in only 3/53 cases. Geddes & Whitwell (2004) provide a separate hypothesis than what they deem the “traditional explanation” which includes injury to the child yielding bruising and skull fracture, in addition to brain swelling, subdural hemorrage and retinal hemmorage. They indicate that their hypothesis does not necessarily emanate from injury, it could also be due to genetic susceptibility, which could lead to apnoea, severe hypoxia, brain swelling and then subdural and retinal bleeding. Geddes & Whitwell (2004) indicate that intracranial bleeding may be “a phenomena resulting from deranged infant physiology rather than a direct result of trauma” and that “such a possibility highlights the difficulty of being certain that abuse has occurred in cases where there is no objective evidence of trauma or violence.”

 Geddes et al. (2003) conducted a review of dura mater taken from post mortem series of 50 pediatric patients. Their results indicate that a combination of severe hypoxia, brain swelling and raised central venous pressure “causes blood to leak from intracranial veins into the subdural space” and is therefore a phenomenon of immaturity. Geddes et al. (2003) claim that hypoxia with brain swelling would therefore account for retinal hemorrhages as well without “considerable force being necessary.” Dr. Geddes, however, when confronted in testimony before the highest court in the United Kingdom admitted that her hypotheses were only hypotheses which she and her colleagues may not have “just right” and further stated that the “unifying hypothesis” she and colleagues proposed was not ready to be used in the courtroom. Effectively, she withdrew the claims contained in her articles. – cite the UK case.

 Other alternate theories not discussed before include that normal, healthy infants suddenly die after birth because a birth related hematoma spontaneously rebleeds, that subdural hemorrhages in infants are caused by immunizations, and that short falls can cause the same signs and symptoms of abusive head trauma (Jenny, 2014). Despite these alternate theories, Albert et al. (2013) indicate that most physicians treating AHT agree that these cases can be diagnosed or ruled out on the basis of routine diagnostic or follow up studies. According to Albert et al. (2013), the issue arises when some defense lawyers choose to present an isolated portion of medical findings rather than the totality of all medical findings in order to “confuse the jury”. Furthermore, the presentation of such complex medical information itself presents a problem in that expert witnesses have to explain the material in a clear and understandable way to the judge and jury (Albert et al., 2013). Although the list of alleged alternative explanations offered in the courtroom is long, none of them have been proven through valid empirical research to explain the collection of head, eye and other injuries which are part of the diagnosis of AHT.

 The Consensus Statement on Abusive Head Trauma in Infants and Young Children, endorsed by The American Professional Society on the Abuse of Children and the Society for Pediatric Radiology, summarized various unsubstantiated theories which are used to explain pediatric SDH (Palusci, 2017). The following are summarized herein.

1. Cerebral sinovenous thrombosis (CSVT) represents a serious disorder with high rates of morbidity and mortality; however, reviews of large pediatric studies of CSVT have failed to show the connection between CSVT and SDH. Therefore, given the weight of this literature, there is no scientific support to CSVT within courtroom speculation (Palusci, 2017).
2. Hypoxic Ischemic Injury (HII) has been the Geddes et al. (2003) proposed mechanism of injury. This hypothesis was tested comparing HII alone with HII along with AHT. No SDH was identified in the non-traumatic HII cohort (Rao, Carty & Pierce, 1999).
3. SDH following lumbar puncture has been posited as a mechanism due to CSF leak and then intracranial hypotension; there is currently no body of medical evidence to support this hypothesis (Palusci, 2017).
4. Dysphagic choking has also been used as an explanation for SDH and retinal hemorrhages – sudden increases in intrathoracic pressure during coughing; choking or vomiting has been proposed as the mechanism leading to SDH and RH (Palusci, 2017). Although one case study has shown this to be the case (Barnes et al., 2010) recent studies do not support this assertion and in fact support the identification of AHT (Curcoy et al., 2010).
5. Benign Enlargement of the Subarachnoid Space has been used as an explanation factor for SDH, however out of 712 reported cases of BESS only 1.7% represented subdural collections which were hemorrhagic in nature (Tucker et al., 2016); 41.7% of subdural collections which were hemorrhagic were due to accidental trauma or abuse (Tucker et al., 2016).

**AHT/SBS in the Courtroom**

Criminal prosecutions and juvenile court child protection proceedings which to some extent involve inflicted childhood head injuries have been filed at least over the last four decades, and as the medical field has advanced in its own knowledge of the significance of a unique pattern of injuries seen in inflicted head trauma but not in other situations, the legal system has also evolved to find new ways of proving the cause, timing and mechanism of child head injuries. As the numbers of such diagnoses have increased over the years, so have the number of courtroom cases increased. While the medical diagnoses of “shaken baby syndrome” or “abusive head trauma” have never been an essential element of the substantive definition of crimes against children in the United States, medical diagnostic expertise has contributed significantly to the proof of child abuse, inflicted child injuries, and child homicides. The reality, however, is that criminal prosecution and juvenile court pursuit of child protection cases is accomplished by a wide variety of prosecutors and child protection attorneys ranging from those in major metropolitan areas to those in small jurisdictions with only one or two attorneys. As a result, the specialized training and knowledge needed to handle such cases is sometimes not available. Proof of cases involving inflicted childhood head injuries has always involved a mix of both expert evidence and opinion with investigative facts concerning the health history of the child and how caregivers accounted for the cause of the child’s injuries. Medical expert opinion has always involved testimony by those who regularly care for, diagnose, and treat the injuries to children, who apply a differential diagnosis in deciding the appropriate medical diagnosis. It’s important to note, however, that the medical diagnosis of “shaken baby syndrome” or “abusive head trauma” is different from the elements of criminal or child welfare substantive statutes which form the basis of criminal charges or the basis for a child protection petition. This reality undercuts some recent claims by biased law professors and law students and in the mass media that “shaken baby syndrome” or “abusive head trauma” is a “diagnosis of murder”, as will be thoroughly explained in this section.

Although criminal defendants and caretakers accused of abusing their children in juvenile court actions have raised claims and defenses based primarily on the “alternative theories” of the small group of largely unqualified physicians discussed above, no appellate court in the United States has found that the underlying scientific basis for the medical diagnoses of “shaken baby syndrome” or “abusive head trauma” fails to meet the relevant standard for admissibility of expert testimony under either Frye v. United States, 293 F. 1014 (1923) – general acceptance of the expert opinion and its basis within the relevant scientific community; Daubert v. Merrell Dow Pharmaceuticals, 509 U.S. 570 (1993) – general acceptance or meeting a threshold of scientific reliability based on suggested criteria; or other equivalent state tests for scientific reliability under Federal and State rules of evidence. See Moreno, J., What do pediatric healthcare experts really need to know about Daubert and the rules of evidence, Pediatr. Radiol (2013) 43:135-139 for a full explanation of Frye and Daubert rules, Rule 702 of the Federal Rules of Evidence and how the tests apply to medical science experts and to the trial judge’s gatekeeper role to “separate the wheat of valid scientific methodology from the chaff of chicanery.” Id. p.135.

Several jurisdictions have not accepted the Daubert factors as the exclusive method for judging the reliability and relevancy of expert testimony and several courts have recognized the Daubert factors were neither intended to be applied to every case nor to be applied mechanically by courts acting as the gatekeeper of expert opinion evidence. Higgs v. State, 222 P.2d 648 (Nev. 2010) – Nevada Supreme Court rejected rigid application of Daubert factors after examining the history of federal and state cases decided since Daubert and reaffirming that each case is different and the judge deciding on whether expert evidence is admissible must apply differing factors depending on the situation presented in each case. “But, to the extent that courts have construed Daubert as a standard that requires mechanical application of its factors, we decline to adopt it.” Id. 657-658. Another very insightful case, which applies directly to the process of medical diagnosis, is State v. McMullen, 900 A. 2d 103 (Del. Super. 2006). The court discusses the process of medical diagnosis and explains that there are no standard diagnostic criteria that can be applied to every case, no “cookie-cutter” method for medical diagnosis, which involves a mix of science and art. The defense attempt to apply the Daubert factors strictly to the medical diagnosis and to have the court find the diagnosis is invalid because of the lack of “strict diagnostic criteria” or “clinical algorithms” to meet the diagnosis is rejected. “Even with all the advances of medical science, the practice of medicine remains an art. This pointed observation perhaps best illustrates the often vexing challenge confronting the judicial gatekeeper when applying a Daubert analysis to the discipline of clinical medicine as opposed to the practice of ‘hard science.’” Id. 114. The McMullen court then carefully explains the process of applying a differential diagnosis in reaching a medical conclusion, focusing on the fact that although the diagnosis applies medical knowledge, peer-reviewed literature, and actual clinical experience, it is always somewhat subjective to meet the individual circumstances of each patient. The Court recognizes that the diagnosis in each case is based upon experience with many patients, discussions with peers, attendance at conferences and seminars, detailed review of the patient’s history and thorough examination of the patient. “In sum, a soundly performed differential diagnosis alone satisfies the Daubert requirements for reliability in the context of clinical medicine.” Id. 118-119. If a differential diagnosis provides a sufficient basis for prescribing a potentially life or death treatment plan, it should be considered reliable enough to assist a fact finder in understanding medical evidence or fact issues relevant to the case.

In their 1997 article, Drs. David Chadwick and Henry Krous suggested several criteria for judging whether an expert witness is acting irresponsibly or appropriately in child abuse cases in Irresponsible testimony by medical experts in cases involving the physical abuse and neglect of children, Child Maltreat 1997, 2:313. Their list has been widely accepted as a definition of an irresponsible expert witness since that time and includes: (1) absence of proper qualifications (because of no experience diagnosing childhood injuries), (2) use of unique theories of causation; (3) use of unique or unusual interpretations of medical findings; (4) alleging nonexistent medical findings; (5) flagrant misquoting of medical journals or texts; (6) making false statements, or (7) deliberate omission of important facts or knowledge pertinent to the opinions being offered. Ironically, this list applies to the vast majority of agenda-driven child abuse denialists who testify exclusively for criminal defendants or parents accused of child abuse in courtrooms today. Some of those same “experts” have written articles accepting the Chadwick/Krous definition of an irresponsible expert witness, yet fail to mention that they violate many of the rules on a regular basis, and their testimony qualifies as irresponsible. Barnes, P., Ethical issues in imaging nonaccidental injury, Topics in Magnetic Resonance Imaging, 13(3), 85-94 (2002) – author advises against becoming an advocate for any particular party, yet since the late 1990’s has solely testified in courtrooms for criminal defendants and parents accused of abuse, offering opinions that have been widely criticized by mainstream physicians.

Although no appellate court in the United States has found SBS/AHT to be scientifically unreliable and thus opinions based on the diagnoses inadmissible, there have been some troubling pronouncements by trial and appellate court judges reversing convictions and ordering new trials based on scientifically unsound and unsupported claims by scientific denialists of a “shift in mainstream” acceptance of the diagnoses or that alternative explanations account for the entire collection of a child’s injuries. An example widely cited by criminal defense attorneys, Innocence Project lawyers, and others attempting to defend those accused of abuse is State v. Edmunds, 746 N.W. 2d 590 (Wis. Ct. App. 2008), where the Court was misled by a small group of professional witnesses with a particular agenda to erroneously find that there had been a “shift in mainstream opinion” concerning the scientific validity of the shaken baby syndrome. Recently, that claim has been shown to be false; essentially a courtroom sham intended to create confusion when there is no such change in mainstream acceptance of SBS/AHT by those physicians who regularly work with and diagnose injuries in young children, and who constitute the “relevant medical field” for purposes of scientific reliability assessment. Narang, S. et al. Acceptance of shaken baby syndrome and abusive head trauma as medical diagnoses, J. Pediatr 177: 273-278 (2016). The authors surveyed multiple specialists frequently involved in the actual evaluation, diagnosis and treatment of injured children at ten leading children’s hospitals as well as pathologists regularly conducting forensic autopsies involving child deaths. Their results establish that 88% of those involved in the “relevant scientific field” under Frye or Daubert tests accept the shaken baby syndrome as a valid medical diagnosis and that 93% of the group accepts abusive head trauma as a valid medical diagnosis. This directly contradicts the courtroom claims of the group of agenda-driven child abuse denialists of a “shift in mainstream acceptance” of the shaken baby syndrome and abusive head trauma diagnoses. While there may be other physicians outside the mainstream who challenge the diagnoses, those who do evaluate, treat and diagnose the cause of childhood head injuries generally accept SBS/AHT as valid scientifically based diagnoses. Narang and his colleagues also showed that same group of relevant medical experts soundly reject the “alternative explanations” offered by the small group of child abuse denialist expert witnesses for the collection of injuries which are part of the diagnosis of SBS/AHT. “This high degree of consensus, irrespective of specialty, experience, or age, refutes recent reports in the lay press and legal community of a substantial controversy within the medical community regarding SBS and AHT.” Id. at p. 277.

Interestingly, the evidence presented by the witnesses for the defendant in Edmunds regarding the alleged “shift in mainstream” medical opinion, was offered almost exclusively by those witnesses who don’t themselves specialize in the diagnosis of childhood injuries, or who have a particular bias which makes them popular among those who seek the services of a physician to refute the diagnosis of the shaken baby syndrome or abusive head trauma. In real life science, the existence of a few critics of a diagnosis that is widely or almost universally accepted by those who actually apply the diagnosis in their daily medical practices would never be characterized as a “shift in mainstream medical opinion”, yet that is what the Edmunds defense witnesses claimed and the court was deceived into believing the claim. In addition, those same claims are now presented on a regular basis by Innocence Project lawyers, criminal defense attorneys, and even the American Civil Liberties Union through “canned briefs” which represent nothing more than the polemic claims of this small group of unqualified or biased physicians who have never scientifically proven any of their claims and who regularly violate the ethical guidelines for physicians testifying as expert witnesses.

While the child abuse denialists who frequently appear in courtrooms continue to offer the same basic opinions in cases involving childhood head injuries, Innocence Project lawyers and defense or parents’ attorneys often “glom onto” their false and unscientific claims uncritically since they have to find some way to defend those accused of abuse. As Dr. Christopher Greeley points out in his article, Abusive head trauma: A review of the evidence base, AJR 2015; 204:967-973, “A diverse, complicated, international, transdisciplinary, and voluminous evidence base characterizes AHT. When this expansive evidence base is pieced together and taken in toto, AHT can be readily differentiated from alternative explanations of a child’s injuries. The debate surrounding AHT is neither scientific nor medical, but legal…As in the antivaccine effort, many skeptics of AHT misrepresent or simply misunderstand the breadth of the published medical evidence and introduce this into courtrooms as so-called new science.” Id. at p. 971 (emphasis added). Dr. Greeley cogently collects and summarizes the evidence base which shows that the collection of injuries virtually unique in inflicted head trauma along with aspects of the history provided and ruling out other causes of medical findings justifies the diagnosis and “the differential diagnosis evaporates.” Id. at p. 969.

Under all United States jurisdictions and federal case law relating to expert witness testimony, expert opinion based on science or specialized knowledge can’t be based exclusively on a guess or mere speculation but must be grounded in sound science. The problem with the claims of the child abuse denialists is they have no actual scientific basis to support their courtroom-only opinions. When challenged on cross-examination, all they can point to is the small number of polemic articles written by their fellow denialists rather than actual original scientific research subjected to peer-review. Even when this group purports to have found something new, it is exposed as deeply flawed, not new at all, or not relevant to the claims the expert makes in court. Examples include Mark Donohoe’s deeply flawed article claiming lack of “evidence based support” for the shaken baby syndrome where he only found 55 articles to review though there were over 700 articles in the peer-reviewed literature at the time, Forest Bandak’s article claiming to have proven that neck injuries must precede head injuries in shaking where the math errors he made invalidated his conclusions, and John Plunkett’s article claiming to have disproven the shaken baby syndrome by finding child deaths that didn’t fit his “straw man” version of the syndrome. While agenda-driven expert witnesses become very accomplished at their role in courtrooms, especially if a great majority of their time is spent as a professional witness rather than actively practicing clinical medicine, their ability to obfuscate, confuse, and make their conclusions sound credible while telling only half-truths about their qualifications and the underlying basis for their opinions should have no room in a modern court proceeding. If Daubert and later cases relating to expert testimony have taught anything it is that there should be some degree of appropriate “fit” between the expertise and actual recent experience of the proposed expert witness and the “topic at hand”. In the child abuse arena, that should mean that those who testify as experts actually spend a good deal of their time evaluating, treating and diagnosing the cause of injuries to young children. With very rare exceptions, the group of child abuse denialists who regularly testify for criminal defendants and accused parents lack that experience, and many of them retired years or even decades ago from the active practice of medicine. For some, becoming a professional witness has offered an early retirement, a second income, or media and other recognition they would have otherwise been denied. Some make quite significant amounts of money in this pursuit. Others truly believe that ‘normal’ people would never abuse children and thus suspend reason in order to believe anything other than the truth of child abuse. Whatever their underlying motivation, without an adequate scientific foundation for their expert opinion testimony, it should be inadmissible in every court. Though vociferous and boisterous in voicing their views in courtrooms, they have never conducted any original research which establishes their claims.

These professional witnesses have at times turned to defense-biased law professors, law students and Innocence Project lawyers to provide legal writing to support their views. The most prolific of these biased authors has been law professor Deborah Tuerkheimer, who authored several law review articles which are deeply flawed and based on several dozen misassumptions about everything from how the medical diagnostic process happens to how lawyers prove SBS or AHT cases in the courtroom. Not satisfied with just writing such articles in the legal literature, Ms. Tuerkheimer then had an opinion piece published in the New York Times magazine claiming that the shaken baby syndrome was a false diagnosis which had sent hundreds of innocent people to prison. Though both claims were false, reporter Emily Bazelon also had an article published in the New York Times parroting all the claims of the child abuse denialist witnesses, citing Tuerkheimer, and again claiming people were being innocently convicted of shaken baby syndrome or abusive head trauma because when doctors diagnose either, it amounts to a “medical diagnosis of murder.” Tuerkheimer’s rhetoric is catchy and mainstream media around the time her articles were published couldn’t resist the headlines, but it is completely and totally false, based solely on the child abuse denialist courtroom witnesses who were seeking her as a spokesperson to affect public opinion because their opinions weren’t getting them very far in actual court cases. As with the professional witnesses upon whose word Tuerkheimer based her articles, her themes included claims of “new science”, the “demise” of the shaken baby syndrome, the “triad” having a “talismanic” effect on doctors diagnosing child injuries, and people being “falsely convicted of the shaken baby syndrome” upon the testimony of experts alone. While her writings can hardly be referred to as “scholarly”, they are a fascinating study in the use of logical fallacies, unproven hypotheses, and hyperbole with no underlying support. Tuerkheimer even wrote a book featuring all of her two dozen or so false assumptions which included the assumption that she had single-handedly proven the medical diagnoses of shaken baby syndrome and abusive head trauma were false diagnoses. In the book, she even makes the ridiculous claim that if prosecutors would quit filing criminal charges based on the testimony of experts, the diagnosis would wither and die away. As will be shown, legal scholars have dissected Tuerkheimer’s claims and thoroughly refuted them, as have child abuse pediatricians and others who really do diagnose the cause of childhood injuries. Keith Findley is also often cited by the child abuse denialist witnesses in support of their claims that the shaken baby syndrome and abusive head trauma are faulty diagnoses. Findley was the defense attorney for Audrey Edmunds and assembled the group of professional witnesses in that case who were successful in deceiving the Wisconsin courts. As an Innocent Project director himself, it should be no surprise that Mr. Findley would attempt to help those who are similarly tasked with defending those charged with abusing children, but it was surprising that in one of his articles, he asked biased professional witnesses to co-author the paper with him, supposedly responding to the first paper by Dr. Sandeep Narang, which will be discussed below. One of those co-authors has recently been under great pressure in the United Kingdom for providing expert testimony outside her field of expertise which is biased and without underlying scientific support. While some biased legal authors will always try to provide support for those who defend people accused of crime, the fact that these claims were at the heart of widespread false media coverage caused significant concern, especially since the message sent to child caregivers was that “shaking a baby isn’t dangerous”.

Given this backdrop, several authors who actually are experts in the field of child maltreatment have accurately characterize the “debate” over the shaken baby syndrome or abusive head trauma as a “legal” debate, not a serious scientific debate. Within the relevant scientific field of those who regularly diagnose the cause of infant and toddler injuries, the validity of the diagnoses is not questioned and the alternative theories offered by the child abuse denialists are not accepted as valid. In the article Child abuse: we have problems, J. Pediatr Radiol (2016) published online DOI 10.1007/s00247-016-3551-9, Dr. Peter Strouse makes a persuasive case that child abuse denialism “has at its base a very small number of physicians who perpetuate false science while ignoring the bulk of the scientific literature and the experience of the overwhelming majority. . .The names are familiar, they reference one another in the literature and they show up in court, often together and all too frequently…The denialists create the appearance of scientific and medical controversy when, in almost all cases, there is none. Rather than providing clarification, the denialists’ tactics are to confuse judges and jurors, to bias the news media and to mislead the public.” In Understanding Abusive Head Trauma in Infants and Children: Answers from America’s Pediatricians, 2015 – Child Abuse Pediatrician Dr. Cindy Christian clarifies the position of the American Academy of Pediatrics that both shaken baby syndrome and abusive head trauma are well-accepted legitimate diagnoses. “There is no legitimate medical debate amount the majority of practicing physicians as to the existence or validity of AHT/SBS. The only real debate and controversy appear to be in the legal system and the media.” While some have offered alternative hypotheses in the courtroom, “the evidence for these hypotheses is lacking.” Dr. Christian concludes by refuting the validity of many of the courtroom claims of the child abuse denialists and pointing out there are well over 1000 articles in the peer-reviewed clinical literature supporting the diagnoses of SBS/AHT.

Dr. Christopher Greeley in the article Abusive head trauma: a review of the evidence base, AJR 2015; 204:967-973, persuasively summarizes the evidence-base supporting the diagnoses of shaken baby syndrome and abusive head trauma as accepted among a wide range of medical disciplines. After explaining the history of the diagnoses, he makes clear that “although each of the clinical findings has a meaningful association with AHT, it is in combination that dramatic correlations emerge”, to refute the courtroom claims of the denialist witnesses that individual clinical findings can be caused by a wide variety of things. He then concludes: “A diverse, complicated, international, transdisciplinary, and voluminous evidence base characterizes AHT. When this expansive evidence base is pieced together and taken in toto, AHT can be readily differentiated from alternative explanations of a child’s injuries. The debate surrounding AHT is neither scientific nor medical, but legal.” Id. at 971 (emphasis added). Dr. Greeley further says: “As in the antivaccine effort, many skeptics of AHT misrepresent or simply misunderstand the breadth of the published medical evidence and introduce this into courtrooms as so-called new science,” although it is neither new nor science-based.

One of the best explanations of the lack of a real controversy about the diagnoses of SBS or AHT in the field of medicine is contained in Moreno, J and Holmgren B, Dissent into confusion: The Supreme Court, denialism, and the false ‘scientific’ controversy over shaken baby syndrome, 2013 Utah L. Rev. 153-217. The authors compare the alleged controversy about the validity of the medical diagnosis of SBS with challenges to the existence of global warming and claims that childhood vaccines cause autism, saying “…false scientific controversies have been fabricated and are a form of denialism – the rejection of scientifically sound information in favor or purported ‘truth’ claims that cannot be empirically supported.” Id. at p. 153-154. They then turn to the group of a small partisan group of law professors and law students who have challenged the diagnostic validity of AHT/SBS, concluding that such individuals have “advanced their own specious claims of ‘scientific controversy’,” citing the articles by Tuerkheimer, Findley, Burg and Lyons, all of which ignore the hundreds of peer-reviewed articles supporting the diagnoses and focus solely on the cherry-picked few that support their premise. P. 158. “Despite all the ballyhoo, there has been no paradigm shift in the scientific support for the diagnosis of AHT/SBS. The empirical evidence includes a continuous growing body of evidence-based, peer reviewed medical literature with 40 years of contributions by pediatricians, neuroradiologists, clinical and forensic pathologists, ophthalmologists, and physiologists clearly supporting the construct of a medical diagnosis of AHT.” p. 160. The authors then point out that the false controversy has real-world implications by suggesting without scientific basis that shaking of young children is not injurious, undoing decades of prevention efforts. []

Many other medico-legal articles have thoroughly refuted the claims of the agenda-driven child abuse denialists as well as the legal articles often featured in media reports alleging the demise of the shaken baby syndrome or the abusive head trauma medical diagnosis. Most significant among these is the two-part series whose primary author is Dr. Sandeep Narang. In part one, A Daubert analysis of abusive head trauma/shaken baby syndrome, Houston Journal of Health Law and Policy 2011: 11:505-633, Dr. Narang thoroughly explains the evidence base for the diagnoses of both SBS and AHT and then dissects and refutes the claims of the child abuse denialist expert witnesses and the articles upon which their testimony is based as well as the flawed claims of Professor Tuerkheimer and other legal writers. Dr. Narang summarizes: “Much of what we currently know about AHT is the result of decades of meticulous, tireless work by physicians from various disciplines from all over the world.” Id. 523.

Just one example of Dr. Narang’s expose of the flaws of the child abuse denialists is summarized here. The professional witnesses addressed herein almost universally rely on the article by Mark Donohoe, an environmental physician in Australia, who purportedly showed that the “shaken baby syndrome” diagnosis was not evidence-based. Donohoe, M., Evidence-based medicine and shaken baby syndrome, Part 1: Literature review 1966-1998, Am J Forensic Med Pathol, 2003, 24: 239-242. Dr. Narang and many other authors have pointed out the deep flaws in Donohoe’s article, illustrating the irony of his critique of the evidence-base for the SBS/AHT diagnosis while Donohoe’s own article is poorly constructed and without any scientific validity. Dr. Narang begins by saying this article “is a prime example of poor medical literature, which somehow makes its way into a medical publication. Ironically, the article itself suffers from fatal methodological flaws and data gaps, but professes to assess the methodology of SBS studies and finds data gaps in them.” P. 534. He then points to the following flaws of Donohoe’s article: (1) limits his “review” to articles from 1966 to 1998, before the hypothesis of SBS was advanced in the early 1970’s; (2) searched using only one search engine and solely for the confining term “shaken baby syndrome”, which resulted in only 55 articles Donohoe reviewed even though at the time there were well over 700 articles in the peer-reviewed medical literature; (3) missed the vast majority of the medical literature, including the seminal articles by Dr. Guthkelch and Dr. Caffey; (4) incorrectly uses the evidence rating system and assumes that randomized control trials could be conducted on living human infants; (5) offers no critical analysis of the articles cited, and even admits he didn’t even read some of the articles to which he refers. Dr. Narang concludes: “It is troubling that legal scholars and some courts have relied upon this article as an adequate assessment of the medical literature surrounding AHT. Any future reliance upon his article should be seriously questioned.” P. 535 (emphasis added). Yet the briefs and memoranda filed by defense and parents’ attorneys, Innocence Project lawyers, and the ACLU challenging the diagnoses of SBS/AHT continue to cite Donohoe as a major part of their contentions and the group of child abuse denialist professional witnesses continue to cite the article without admitting its fatal methodological flaws.

In A Daubert Analysis of Shaken Baby Syndrome/Abusive Head Trauma – Part II: An examination of the differential diagnosis, 13 Hous J Health L and Policy, 203-313, Dr. Narang and multiple co-authors provide a complete analysis of how those who actually diagnose the cause of childhood head injuries apply the differential diagnosis and the evidence-base upon which those diagnostic decisions are based. After focusing on the methodology used, the authors shift to discussing several of the primary “alternative explanations” which the child abuse denialists and legal writers who absorbed and repeated their claims often use in the courtroom along with the averment that the alternative explanation can be indistinguishable from abusive head trauma. The alternative explanations confronted and persuasively explained away include (1)claims that short falls caused the same collection of injuries as seen in AHT; (2)claims that bleeding disorders explain the AHT findings; (3) claims related to biomechanics literature that thresholds for SDH in adult primates can be scaled down to apply to human infants and toddlers, that neck injury must precede serious head injury (Bandak), and that Dr. Duhaime’s 1987 article proved that shaking a human infant or toddler can’t cause injury; (4)assertions that anything that causes hypoxia to the brain can also result in the findings associated with AHT (Geddes’ unified hypothesis and Barnes’ dysphagic choking claim). The authors also persuasively refute the claims of legal writers such as Deborah Tuerkheimer and Keith Findley – “some legal scholars have fallaciously confounded standards for diagnostic sufficiency with standards for criminal conviction sufficiency”, Id. 291. The article concludes with a well-supported Daubert analysis of the underlying science behind the diagnoses of SBS and AHT and a summary of the actual diagnostic process followed by those who actually diagnose the cause of childhood head injuries. “Ultimately, the differential diagnosis methodology is a marriage of evidence-based literature and experience; a symbiosis of inferential and deductive reasoning; a synergy of linear and non-linear dynamic thought.” Id. 321.

The naysayers and their unscientific courtroom-only claims have been involved in court proceedings since the early 1980’s, with nothing offered to scientifically prove their alternative theories for the collection of injuries which make up part of the diagnosis of SBS or AHT through actual research. Instead, their claims are based on polemic articles decrying the lack of proof for the shaken baby syndrome, mis-citing other medical literature or relying on articles which have been thoroughly refuted, or just plain deceiving others about the basis of their fringe claims. Despite media and other articles claiming “new scientific developments” in the field, that claim is false and without any empirical support. With very few exceptions, the courtroom testimony of these professional witnesses continues to involve the same themes, claims and focus as was used by this same group of courtroom physicians since the 1980’s. Many of the articles they have published proceed with false assumptions about how actual diagnosticians go about diagnosing the cause and timing of childhood injuries, invoke a “straw man” version of the diagnoses of shaken baby syndrome or abusive head trauma, claim that diagnosticians engage in a “rush to judgment” based on a “triad” of findings, and proceed to refute the straw man version of the diagnoses even though it has no place in the real world of child abuse diagnosis. Along the way, these professional witnesses engage in a plethora of logical fallacies which appear to be intended to confuse judges and juries.

What attorneys, judges, jurors, and everyone else associated with the various justice systems need to know is that both the diagnoses of shaken baby syndrome and abusive head trauma are based on well over 1000 plus articles in the peer-reviewed literature; are applied based upon the collective experience of well-trained and very experienced pediatricians, child abuse pediatricians, and specialists who actually diagnose the cause of child injuries on a regular basis; and are almost universally accepted as valid diagnoses among those who are part of that “relevant scientific field.” Over forty years of scientific research and refinement of the original hypotheses advanced by Dr. John Caffey and Dr. Norman Guthkelch have yielded one of the strongest and most evidence-based diagnoses available in medicine. The application of that diagnosis is never based solely on any magic “triad” of injuries, but upon careful and conscientious consideration of the differential diagnosis which might account for a child’s entire collection of injuries in the context in which those injuries occurred. Each presentation is different and diagnosticians in the real world know this from long experience with both inflicted injuries and accidental injuries in young children. If there is any concern about “junk science” being allowed into the courtroom in these cases, it is not about the underlying basis for the opinions of those who diagnose childhood injuries. There has been no “shift in mainstream opinion” relating to the validity or general acceptance of these diagnoses and the few courts which have been deceived by the false claims of a few do not add weight to the naysayer’s contentions. Courtrooms make lousy arbiters of the ultimate validity of medical science and diagnoses. As Dr. Sandra Hassink, then President of the American Academy of Pediatrics said in the comment Courtrooms shouldn’t decide science, “It’s inaccurate to state, as this article does, that Shaken Baby Syndrome is an unproven theory. Medical opinion on this has not shifted. What is shifting are the arguments used in the courtroom by attorneys and witnesses hired by the defense. We believe in a vigorous defense of those accused of a crime, but the courtroom is not an ideal venue to arbitrate science.” www.chicagotribune.com/news/opinion/letters/chi-courtrooms-shouldn’t-decide-science-20150414-story.html. Few would seek a judge’s ‘second opinion’ when their physician recommends any particular medical procedure or diagnosis, and even fewer would seek a binding decision by a panel of eight or twelve members of the lay public who are chosen because they don’t have prior information about the subject matter of the litigation. More fundamentally, legal decisions have virtually nothing to do with the underlying appropriateness of any particular medical diagnosis applied to the victim in that case. So, diametrically contrary to the claims of Professor Tuerkheimer, a prosecutor’s decision not to file a case, a dismissal of a case, an appellate reversal of a conviction, or a successful motion for a new trial have absolutely nothing to do with the accuracy or medical soundness of the diagnoses of the cause of the victim’s injuries. This and similar obvious attempts to mislead should be soundly rejected by the thinking public, by juries and judges, and by appellate courts in this country. More importantly, it is vital that those who care for infants and children realize that shaking a child’s head in a violent, sustained way can and does cause severe brain injuries and in the worst cases, death. Sending any opposite message is socially irresponsible and deserves the highest condemnation.

RECOMMENDATIONS AND GOALS

1. Provide specialized multi-disciplinary training to all prosecutors and child protection attorneys who are tasked with handling a case involving AHT. Form statewide teams of experienced lawyers and investigators available to assist rural and other local law enforcement and child protection agencies to adequately understand and respond to AHT cases. Provide expert assistance through referrals to experienced professionals through the American Professional Society on the Abuse of Children (APSAC), the National District Attorneys’ Association and the Association of Prosecuting Attorneys.

2. Empower those who regularly diagnose the cause of childhood injuries with the tools necessary to confidently and accurately reach a diagnosis, understanding the evidence-base for the decision is based upon collective clinical experience in the field of child maltreatment, the medical literature, and the differential diagnosis which will differ in every case.

3. Provide assistance and training to front-line diagnosticians as to what to expect in their role in the courtroom, best methods to explain their opinions to juries and judges, and how to respond to unscientific claims of others allowed to testify as expert witnesses.

4. Work with judicial training organizations to make accurate training accessible to all judges who deal with child maltreatment cases, to assist judges in recognizing the difference between well-qualified physician witnesses who have a sound scientific basis for their conclusions and those who are agenda-driven, lack scientific support for their opinions, or who fit the category of “irresponsible expert witness.”

5. Encourage reform of the judicial systems in the United States to move toward using neutral and pre-qualified expert witnesses to educate judges and juries as to the medical science applicable to a case while moving away from the current litigation-driven pressure on some expert witnesses to assume the role of advocate in lieu of being a neutral scientist unmotivated by attempts to help the party retaining their expert testimony.

6. Encourage national associations to form consensus statements as to the diagnostic validity of both shaken baby syndrome and abusive head trauma and access the pubic media to get the truth before the general public, refuting previous false claims based on the assertions of agenda-driven witnesses.

7. Provide local prosecutors and child protection attorneys with the resources needed to respond to the “canned briefs” used by the ACLU, Innocence Projects, and defense and parents’ attorneys who challenge the science behind the shaken baby syndrome or abusive head trauma diagnoses and who challenge convictions years after the fact with false claims of “new science” or a non-existent “shift in mainstream medical opinion.”

8. Move toward mandating coordination between criminal justice professionals and child welfare professionals involved with the same family in the two different court systems to avoid different approaches and outcomes in the separate courts and to focus on the overall health of the children involved in each court system.

**References**

Adamsbaum, C., Grabar, S., Mejean, N., & Rey- Salmon, C. (2010). Abusive head trauma: Judicial admissions highlight violent and repetitive trauma. *Pediatrics*, *126*(3), 546-555. doi:10.1542/peds.2009-3647

American Academy of Pediatrics. Committee on child abuse and neglect. Shaken baby syndrome: rotational cranial injuries—technical report. Pediatrics. 2001;108:206–10.

Albert, D. M., Blanchard, J. W., & Knox, B. L. (2012). Ensuring appropriate expert testimony for cases involving the “shaken baby”. *Jama*, *308*(1), 39-40.

Altman, R. L., Canter, J., Patrick, P. A., Daley, N., Butt, N. K., & Brand, D. A. (2011). Parent education by maternity nurses and prevention of abusive head trauma. *Pediatrics*, *128*(5), e1164-e1174. doi:10.1542/peds.2010-3260

Agrawal, S., Peters, M. J., Adams, G. G., & Pierce, C. M. (2012). Prevalence of retinal hemorrhages in critically ill children. *Pediatrics*, peds-2011.

Bailhache, M., Bénard, A., & Salmi, L. (2016). Simulation of the impact of programs for prevention and screening of pediatric abusive head trauma. *Journal Of Neurotrauma*, *33*(14), 1397-1403. doi:10.1089/neu.2015.4014

Barr, R. G. (2012). Preventing abusive head trauma resulting from a failure of normal interaction between infants and their caregivers. *PNAS Proceedings Of The National Academy Of Sciences Of The United States Of America*, *109*(Suppl 2), 17294-17301. doi:10.1073/pnas.1121267109

Barr, R. G., Barr, M., Fujiwara, T., Conway, J., Catherine, N., & Brant, R. (2009). Do educational materials change knowledge and behaviour about crying and shaken baby syndrome? A randomized controlled trial. *Canadian Medical Association Journal*, *180*(7), 727-733. doi:10.1503/cmaj.081419

Barr, R. G., Trent, R. B., & Cross, J. (2006). Age-related incidence curve of hospitalized shaken baby syndrome cases: convergent evidence for crying as a trigger to shaking. *Child abuse & neglect*, *30*(1), 7-16.

Barnes PD, Galaznik J, Gardner H, Shuman M (2010) Infant acute life-threatening event--dysphagic choking versus nonaccidental injury. Semin Pediatr Neurol 17:7-11.

Biron, D., & Shelton, D. (2005). Perpetrator accounts in infant abusive head trauma brought about by a shaking event. *Child Abuse & Neglect*, *29*(12), 1347-1358. doi:10.1016/j.chiabu.2005.05.003

Bechtel, K., Stoessel, K., Leventhal, J. M., Ogle, E., Teague, B., Lavietes, S., & Duncan, C. (2004). Characteristics that distinguish accidental from abusive injury in hospitalized young children with head trauma. *Pediatrics*, *114*(1), 165-168.

Berger, R. P., Fromkin, J. B., Stutz, H., Makoroff, K., Scribano, P. V., Feldman, K., & ... Fabio, A. (2011). Abusive head trauma during a time of increased unemployment: A multicenter analysis. *Pediatrics*, *128*(4), 637-643. doi:10.1542/peds.2010-2185

Bhardwaj, G., Chowdhury, V., Jacobs, M. B., Moran, K. T., Martin, F. J., & Coroneo, M. T. (2010). A systematic review of the diagnostic accuracy of ocular signs in pediatric abusive head trauma. *Ophthalmology*, *117*(5), 983-992.

Byard, R. W. (2014). Shaken baby syndrome” and forensic pathology: an uneasy interface. *Forensic Sci Med Pathol*, *10*(239), e41.

Caffey, J. (1972). On the theory and practice of shaking infants: its potential residual effects of permanent brain damage and mental retardation. *American Journal of Diseases of Children*, *124*(2), 161-169.

Caffey J. (1972) The American journal of roentgenology, radium therapy, and nuclear medicine: The parent-infant traumatic stress syndrome; (Caffey-Kempe syndrome).

Case ME, Graham MA, Handy TC, Jentzen JM, Monteleone JA. Position paper on fatal abusive head injuries in infants and young children. Am J Forensic Med Pathol. 2001;22:112–22.

Christian, C. W., & Block, R. (2009). Abusive head trauma in infants and children. *Pediatrics*, *123*(5), 1409-1411. doi:10.1542/peds.2009-0408

Coats, B., Binenbaum, G., Peiffer, R. L., Forbes, B. J., & Margulies, S. S. (2010). Ocular hemorrhages in neonatal porcine eyes from single, rapid rotational events. *Investigative ophthalmology & visual science*, *51*(9), 4792-4797.

Cowley, L. E., Morris, C. B., Maguire, S. A., Farewell, D. M., & Kemp, A. M. (2015). Validation of a prediction tool for abusive head trauma. *Pediatrics*, *136*(2), 291-298.

Curcoy AI, Trenchs V, Morales M, et al (2010) Retinal hemorrhages and apparent life-threatening events. Pediatr Emerg Care 26:118-120.

Dias, M.S., Smith. K., deGuehery, K., Mazur, P., Li, V. & Schaffer, M.L. (2005). Preventing Abusive Head Trauma among infants and young children: A hospital based, parent education program. *Pediatrics, 115*(4), 470-477.

Dubowitz, H., Feigelman, S., Lane, W., & Kim, J. (2009). Pediatric primary care to help prevent child maltreatment: The Safe Environment for Every Kid (SEEK) Model. *Pediatrics*, *123*(3), 858-864. doi:10.1542/peds.2008-1376

Dubowitz, H. (2014). The Safe Environment for Every Kid (SEEK) model: Helping promote children's health, development, and safety: Seek offers a practical model for enhancing pediatric primary care. *Child Abuse & Neglect*, *38*(11), 1725-1733. doi:10.1016/j.chiabu.2014.07.011

Esernio-Jenssen, D., Tai, J., & Kodsi, S. (2011). Abusive head trauma in children: A comparison of male and female perpetrators. *Pediatrics*, *127*(4), 649-657. doi:10.1542/peds.2010-1770

Findley, K., & Barnes, P. (2012). MD, David Moran & Carrie Sperling, Oklahoma City University Law Review Summer 2012 Symposium Examining Shaken Baby Syndrome Convictions In Light Of New Medical Scientific Research. *Okla. City UL Rev.*, *37*, 219-223.

Fujiwara, T., Yamada, F., Okuyama, M., Kamimaki, I., Shikoro, N., & Barr, R. G. (2012). Effectiveness of educational materials designed to change knowledge and behavior about crying and shaken baby syndrome: A replication of a randomized controlled trial in Japan. *Child Abuse & Neglect*, *36*(9), 613-620. doi:10.1016/j.chiabu.2012.07.003

Gabaeff, S. C. (2016). Exploring the controversy in child abuse pediatrics and false accusations of abuse. *Legal Medicine*, *18*, 90-97.

Geddes, J. F., & Plunkett, J. (2004). The evidence base for shaken baby syndrome: Authors' reply. *BMJ: British Medical Journal*, *328*(7451), 1317.

Geddes, J. F., Tasker, R. C., Hackshaw, A. K., Nickols, C. D., Adams, G. G. W., Whitwell, H. L., & Scheimberg, I. (2003). Dural haemorrhage in non‐traumatic infant deaths: does it explain the bleeding in ‘shaken baby syndrome’?. *Neuropathology and applied neurobiology*, *29*(1), 14-22.

Geddes, J. F., Whitwell, H. L., & Graham, D. I. (2000). Traumatic axonal injury: practical issues for diagnosis in medicolegal cases. *Neuropathology and applied neurobiology*, *26*(2), 105-116.

Gennarelli, T. A., Thibault, L. E., Adams, J. H., Graham, D. I., Thompson, C. J., & Marcincin, R. P. (1982). Diffuse axonal injury and traumatic coma in the primate. *Annals of neurology*, *12*(6), 564-574.

Henneberg, M. L. (2015). Admissibility frameworks and scientific evidence: controversies in relation to shaken baby syndrome/abusive head trauma. *Brit. J. Am. Legal Stud.*, *4*, 555.

Holbourn, A. H. S. (1943). Mechanics of head injuries. *The Lancet*, *242*(6267), 438-441.

Hymel, K. P., Herman, B. E., Narang, S. K., Graf, J. M., Frazier, T. N., Stoiko, M., & ... Wang, M. (2015). Potential impact of a validated screening tool for pediatric abusive head trauma. *The Journal Of Pediatrics*, *167*(6), 1375-1381. doi:10.1016/j.jpeds.2015.09.018

Imagawa, K. K., Hamilton, A., Ceschin, R., Tokar, E., Pham, P., Bluml, S., & ... Panigrahy, A. (2014). Characterization of microstructural injury: A novel approach in infant abusive head trauma—Initial experience. *Journal Of Neurotrauma*, *31*(19), 1632-1638. doi:10.1089/neu.2013.3228

Jenny, C. (2014). Alternate theories of causation in abusive head trauma: what the science tells us. *Pediatric radiology*, *44*(4), 543-547.

Jenny, C. (2007). The intimidation of British pediatricians. *Pediatrics*, *119*(4), 797-799.

Jenny, C., Hymel, K. P., Ritzen, A., Reinert, S. E., & Hay, T. C. (1999). Analysis of missed cases of abusive head trauma. *Jama*, *281*(7), 621-626.

Kelly, P., Thompson, J. M., Koh, J., Ameratunga, S., Jelleyman, T., Percival, T. M., & Mitchell, E. A. (2017). Perinatal risk and protective factors for pediatric abusive head trauma: a multicenter case-control study. *The Journal of Pediatrics*.

Kelly, P., Wilson, K., Mowjood, A., Freidman, J., Reed, P. (2016). Trialling a shaken baby syndrome prevention program in the Auckland District Health Board. *NZMJ, 129(*1430), 39-50.

Keenan, H. T., Runyan, D. K., Marshall, S. W., Nocera, M. A., Merten, D. F., & Sinal, S. H. (2003). A population-based study of inflicted traumatic brain injury in young children. *Jama*, *290*(5), 621-626.

Kimbrough-Melton, R. J., & Melton, G. B. (2015). 'Someone will notice, and someone will care': How to build Strong Communities for Children. *Child Abuse & Neglect*, *41*67-78. doi:10.1016/j.chiabu.2015.02.015

Krous, H. F., & Byard, R. W. (2005). Controversies in pediatric forensic pathology. *Forensic science, medicine, and pathology*, *1*(1), 9-18.

Lazoritz, S., & Palusci, V. J. (2001). *The Shaken Baby Syndrome: A multidisciplinary approach*. Binghamton, NY, US: Haworth Maltreatment and Trauma Press/The Haworth Press.

Letson, M. M., Cooper, J. N., Deans, K. J., Scribano, P. V., Makoroff, K. L., Feldman, K. W., & Berger, R. P. (2016). Prior opportunities to identify abuse in children with abusive head trauma. *Child Abuse & Neglect*, *60*36-45. doi:10.1016/j.chiabu.2016.09.001

Levin, A. V., Luyet, F. M., & Knox, B. L. (2016). Ophthalmologic concerns in abusive head trauma. *Journal Of Family Violence*, *31*(7), 797-804. doi:10.1007/s10896-016-9840-0

Lind, K., Toure, H., Brugel, D., Meyer, P., Laurent-Vannier, A., & Chevignard, M. (2016). Extended follow-up of neurological, cognitive, behavioral and academic outcomes after severe abusive head trauma. *Child Abuse & Neglect*, *51*358-367. doi:10.1016/j.chiabu.2015.08.001

Maguire, S. A., Watts, P. O., Shaw, A. D., Holden, S., Taylor, R. H., Watkins, W. J., & Kemp, A. M. (2013). Retinal haemorrhages and related findings in abusive and non-abusive head trauma: a systematic review. *Eye*, *27*(1), 28.

Maguire, S. A., Watts, P. O., Shaw, A. D., Holden, S., Taylor, R. H., Watkins, W. J., ... & Kemp, A. M. (2013). Retinal haemorrhages and related findings in abusive and non-abusive head trauma: a systematic review. *Eye*, *27*(1), 28.

McDonell, J. R., Ben-Arieh, A., & Melton, G. B. (2015). Strong Communities for Children: Results of a multi-year community-based initiative to protect children from harm. Child Abuse & Neglect, 4179-96. doi:10.1016/j.chiabu.2014.11.016

Miller, T. R., Steinbeigle, R., Lawrence, B. A., Peterson, C., Florence, C., Barr, M., & Barr, R. G. (2017). Lifetime cost of abusive head trauma at ages 0–4, usa. *Prevention Science*, doi:10.1007/s11121-017-0815-z

Minns, R. A., & Busuttil, A. (2004). Patterns of presentation of the shaken baby syndrome: four types of inflicted brain injury predominate. *BMJ: British Medical Journal*, *328*(7442), 766.

Moreno, J. A., & Holmgren, B. (2013). The Supreme Court Screws up the Science: There Is No Abusive Head Trauma/Shaken Baby Syndrome Scientific Controversy. *Utah L. Rev.*, 1357.

Morrill, A. C., McElaney, L., Peixotto, B., VanVleet, M., & Sege, R. (2015). Evaluation of all babies cry, a second generation universal abusive head trauma prevention program. *Journal Of Community Psychology*, *43*(3), 296-314. doi:10.1002/jcop.21679

Narang, S., & Clarke, J. (2014). Abusive head trauma: Past, present, and future. *Journal Of Child Neurology*, *29*(12), 1747-1756. doi:10.1177/0883073814549995

Niederkrotenthaler, T., Xu, L., Parks, S. E., & Sugerman, D. E. (2013). Descriptive factors of abusive head trauma in young children—United States, 2000–2009. *Child abuse & neglect*, *37*(7), 446-455.

Ommaya, A. K., Faas, F., & Yarnell, P. (1968). Whiplash injury and brain damage: an experimental study. *Jama*, *204*(4), 285-289.

Peterson, C., Xu, L., Florence, C., & Parks, S. E. (2015). Annual cost of U.S. hospital visits for pediatric abusive head trauma. *Child Maltreatment*, *20*(3), 162-169. doi:10.1177/1077559515583549

Piteau, S. J., Ward, M. K., Barrowman, N. J., & Plint, A. C. (2012). Clinical and radiographic characteristics associated with abusive and nonabusive head trauma: A systematic review. *Pediatrics*, *130*(2), 315-323. doi:10.1542/peds.2011-1545

Rao P, Carty H, Pierce A (1999) The acute reversal sign: comparison of medical and non-accidental injury patients. Clin Radiol 54:495-501.

Reece, R.M. & Nicholson, C.E. (2003) Eds. Inflicted Childhood Neurotrauma.

Reese, L. S., Heiden, E. O., Kim, K. Q., & Yang, J. (2014). Evaluation of period of PURPLE Crying, an abusive head trauma prevention program. *Journal Of Obstetric, Gynecologic, & Neonatal Nursing: Clinical Scholarship For The Care Of Women, Childbearing Families, & Newborns*, *43*(6), 752-761. doi:10.1111/1552-6909.12495

Ricci, L., Giantris, A., Merriam, P., Hodge, S., & Doyle, T. (2003). Abusive head trauma in Maine infants: Medical, child protective, and law enforcement analysis. *Child Abuse & Neglect*, *27*(3), 271-283. doi:10.1016/S0145-2134(03)00006-1

Scribano, P. V., Makoroff, K. L., Feldman, K. W., & Berger, R. P. (2013). Association of perpetrator relationship to abusive head trauma clinical outcomes. *Child Abuse & Neglect*, *37*(10), 771-777. doi:10.1016/j.chiabu.2013.04.011

Shanahan, M., Fleming, P., Nocera, M., Sullivan, K., Murphy, R., & Zolotor, A. (2014). Process evaluation of a statewide abusive head trauma prevention program. *Evaluation And Program Planning*, *47*18-25. doi:10.1016/j.evalprogplan.2014.07.002

Sheets, L. K., Leach, M. E., Koszewski, I. J., Lessmeier, A. M., Nugent, M., & Simpson, P. (2013). Sentinel injuries in infants evaluated for child physical abuse. *Pediatrics*, *131*(4), 701-707. doi:10.1542/peds.2012-2780

Shein, S. L., Bell, M. J., Kochanek, P. M., Tyler-Kabara, E. C., Wisniewski, S. R., Feldman, K., & Berger, R. P. (2012). Risk factors for mortality in children with abusive head trauma. *The Journal Of Pediatrics*, *161*(4), 716-722. doi:10.1016/j.jpeds.2012.03.046

Simonnet, H., Laurent-Vannier, A., Yuan, W., Hully, M., Valimahomed, S., Bourennane, M., & Chevignard, M. (2014). Parents’ behavior in response to infant crying: Abusive head trauma education. *Child Abuse & Neglect*, *38*(12), 1914-1922. doi:10.1016/j.chiabu.2014.06.002

Slovis, T. L., Strouse, P. J., Coley, B. D., & Rigsby, C. K. (2012). The creation of non-disease: an assault on the diagnosis of child abuse. *Pediatric radiology*, 1-3.

Spivack, B. S. (2001). Biomechanics of abusive head trauma. *Journal Of Aggression, Maltreatment & Trauma*, *5*(1), 55-78. doi:10.1300/J146v05n01\_05

Taşar, M. A., Bilge, Y. D., Şahin, F., Çamurdan, A., Beyazova, U., Polat, S., & İlhan, M. N. (2015). Shaken baby syndrome prevention programme: A pilot study in turkey. *Child Abuse Review*, *24*(2), 120-128. doi:10.1002/car.2326

Tuerkheimer, D. (2009). The next innocence project: shaken baby syndrome and the criminal courts. *Wash. UL Rev.*, *87*, 1.

Tucker J, Choudhary AK, Piatt J (2016) Macrocephaly in infancy: benign enlargement of the subarachnoid spaces and subdural collections. J Neurosurg Pediatr 18:16-20.