



Preventing Abusive Head Trauma- What Research Can Tell Us

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Introduction

Abusive head trauma (AHT) consists of inflicted injuries to children with lesions in the brain, skull, and other parts of the body which result from blunt trauma or violent shaking. While it can affect children of all ages, it is most common under the age of 5 years. AHT is the most common cause of death from child abuse, and it is the most common cause of injury and death for children between 1 month and 1 year of age (Palusci et al., 2014; Raza et al., 2022). Mortality rates have been estimated at between 15% and 38%, and neurological morbidity for survivors is high (Keenan et al., 2004). The reported incidence of AHT, at 30 per 100,000 infants annually, is likely an underestimate (Parks et al., 2012; Kelly et al., 2017).

AHT can produce severe injuries, including intracranial hemorrhage, brain parenchymal damage, and retinal hemorrhages and injuries, and some children experience bruising, other internal injuries and bone fractures (Choudhary et al., 2018). Children who survive AHT often have significant physical disabilities, neurological impairments, and subsequent behavior problems.

In previous work on this topic, we completed a scoping review of empirical studies that had been published between 2000 and 2019 (Roygardner et al., 2021). Since then, a number of articles have been published, including a section of a special issue of *Child Abuse Review* (Otterman & Palusci, 2020). In this updated article, we provide an overview and synthesis of this additional body of available research. To identify relevant studies, we searched PubMed and Psychinfo for the years 2000–2022 using the terms “shaken baby syndrome” AND “prevention”; “abusive head trauma” AND “prevention”; and “abuse” AND “head” AND “trauma” AND “prevention.” We excluded non-empirical articles, duplications, and articles that did not pertain to prevention. We subsequently identified three key topics for exploration: (1) strategies to teach parents how to respond to a crying infant and the dangers of shaking babies, (2) strategies to educate professionals and to promote more effective direct practice in preventing and responding to AHT, and (3) social and community factors that can enhance AHT prevention.

Strategies to Teach Parents How to Respond to Crying Infants and the Dangers of Shaking Babies

The largest number of studies about AHT prevention were related to parent education strategies. Some of these programs were effective in changing parents' responses to crying infants, but the strategies had mixed results in their capacity to actually reduce the incidence of AHT.

The studies related to parent education can be divided into four groups. The first group examined parents' use of shaking and their knowledge about its potential consequences. The second described components of a prevention program called the Period of PURPLE Crying® (PoPC) (Barr, Barr, Fujiwara et al., 2009; Barr et al., 2015, Barr et al., 2018; Fujiwara et al., 2012; 2015; Ornstein et al., 2016; Stolz et al., 2017; Zolotor et al., 2015). The third group of studies examined programs to educate parents immediately after giving birth while still in the hospital (Altman et al., 2011; Bravo, 2014; Dias et al., 2005, 2017; Duzinski et al., 2018; Keenan & Leventhal, 2010; Kelly et al., 2016; Palusci et al., 2006; Trossman, 2016). The fourth group included assessments of a variety of other parent education programs (Bechtel et al., 2011; Coster, 2017; Deyo et al., 2008; Eismann et al., 2019; Lopes et al., 2018; Morrill et al., 2015; Rabbitt et al., 2018; Russell et al., 2008; Simonnet et al., 2014; Taşar et al., 2015).

Parental Knowledge

Results of studies of parents' knowledge about AHT and its associated dangers were mixed. Some parents reported not being at all aware of AHT. A majority of parents who knew about AHT reported that they had heard about it in the media. Berthold et al. (2019) found that women had a higher knowledge of AHT than did men (67.9% compared with 48.8%) and that being female gender, having children, being older, and having higher levels of education were predictors for being more aware of AHT. These authors concluded that awareness of AHT differs significantly within the general population and that men, young caregivers, and persons with less formal education were at higher risk of



perpetuating AHT and should be targeted for tailored education programs to increase their understanding of AHT and the risks of shaking their infants.

A study in China by Gao et al. (2021) found that 42.6% of the surveyed parents reported having heard of AHT, but only 17.1% reported knowing about the dangers of infant shaking. About 45% indicated they had shaken their infants at least once. In another study by Simonnet et al. (2014), 27% of mothers and 36% of fathers had never heard of AHT, and a brief presentation by medical staff was found to be useful in increasing their knowledge. Altman et al. (2011) evaluated the effectiveness of a leaflet on AHT accompanied by an 8-minute video on the topic. Pre-post analysis indicated there was a 75% reduction in child injuries from AHT in the years after the training program had been introduced. Some of these programs have also been evaluated internationally. Programs developed in the United States have used international replication studies for empirical cross-cultural validation. For example, a study in Turkey used an educational film to prevent AHT. Outcomes suggested that the average levels of parent knowledge increased over time, with the most effective period of

learning occurring prior to the child's birth and between 3 and 7 days after birth (Taşar et al., 2015).

Period of PURPLE Crying

Infant crying is widely seen as a primary trigger for AHT (Wiley et al., 2020). Even though long periods of crying are typical for newborns, parents may lack the knowledge, the relationship skills, or the impulse control to manage prolonged crying, particularly when attempts to soothe the infant don't work. Barr and colleagues recommended strategies aimed at educating parents about normal infant development and how to respond appropriately to crying and developed the Period of PURPLE Crying (PoPC) intervention (Barr, Barr, Fujiwara et al., 2009; Barr, Rivara, Barr et al., 2009; Fujiwara et al., 2012). Each of the letters in PURPLE represents one aspect of the type of crying found most frustrating by caregivers. P stands for peak; U for unexpected; R for resistance; P for a pain-like look; L for long bouts of crying; and E for evening. Barr and colleagues (2018) subsequently tested PoPC in both small groups and larger populations and assessed both the development and implementation of the program, measured parental responses to the intervention, and compared rates of AHT after program implementation by comparing study participants to controls. They showed that mothers who had just given birth particularly found the program useful in learning about normal infant crying, soothing techniques, and coping strategies.

The PoPC program has been widely researched using both observational studies and prospective randomized controlled trials. One RCT with a sample of 1,279 mothers showed statistically significant levels of improvement in their knowledge of AHT and in self-reports of walking away from an inconsolable crying infant. A cross-cultural replication study in Japan also showed increased knowledge scores and self-reported walking away behavior by parents, both of which were significantly higher in the intervention group (Fujiwara et al., 2012). Barr et al. (2015) found education about crying in normal infants was associated with a reduction in pediatric emergency room visits for crying complaints. In North Carolina, two years after implementation of PoPC throughout the state, Zolotor et al. (2015) noted that telephone calls to a nurse advice line for help with crying infants had been reduced by 20% for parents of children younger than 3 months



(rate ratio, 0.80) and by 12% for parents of children 3–12 months (rate ratio, 0.88). However, the study found no statewide reduction in AHT rates. Groisberg et al. (2020) did find a statistically significant 75% reduction in injuries from 2.8 to 0.7 AHT injuries per year in the first year of a child's life when their parents had participated in PoPC. When Beaulieu et al. (2020) assessed the effectiveness of PoPC across economically disadvantaged populations, they concluded that additional targeted AHT prevention services were needed proportionate to the levels of neighborhood disadvantage, in addition to universal AHT programs.

Hospital-Based Programs

Dias et al. (2005) implemented and studied a hospital-based AHT prevention program designed specifically for parents of newborns. Nursing and medical staff provided parents with information about the dangers of infant shaking and educated them about alternative parenting strategies. Parents were also asked to sign a voluntary “commitment statement” affirming that they would never shake their child. Parents were also asked to commit to eliciting the same promise from any others who were caring for their child. This study used a quasi-experimental, retrospective longitudinal design and demonstrated that the incidence of child maltreatment was reduced by 47% after the introduction of the prevention program. In 2006, Palusci et al. replicated the program with over 15,000 families in Michigan but found only a 25% reduction in hospital admissions for AHT.

Using a randomized controlled design, Lopes et al. (2018) evaluated the Dias program and found an increase in participants' knowledge about the unique



characteristics of infant crying and the consequences of shaking, as well as increases in caregiver well-being, caregiver strategies to deal with crying, and positive beliefs about infant care. Bravo (2014) found that the Dias program produced increases in knowledge about AHT and the types of injuries it could cause, as well as ways to prevent it. Coster (2017) used a quasi-experimental evaluation design to measure outcomes after parents viewed a film about AHT. Parents who had viewed the film were significantly more likely to use a range of coping skills than were parents in a comparison group who had not seen the film. Sampei et al. (2021) had similar results in Japan. Kelly et al. (2016) did an independent, cross-cultural replication study in New Zealand using a quasi-experimental design on a sample of 2,592 caregivers. Their results showed that 85% of respondents remembered at least one key message from the intervention and that 92% had made a plan about what they would do when feeling frustrated by their crying infant. Interestingly, the results were statistically significant even without the commitment statements that were hypothesized in the original study to be a key determinant of program success. Dias and colleagues (2017, 2021) later reported that two large statewide replication trials on their intervention had failed to demonstrate any impact on AHT rates. They suggested that consistent and repetitive messages for parents over the period of greatest risk for AHT might be another direction for intervention and research.

Other Parent Education Programs

Another group of studies evaluated different AHT prevention programs, many of which contained elements derived from programs by Dias and Barr. Each of these

studies (ABC, Calm Baby Gently, Love Me Never Shake Me, Take 5) was observational, often with pre-test/post-test comparisons or quasi-experimental designs, and showed improvements in parental knowledge or behavior. Some of these were evaluated in an international context. Altman et al. (2011) evaluated the use of written materials about AHT, a video, and education provided by nurses during a mother’s hospital stay immediately after the infant’s birth. Early reports found that the program was well accepted by parents and staff, showed a significant reduction in AHT, and identified increases in parent knowledge and coping skills. However, the reductions in AHT could not be fully replicated when tested using different research designs or when comparing larger populations to control groups.

Bechtel et al. (2020) found that infants whose caregivers received Take 5 were 79% less likely to have suffered AHT. Morrill et al. (2015) implemented and evaluated a media-based program called All Babies Cry, which focused on soothing infants and reducing parents’ stress. Results indicated that after 17 weeks, the intervention group used a wider variety of coping skills than did the control group. The parents also reported using the stress reduction strategies taught in the program. Deyo et al. (2008) evaluated the Love Me... Never Shake Me program and found that 98% of participants remembered the education they had received just after delivery, but 62% reported never receiving any follow-up education from their physicians. Most of the mothers (79%) practiced soothing techniques, but fewer (36%) practiced self-coping strategies or accessed community support services (9%). Eisenman et al. (2019) found that mothers participating in the Calm Baby Gently program were more confident and had more knowledge about how to respond appropriately when their infants were crying.



Home visiting has a large body of research supporting its effectiveness in reducing child abuse, and some studies point to its use in preventing AHT (Donelan-McCall et al., 2009). Fujiwara et al. (2020) concluded that their educational video on infant crying and on the dangers of shaking and smothering shown by midwives during home visits when newborns were 2 months old may reduce by half the likelihood of self-reported shaking and smothering of 4-month-old infants. A similar program implemented in Turkey, administered when infants were between 2 and 4 months of age, reported similar positive results (Kaya et al., 2022).

Since many follow-up studies have failed to show the same results as in earlier studies, Leventhal et al. (2017) speculated that perhaps the specific timing for delivering postpartum education may not have been ideal, or that the intervention may not have reached the most appropriate audience. They recommended providing multiple sources for these interventions, focusing on parents' feelings rather than infant behaviors, and combining them with programs that targeted whole populations or that specifically engaged all of an infants' caregivers, especially fathers and maternal boyfriends, since studies have shown greatly increased risk for AHT inflicted by unrelated male caregivers (Schnitzer et al., 2005).

Strategies to Improve Professional Education and Practice

Unfortunately, at times physicians fail to diagnose AHT, which can result in further serious injury to vulnerable children (Jenny et al., 1999). These authors explored risk factors associated with AHT and tried to determine how often AHT was missed in diagnosis. Their study reported that in 31% of AHT cases, there had been at least one earlier opportunity for a child to have been identified and diagnosed. Letson et al. (2016) assessed the number of times medical or child protective service staff might have identified a child with symptoms consistent with AHT, but did not. The authors found that in 31% of the cases, there had been a prior opportunity to identify the abuse (25% in the medical system, 6% in CPS). This was consistent in spite of differences in age, gender, race, or insurance status of the study participants. The most common missed warning signs included chronic subdural hemorrhage,



healing fracture in addition to vomiting, prior CPS contact and bruising (Letson et al., 2016). Missing sentinel injuries, defined as previous injuries that were suspicious of AHT, was also a concern. Sheets et al. (2013) found that 27.5% of 200 abused infants had previously had a sentinel injury, but none of the 101 non-abused infants in the sample did. The most common form of sentinel injury in the cohort of abused infants was bruising (80%). Others included intraoral injuries and fractures. Sentinel injuries tended to occur early in infancy, with 95% occurring before the age of 7 months (Sheets et al., 2013).

Studies of physician practice highlight several potentially promising ways to increase professional knowledge and competence in identifying and diagnosing AHT within medical settings. These strategies generally include education to improve practitioners' identification of families at increased risk for AHT and the treatment of infants after AHT has occurred. There were promising results for programs intended to increase professionals' awareness, case handling, and training using a variety of approaches. Bechtel et al. (2019) proposed using simulation-based research to teach physicians about AHT. Fraser et al. (2017), studying AHT prevention in Vietnam, found that the training of medical professionals improved their capacity to talk with parents about AHT prevention. Several additional studies also had positive results in training professionals in strategies to educate parents. Goulet et al. (2009) trained nurses on prevention and found that the program was highly relevant to parents, especially for new parents. Stewart et al. (2011) and Nocera et al. (2016) had similar findings. Unfortunately, none of the studies in this category measured the effects of



professional education on the subsequent incidence of Abusive Head Trauma.

Iqbal O'Meara et al. (2020) proposed that clinical prediction rules, biomarkers, and imaging modalities held promise in improving the identification of AHT, even though these tools have largely been developed and validated in children who have already sustained clinically-evident AHT (tertiary prevention). Based on the study of sentinel injuries, Pierce et al. (2021) refined and validated a previously developed clinical decision rule related to bruising – TEN-4 (bruising to torso, ear, neck, or any bruising on an infant < 5 months of age) to help identify children likely to have been physically abused who might subsequently experience more serious injury such as AHT.

Bailhache et al. (2016) raised some concern about these tools after identifying a potential outcome of parents being wrongfully accused of having abused their child. Still, their research indicated that after a 2-year period, the median number of deaths prevented by using the screening protocol ranged from 6 to 28 per 100,000 newborns. However, these authors concluded that the overall impact of the screening process was uncertain.

Some of these tools have been integrated into electronic medical records, and others are used separately. For instance, deep learning models can accurately distinguish child physical abuse from non-abuse with natural language processing NLP in the medical record (Shahi et al., 2021). This model could be developed to run in real-time to alert clinicians when certain criteria are met, which would then prompt them to consider the diagnosis. Clinical tools designed to help predict AHT can impact clinicians' estimates of the likelihood of AHT. Hymel, in

collaboration with several colleagues (2014, 2015, and 2022), developed and validated a clinical screening tool (PediBIRN-4) to help identify AHT. They determined that the AHT screening tool could improve AHT detection in the pediatric intensive care setting from 87% to 96% and could increase the overall diagnostic yield of completed evaluations from 49% to 56% while targeting fewer children for this evaluation. A preliminary analysis of its performance in pediatric emergency departments found that screening efficiency could be increased if the tool's fourth predictor variable was eliminated and a three-factor model was used instead. Another screening tool described by Cowley, Maguire, et al. (2018) and Cowley, Farewell, and Kemp (2018) named Predict AHT (PredAHT) also showed promise, with a sensitivity of 72.3% and a specificity of 85.7%. The tool was later validated (Pfeiffer et al., 2020). Berger et al. (2016) validated another tool, the Pittsburgh Infant Brain Injury protocol for abusive head trauma.

Social and Community Factors in AHT Prevention

Current research continues to support the conclusion that AHT has high costs for both child victims and for communities and is therefore worth preventing. One study demonstrated the per-patient medical cost of AHT in the United States to be between \$40,219 and \$55,685 over the course of four years post-diagnosis (Peterson et al., 2014). Several studies also highlighted the difference in financial cost of AHT prevention versus the cost of caring for or treating victims of AHT. One study by Beaulieu et al. (2019) analyzed AHT outcomes and expected costs per child victim both before and after the implementation of the Period of PURPLE Crying program. The authors determined that a cost of \$5.00 per child to implement PoPC resulted in a reduction in cost of \$273.52 per child from a societal perspective, and a reduction of \$14.49 per child from a health services perspective. Another study examined costs in a 5-year cohort of infants admitted to a hospital in New Zealand for AHT (Friedman et al., 2012). Study results demonstrated high lifetime costs for AHT patients, a strong economic argument for developing effective primary AHT prevention programs (Friedman et al., 2012).

Community-level interventions, such as community-wide information campaigns and targeted efforts to reach families with increased risk may be both useful and cost-effective in preventing AHT (Beaulieu et al., 2019; Berthold et al., 2019; Cala Cala et al., 2020; Friedman et al., 2012; Shanahan et al., 2014). In their study, Stewart et al. (2015) found that prevention messages placed on billboards were more effective when they were placed in communities with more new families, high-population density, and high percentages of single parents. They concluded that the use of ranked factors and geographic information systems, as well as targeting geographic locations with high visibility and specific risk factors for AHT, would increase the likelihood of reaching populations that most needed the information.

Studies have also documented a correlation between economic hardship in families and the incidence of AHT. Two studies have indicated that AHT rates appeared to rise during economic recession (Berger et al., 2011; Huang et al., 2011). Berger et al. (2011) found that the rate of AHT increased significantly in three distinct geographic regions during the 19 months of an economic recession when compared with the 47 months before the recession, suggesting that prevention efforts might need to be increased in situations of economic hardship. Others have studied the effect of providing families with material benefits, such as an earned income tax credit or paid family leave, and reported that both programs led to a reduction in the incidence of AHT (Klevens et al., 2016; Klevens et al., 2017). For example, California’s 2004 paid family leave program was associated with a significant decrease of hospital admissions for AHT in children aged less than 2 years old when compared with rates in seven states with no paid family leave (Klevens et al., 2016). According to Klevens et al. (2017), an earned income tax credit (EITC) that was refunded to the parents was associated with a decrease of 3.1 hospital admissions for AHT per 100,000 of population in children under 2 years old, after controlling for confounding variables. The amount of money ranged from \$108 to \$1014 and \$165 to \$1648 for a single parent, working full time at minimum wage, with one or two children, respectively.

Conclusions

During the past two decades, published research studies have evaluated several potential strategies to



reduce and prevent AHT. Primary prevention in AHT is most well developed in the areas of parent education and home visiting, but there has been wide variability in the efficacy of the studied programs. The fact that some studies report non-significant findings suggests a need to better identify the groups for whom such strategies can be most effective, as well as creating better means of reaching families with high risk. Additional research is needed to determine the best location and timing for AHT prevention activities to most effectively involve hard-to-reach families. Questions also remain regarding home visiting services for AHT prevention, on which populations services should be focused, and the degree to which these services have an impact on AHT.

When considering secondary and tertiary prevention, the early and accurate identification of AHT and effective child protection remain the mainstay of prevention. These strategies should include professional training to improve the identification and reporting of AHT as well as improving parent education. Although current research findings are promising, additional research is needed to determine whether parent training reduces the actual number of AHT cases. Prediction tools are also promising, as is their potential inclusion in electronic medical records, along with real-time notification of AHT risk.

Current evidence suggests there is a correlation between economic hardship and an increase in AHT rates, and economic benefit programs and education programs offered during recessions may help to counter this increase. A skeptical economist might point out that all programs, especially material benefit programs, cost money, but based on the research included in this review, it seems that money spent on

preventing AHT is well-spent when measured against the overall cost of AHT. Furthermore, a relatively small amount of monetary support, such as through earned income tax credits, can reduce AHT and save money.



Abusive Head Trauma prevention science has developed considerably over the past 20 years, but there is still far to go if we are to prevent abusive head trauma. Strategies with the most evidence and the most promise appear to be universal home-visiting of families with infants, information for all new parents, incorporation of screening tools into electronic medical records, and economic supports for all parents.

Photographers

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