STATE OF NEW JERSEY,

Plaintiff-Appellant,

v.

DARRYL NIEVES,

Defendant-Respondent.

SUPERIOR COURT OF NEW JERSEY
APPELLATE DIVISION
DOCKET NO. A-2069-21T4

CRIMINAL ACTION

On Appeal From Final Order of the
Superior Court of New Jersey,
Law Division, Middlesex County

Indictment No. 17-06-785

Sat Below:
Hon. Pedro J. Jimenez, Jr., J.S.C.

BRIEF OF PROPOSED *AMICI CURIAE* BIOMECHANICAL ENGINEERS LINDSAY "DUTCH" JOHNSON, PH.D., KEN MONSON, PH.D., AND KIRK THIBAULT, PH.D., D-IBFES

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PRELIMINARY STATEMENT

Abusive Head Trauma (AHT) by shaking, formerly known as Shaken Baby Syndrome (SBS), refers to the medical diagnosis that a child who suffers a specific "triad" of symptoms—subdural hematoma or hemorrhage (bleeding in the brain); retinal hemorrhage (bleeding in the eye); and encephalopathy (neurological impairment)—has been subject to abuse via intentional physical shaking. Shaking-only AHT refers to a diagnosis of child abuse based on these three symptoms alone, *without* evidence of physical impact, bruising, injury to the neck or spine, or other physical indications of abuse. This appeal asks the fundamental question whether the State clearly established the scientific reliability of shaking-only AHT—the unproven theory that formed the basis for its prosecution of Defendant Darryl Nieves.

The facts underlying this appeal demonstrate the enormous stakes. On February 10, 2017, Nieves's 11-month-old son, D.J., was rushed to the hospital after Nieves found him tightening his jaw and appearing unresponsive. At this point in his young life, D.J. had already suffered from several serious medical conditions, causing him to spend the first seven months of his life in the hospital.

D.J. did not have any neck injuries, fractures, bruising, or other signs of physical abuse. But tests revealed that D.J. had subdural and retinal hemorrhages. Based on these symptoms, child abuse pediatrician Dr. Gladibel

Medina diagnosed D.J. with AHT by shaking. Based on that diagnosis, Nieves was charged with second-degree aggravated assault and second-degree endangering the welfare of a child.

After the trial court heard extensive expert testimony during a five-day *Frye* hearing, at which the State chose to present only Dr. Medina's testimony, the court held that the State failed to clearly establish the reliability of the shaking-only AHT theory because there is no scientific evidence that confirms it validity. The State now appeals and asks this Court to reverse the reasoned judgment of the trial court and instead find that the State can offer its scientifically unverified shaking-only AHT theory.

Proposed *amici curiae* Lindsay "Dutch" Johnson, Ph.D., Ken Monson, Ph.D., and Kirk Thibault, Ph.D., D-IBFES (collectively, *Amici*)—who are experts in biomechanics and authorities on the scientific literature on the reliability of the AHT theory, and specifically shaking-only AHT—seek to provide the Court with information concerning four inter-related topics with the hope that it will assist the Court in considering this appeal. *First*, they offer a brief background on the field of biomechanics. The field studies the laws of mechanics as they relate to the structure, function, and motion of living biological systems—including the human body.

Second, *Amici* describe the way in which human injury biomechanics specifically studies the physical failure of the human body. Biomechanical engineers are, then, often tasked with using traditional engineering methodologies to conduct research on the mechanical link between a particular force on the human body and a resulting trauma. These rigorous analyses attempt to determine whether the forces that act on a person during a particular mechanical event are enough to produce certain injuries or trauma.

Third, *Amici* show how biomechanics is necessary to determine whether the foundational assumption upon which shaking-only AHT is built—that shaking a child unaccompanied by other physical trauma is capable of causing the triad of symptoms—is mechanically possible. Because biomechanics is necessary to determine the scientific validity of the shaking-only AHT theory, experts in biomechanics must be considered part of the relevant scientific community to determine whether the diagnosis has "gained general acceptance in the particular field in which it belongs." *State v. J.L.G.*, 234 N.J. 265, 280 (2018) (quoting *Frye v. United States*, 293 F. 1013, 1014 (D.C. Cir. 1923)).

And *fourth*, *Amici* summarize the evidence and scholarship showing how there is no reliable biomechanical evidence that the act of shaking an infant can, on its own, generate enough force to cause the triad of symptoms that often lead to an AHT diagnosis. Thus, it is generally accepted in the biomechanics

community that the mere presence of this so-called "triad" of symptoms fails to provide a reliable indicator of child abuse by shaking when there is no evidence of physical impact.

Based upon the science, as they know it, *Amici* respectfully urge this Court to affirm the trial court's order barring the State's proposed testimony concerning the unverified shaking-only AHT theory.

INTERESTS OF PROPOSED *AMICI CURIAE*

Amici are experienced biomechanical engineers[1] who wish to provide this Court with important information regarding the foundations of the field of biomechanics and particularly about how biomechanics is relevant to the theory of shaking-only AHT. *Amici* regularly provide expert testimony in federal and state courts throughout the country concerning biomechanical research, including the most recent biomechanical literature on AHT.

STATEMENT OF FACTS AND PROCEDURAL HISTORY

This case arises from an emergency room visit involving Defendant Darryl Nieves's 11-month-old son, D.J. Born severely premature birth at 25 weeks in March 2016, D.J. suffered from a number of serious health challenges that

[1] *Amici* attach their respective curricula vitae as Exhibits A, B, and C to *Amici*'s appendix. Exhibit D provides the biomechanical studies referenced in this brief.

required him to remain in the hospital for the first seven months of his life, including two cardiac surgeries within four months of his birth. (Pa3-4.)[2]

When he was 11-months old, over the span of a week in February 2017, D.J. suffered a series of three seizure-like episodes while Nieves cared for D.J. and his brother at the home they shared with D.J.'s mother. (Pa4-5.) During the third of these episodes, Nieves discovered D.J. tightening his jaw and appearing unresponsive. Nieves and D.J.'s mother called 911. (Pa5.)

Once at the hospital, D.J.'s symptoms resolved and medical staff performed a battery of tests that demonstrated D.J. had subdural and retinal hemorrhages. (Pa5-6.) D.J. did not, however, have any bruising, neck injuries, fractures, or other signs of physical impact. (4T164-13 to 165-2; 4T170-22 to 171-19.) Dr. Gladibel Medina, a child abuse pediatrician, diagnosed D.J. with AHT by shaking based on the D.J.'s subdural hemorrhages, retinal hemorrhages, and neurological issues. (*See* Pa6.) As a result, on June 30, 2017, Nieves was

[2] References to the record are made as follows: Pa – State's appendix; 1T – Transcript of motion, Nov. 2, 2018; 2T – Transcript of hearing, Jul. 11, 2019; 3T – Transcript of hearing, Aug. 12, 2019; 4T – Transcript of *Frye* hearing, Sept. 24, 2020; 5T – Transcript of *Frye* hearing, Sept. 29, 2020; 6T – Transcript of *Frye* hearing, Sept. 30, 2020; 7T – Transcript of *Frye* hearing, Oct. 13, 2020; 8T – Transcript of *Frye* hearing, Oct. 15, 2020; 9T – Transcript of decision, Jan. 7, 2020; and 10T – Transcript of hearing, Jan. 28, 2022.

charged with second-degree aggravated assault, N.J.S.A. 2C:12-1b(1), and second-degree endangering the welfare of a child, N.J.S.A. 2C:24-4a(2). (Pa1.)

Nieves moved for a *Frye*[3] hearing under New Jersey Rule of Evidence 104(a) to challenge the admissibility of the State's expert testimony concerning shaking-only AHT. (Pa7.) The trial court initially granted Nieves's motion, but later switched course and granted the State's motion for reconsideration. (Pa7.) Nieves appealed, and the Appellate Division remanded the matter to the trial court to hold a *Frye* hearing. (Pa79.) In the end, over the course of five days in the fall of 2020, the Honorable Pedro J. Jimenez, Jr., J.S.C., heard testimony from experts offered by the State and Nieves. (*See* 4T-8T.)

The State presented testimony from Dr. Medina, whom the trial court qualified as an expert in general pediatrics and child-abuse pediatrics (4T; 5T); the State presented no other witnesses. Dr. Medina testified that there is no standard test or "specific diagnostic criteria to define what abusive head [AHT] trauma is." (4T113-14 to 20; 4T158:2 to 6.) Instead, Dr. Medina explained that there are a number of symptoms that may lead to an AHT diagnosis. (4T113-21 to 24.) That list of symptoms, however, "can [each] be explained by other things" and so an evaluation must take into account the child's "history in

[3] *Frye*, 293 F. 1013.

general." (4T158-2 to 6.) In other words, there are many non-abusive causes for these conditions. (*See* 4T113-21 to 115-21.) Three of these symptoms constitute the "triad": subdural hemorrhages, retinal hemorrhages, and a neurological presentation. (4T53-7 to 16.)

Dr. Medina recounted that D.J.'s parents denied any wrongdoing, and that her diagnosis of AHT by shaking was accordingly based on probabilities and process of elimination. (5T63-22 to 64-13; Pa111.) She summarized that the diagnosis was made because "there was no explanation for [D.J.'s] presentation in terms of other potential accidental trauma, and the presence of these specific findings [of the triad] that were not accounted for by a metabolic disorder or an accident." (4T99-4 to 11.)

Nieves, on the other hand, offered three experts at the *Frye* hearing: (1) Dr. Joseph Scheller, an expert in pediatric neurology and neuroimaging; (2) Dr. Julie Mack, an expert in radiology and pediatric radiology; and (3) Dr. Chris Van Ee, an expert in biomechanics. (*See* 5T; 6T; 7T; 8T.) Dr. Scheller and Dr. Mack each took issue with Medina's medical analysis. Dr. Scheller, for example, testified that "there is no gold standard for diagnosing" AHT (5T-23), and both Dr. Scheller and Dr. Mack testified that the AHT theory is tainted by circular reasoning (5T135-4 to 137-11; 6T60-7 to 61-8).

Nieves's third expert witness, Dr. Van Ee, testified that biomechanics is necessary to determine the scientific validity of shaking-only AHT, and that research performed by him and other scientists have failed to demonstrate that shaking alone can cause the three symptoms observed by Medina. (7T 54-6 to 13; 109-4 to 24.) He explained that, on the other hand, studies have demonstrated that shaking can cause neck injuries. (7T39-14 to 21.) But here, D.J. did not present neck injuries. Dr. Van Ee stated that scientists have not determined "if you can get [to the injury threshold for AHT] with shaking for the head," but that scientists do "know you can get there for the neck[.]" (*Id*.) In other words, he summarized, there is no evidence that shaking alone can cause the triad of symptoms without also causing neck injuries. (*Id*.)

On January 7, 2022—nearly 27 months after the *Frye* hearing concluded—the trial court issued a 75-page decision excluding the State's proposed testimony on shaking-only AHT. (Pa2-Pa78.) Judge Jimenez found that the State "failed to prove that the science behind the AHT diagnosis is reliable so that it can be used [] by the State to implicate the defendant in abusive conduct and hold him criminally liable for causing the victim's injuries." (Pa77.) As a result, allowing testimony about AHT "would be the perfect recipe for a conviction not borne of a fair and unbiased decision-making process but, instead, one which would compromise the integrity of this prosecution and our

criminal justice system." (*Id*.) The court subsequently denied the State's motion for reconsideration and dismissed Nieves's indictment. (10T; Pa86-90.)

The State now appeals and asks this Court to reverse the trial court's ruling and instead find that the State can present its shaking-only AHT theory in its prosecution of Nieves.

ARGUMENT

AHT[4] by shaking refers to the hypothesis, formerly known as Shaken Baby Syndrome (SBS), that a child who suffers a triad of symptoms—subdural hematoma or hemorrhage (bleeding between the layers of tissue that cover the brain); retinal hemorrhage (bleeding in the back of the eye); and encephalopathy (neurological impairment)—has been subject to child abuse by physical shaking.[5] Shaking-only AHT, sometimes called triad-only AHT, refers to a diagnosis of child abuse based on these three symptoms but without substantial evidence of physical impact, injury to the neck or spine, or other physical

[4] Consistent with the practice of the parties in this case, *Amici* use AHT to describe the diagnosis sometimes still called SBS. *See* Keith A. Findley, *et al.*, *Shaken Baby Syndrome, Abusive Head Trauma and Actual Innocence: Getting it Right*, 12 Hous. J. Health L. & Pol'y 209, 212 (2012) ("For decades, shaken baby syndrome (SBS) was an accepted medical and legal diagnosis. As the shaking mechanism came into serious question, SBS was renamed abusive head trauma (AHT). Regardless of terminology, SBS/AHT refers to the two-part medicolegal hypothesis that, in the absence of a confirmed alternative explanation, one can reliably diagnose shaking or abuse from three internal findings . . . and that one can identify the perpetrator based on the onset of symptoms."); *id*. at 219-20 ("As shaking came under increasing scrutiny, a plethora of new terms arose that did not invoke shaking as a mechanism. At present, the most popular . . . is abusive head trauma, or AHT.").

[5] Randy Papetti, *et al.*, *Outside the Echo Chamber: A Response to the "Consensus Statement on Abusive Head Trauma in Infants and Young Children"*, 59 Santa Clara L. Rev. 229, 305 (2019) ("[B]y the late 1970s, the original warning that shaking can cause [the triad] began morphing into rather categorical medical dogma that such findings almost always mean SBS. The internal SBS findings had effectively become diagnostic of child abuse.").

indications of abuse.[6] This appeal asks whether the State clearly established the scientific reliability of shaking-only AHT. The biomechanical answer, *Amici* contend, is clear: there is no reliable biomechanical evidence that the act of shaking an infant can, on its own, generate enough acceleration to cause the three symptoms that often lead to an AHT diagnosis, including in this case.

I. BRIEF BACKGROUND ON THE FIELD OF BIOMECHANICS

To begin, *Amici* hope that some brief background on the field of biomechanics will provide helpful context for the Court when considering the scientific research underlying this appeal.

Mechanical engineering is a diverse and wide-ranging field that studies objects and systems in motion.[7] Mechanics, in turn, is a subfield of mechanical engineering that generally refers to the study of how objects respond to the application of force.[8] There are a variety of forces that can affect objects, including gravity, friction, tension, and air resistance.[9] By way of example, the

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[6] *See, e.g.*, Elizabeth A. Walker, *Shaken Baby Syndrome: Daubert and MRE 702's Failure to Exclude Unreliable Scientific Evidence and the Need for Reform*, 210 Mil. L. Rev. 1, 36 (2011).

[7] *What is Mechanical Engineering?*, Columbia University School of Engineering and Applied Science, https://www.me.columbia.edu/what-mechanical-engineering.

[8] *See* Duane Knudson, Fundamentals of Biomechanics 13 (3d ed.) (2021) (hereinafter "Knudson").

[9] *See id*. at 102, 110-11.

field of mechanics can be used to analyze the rolling of a bowling ball down the lane at a bowling alley. To do so, a biomechanical engineer would study, among other things, how the materials that compose the ball and bowling lane, the force of the bowler's hand, the friction of the floor, and air resistance all combine to affect the ball's movement down the lane.

The field of biomechanics specifically refers to the application of mechanics (*i.e.*, the study of how forces affect objects) to biological systems (*i.e.* living organisms).[10] Put another way, biomechanics focuses on understanding the mechanical response of biological tissue to force.[11] Thus, biomechanics requires an examination of the laws of mechanics as they relate to the structure, function, and motion of living biological systems, including the human body.[12]

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[10] *See, e.g.*, Michael D. Freeman & Sean S. Kohles, *An Evaluation of Applied Biomechanics as an Adjunct to Systematic Specific Causation in Forensic Medicine*, 161 Wien Med Wochenschr 458, 458 (2011); Knudson at 3.

[11] *See, e.g.*, *Hisenaj v. Kuehner*, 194 N.J. 6, 13 n.5 (2008) ("[B]iomechanics at its simplest is 'mechanics applied to biology.' . . . When an outside force acts upon a living being, the biomechanical engineer applies concepts of mechanics to explain the physiological effects of that force acting upon a living being, and specifically how that force likely would affect 'the normal functions of [that being] or [its] organs.'" (quoting Y.C. Fung, *Biomechanics: Mechanical Properties of Living Tissues* 1, 6 (2d ed. 1993))).

[12] *See, e.g.*, *ibid.*

Indeed, the human body itself is "a highly complex machine."[13] Accordingly, a foundational precept of biomechanics is that it is necessary to understand the human body's underlying characteristics in light of mechanical principles, in order to understand its movements and interactions with forces. For instance, if instead of rolling a bowling ball down a lane, a bowler drops the ball on another bowler's foot, an expert in biomechanics could examine how the force of the ball would affect a foot based on the specific observed circumstances of the situation—including the height and acceleration of the ball, the ball's material and weight, the construction of the bowler's shoe, and also the biological structure of the foot.

Experts in biomechanics are normally highly educated in mechanical engineering, biomedical engineering, and other related fields. As further explained in Section II, such experts are specifically trained in the study of the processes by which human injuries materialize, the determination of which of multiple possible causes is the most likely to cause a specific injury, and the most effective methods to prevent injuries. For this reason, biomechanics is applied to a wide range of topics, from motor vehicle safety and professional athletic injuries to workplace safety and prosthetics design.[14]

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[13] *What is Mechanical Engineering?*, *supra* note 7.

[14] *See, e.g.*, Knudson at 5-10.

Experts in biomechanics, including *Amici*, provide expert testimony in legal cases of many kinds, often providing expert opinions as to the forces generated in a particular set of circumstances and how those forces affected or injured an individual.[15] As one federal court described it, biomechanical engineering testimony often applies "the principles of mechanics to the facts of a specific [event]," "provide[s] information about the forces generated in that [event]," "explain[s] how the body moves in response to those forces, and . . . determine[s] what types of injuries would result from the forces generated."[16] In other words, biomechanical engineers may testify as to whether "the force sustained . . . in the subject accident could potentially cause certain injuries[.]"[17] Thus, topics of biomechanical expert testimony include, for example, the forces

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[15] Courts have found that biomechanical engineers are generally qualified to testify "about the forces involved [in an incident] and the kinds of injuries that may have resulted therefrom." *Berner v. Carnival Corp.*, 632 F. Supp. 2d 1208, 1212-13 (S.D. Fla. 2009) (collecting cases); *Morgan v. Girgis*, 07-CV-1960, 2008 U.S. Dist. LEXIS 39780, at *12-13 (S.D.N.Y. May 16, 2008) (collecting cases that "have concluded that a biomechanical engineer is qualified to offer testimony regarding the forces generated by certain accidents and the likely effects of such forces on the human body, but not to offer an opinion on whether or not the accident at issue could have caused the plaintiff's injuries.").

[16] *Bowers v. Norfolk S. Corp.*, 537 F. Supp. 2d 1343, 1377 (M.D. Ga. 2007) (quotations omitted); *see Hisenaj*, 194 N.J. at 13 n.5.

[17] *Burke v. TranSam Trucking, Inc.*, 617 F. Supp. 2d 327, 334 (M.D. Pa. 2009) (citation omitted) (biomechanical expert may testify "that the forces Plaintiff sustained in the subject collision were sufficient to cause a brain injury and a cervical region injury").

experienced by humans in various accidents and even during childbirth.[18] Relevant to this appeal, and as explained further in Section III, experts in biomechanics regularly provide expert testimony concerning the biomechanical bases for the symptoms that often result in AHT diagnoses.[19]

II. HUMAN INJURY BIOMECHANICS AND THE FOUNDATIONS OF BIOMECHANICAL RESEARCH

Experts in biomechanics are often tasked with studying and publishing research about how specific injuries to the human body can occur, and relatedly, how to prevent such injuries. Often called "injury biomechanics," this subfield of biomechanics focuses on physical failures of the human body—whether of the entire body or of a particular anatomical region, organ, tissue, or cell.[20] That is, in the same way that conventional engineering materials (*e.g.*, wood, steel, or plastic) can fail when encountering forces of a certain magnitude, human

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[18] *See, e.g.*, *L.M. v. Hamilton*, 436 P.3d 803, 815 (Wash. 2019) (biomechanical expert testimony on forces involved in childbirth); *Johnston-Forbes v. Matsunaga*, 333 P.3d 388, 394 (Wash. 2014) (biomechanical expert "helped the jury understand what forces might have been involved in the [vehicle] collision"); *Yarchak v. Trek Bicycle Corp.*, 208 F. Supp. 2d 470, 499-502 (D.N.J. 2002) (biomechanical expert testimony injuries caused by bicycle seat).

[19] The trial court below found that defense expert Dr. Christopher Van Ee was qualified as an expert in biomechanics based on his extensive qualifications and experience. (Pa57).

[20] *See Injury in America: A Continuing Public Health Problem*, Institute of Medicine and National Research Council Committee on Trauma Research 4 (1985), https://www.ncbi.nlm.nih.gov/books/NBK217482/; *see, e.g.*, Injury Biomechanics Research Center, Ohio State University, https://ibrc.osu.edu/.

biological tissue can also be damaged or fail when subjected to certain forces, if they are sufficient.[21] Damage to biological tissue can be structural (*e.g.*, a broken bone or open wound) or functional (*e.g.*, decreased cognitive motor function after a concussion). In a clinical biomechanical setting, such damage or failure of the body is often referred to as an "injury" or "trauma."

Injuries and trauma are, in turn, explained by the concept of load tolerance. When a force is applied—including to parts of the human body—they create what biomechanists call a "load."[22] The responses of human tissue to various loads—including whether or not the tissue will fail—depends on a number of factors, including the amount of force, the direction of the force, and the strength and shape of the tissue.[23] To put it simply, if the load tolerance, often called the "injury threshold," of human tissue is exceeded by the force exerted on that tissue, the tissue will fail.

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[21] Tissue is generally defined as "a group of cells that have similar structure and that function together as a unit." *Body Tissues*, National Institutes of Health Cancer Institute, https://training.seer.cancer.gov/anatomy/cells_tissues_membranes/tissues. Accordingly, biological tissue comprises all facets of the human body, including the nervous system, skin, muscles, tendons, ligaments, and bones. *Id*.

[22] *See generally* Knudson at 55-72. There are various terms to describe how loads affect a material, including compression (load squeezes material together); tension (load stretches or pulls apart material); and shear (right-angle loads acting in opposite directions). *Id*. at 55. Different types of forces can create combined loads called torsion or bending. *Id*.

[23] *See generally id*. at 55-72.

Many biomechanical engineers aim their research at pinpointing the mechanisms by which human injuries and trauma occur under various loading scenarios and determining injury thresholds. In other words, biomechanical research often attempts to answer the question of whether the forces exerted upon a particular anatomical region, organ, tissue, or cell during a particular event are enough to produce certain injuries or trauma. Such research utilizes traditional engineering methodologies, including the laws of physics and existing research into human anatomy.[24] Most relevant to this case, there is a substantial literature of biomechanical research, discussed further in Section IV, which has studied whether shaking an infant can exert the forces necessary to cause the triad of symptoms associated with shaking-only AHT.

Like most scientific analysis, biomechanical research studies normally begin with a testable hypothesis about the cause and effect of a mechanical circumstance. In order to derive that testable hypothesis, a biomechanical researcher may attempt to recreate the forces involved in a specific hypothetical incident (*e.g.*, a test to verify whether vigorous shaking of an infant would cause forces substantial enough to cause the triad).

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[24] *See, e.g.*, Freeman & Kohles, *supra* note 10 at 458 ("[I]n the context of forensic medicine the discipline [of biomechanics] is used most often to define injury thresholds, and to match injury mechanisms with expected or observed injuries as a means of causal determination.").

When planning a biomechanical experiment, researchers examine a number of important considerations, including:

1. *The loading environment to which the tissue was potentially exposed*: What were the movements and forces acting upon the tissue as a result of the event?
2. *The mechanism of injury*: How did the injury of the biological tissue mechanically and physiologically occur?
3. *The injury tolerance values associated with the observed failure*: What force, acceleration, stress, strain, or other movement was required to cause the tissue injury?

Efforts are then made to test the hypothesis. Biomechanical experts are particularly careful to acknowledge the limits of their research and the extent to which such analysis can and cannot illuminate about a particular event. Thus, a biomechanical researcher will apply a number of methodological constraints to the experiment in order to ensure that the research provides the most accurate and verifiable results, including:

1. *Biomechanical research cannot determine intent*. Because human tissue is sensitive to force—but is unaffected by the intent of the generator of that force—biomechanical research is unable to determine whether or not an injury was the result of an intentional

act or an accident, based solely on the injuries. For example, a foot bone will fracture if struck with a dropped bowling ball applied with enough force regardless of whether the bowling ball was dropped intentionally or as the result of an accident.

2. *Biomechanical research is not generally used to determine exactly what happened in a specific incident*. Instead, biomechanical studies provide an analytical tool that tests whether a hypothesis about the cause and effect of a loading scenario is valid, and thus able to be replicated.[25]

3. *Biomechanical research often uses models in order to test a hypothesis.* Because the response of living human tissue most often cannot be studied ethically in possibly injurious situations, models are commonly used to better understand how human tissue responds to forces. Models often include crash test dummies, human cadavers, animals, and computer models.

[25] This is different than abductive reasoning, which is often used in child abuse investigations. Abductive reasoning begins with a set of known observations and then seeks the simplest or most likely cause of the observed injury. (*See* 4T99-4 to 11; 5T63-22 to 64-13 (Dr. Medina testimony).) Biomechanical experts do not use this mode of reasoning because it may find a hypothetical explanation for the findings, but it is not positively verifiable in the same way as a rigorous biomechanical study.

In sum, it is because of these limitations that biomechanical research studies are valuable in determining biomechanical possibility—in other words, in ascertaining whether a hypothetical trauma can be replicated and is therefore plausible. Put another way, if a biomechanical study demonstrates that a particular loading scenario can cause a certain injury, it tells us that we cannot rule out this possibility.

But biomechanical experts make clear that caution should be exercised when interpreting the results of their research. Plausibility simply means that it is *possible* that the observed injury or trauma was caused by the observed forces. It does not necessarily mean that those forces *in fact* caused the observed injury or trauma. Conversely, that a biomechanical study does not replicate an injury or trauma does not mean that the tested forces cannot cause that result; it simply means that it was unable to be verified. It is for this reasons that biomechanical engineers do not typically testify as to the exact cause of a specific injury. Instead, testimony focuses on whether studies, like those described in Section IV below, have verified that the forces involved in a particular scenario are sufficient to cause the injury observed.

III. EXPERTS IN BIOMECHANICS ARE MEMBERS OF THE RELEVANT SCIENTIFIC COMMUNITY FOR DETERMINING THE SCIENTIFIC RELIABILITY OF SHAKING-ONLY AHT.

It is well-established that New Jersey courts continue to apply the reliability standard first articulated in *Frye*, 293 F. 1013, to determine the admissibility of expert testimony. That standard "requires trial judges to determine whether the science underlying the proposed expert testimony has 'gained general acceptance in the particular field in which it belongs.'" *J.L.G.*, 234 N.J. at 280 (quoting *Frye*, 293 F. at 1014). To do so, the party offering expert testimony must "clearly establish" that the testimony is generally accepted in the relevant scientific community. *State v. Harvey*, 151 N.J. 117, 170 (1997) (citation omitted). As the New Jersey Supreme Court has advised:

> Proof of general acceptance within a scientific community can be elusive, and satisfying the test involves more than simply counting how many scientists accept the reliability of the proffered technique. General acceptance entails the strict application of the scientific method, which requires an extraordinarily high level of proof based on prolonged, controlled, consistent, and validated experience. The proponent of the technique has the burden to clearly establish general acceptance, and may do so using (1) expert testimony, (2) scientific and legal writings, and (3) judicial opinions.
>
> [*State v. Cassidy*, 235 N.J. 482, 492 (2018) (quotations and alterations omitted).]

Often "there might be more than one scientific community to consider." *State v. Pickett*, 466 N.J. Super. 270, 302 (App. Div. 2021); *see Canavan's Case*, 733 N.E.2d 1042, 1050 n.6 (Mass. 2000) (cautioning that courts "must not define the 'relevant scientific community' so narrowly that the expert's opinion will inevitably be considered generally accepted. . . . [It] must be defined broadly enough to include a sufficiently broad sample of scientists so that the possibility of disagreement exists.").

It is certainly true that experts from a variety of fields have expertise concerning AHT—including neurologists, pediatricians, and hematologists. But it is also clear that the testimony of biomechanical experts must be considered as well when surveying the scientific literature on AHT. This is especially true when considering shaking-only AHT, a medical diagnosis by which child abuse is determined based on three symptoms *without* evidence of physical impact, injury to the neck or spine, or other physical indications of intentional abuse.

Pediatricians who evaluate child abuse, as Dr. Medina did in this case, often apply the AHT diagnosis based on the presence of subdural hematoma or hemorrhage, retinal hemorrhage, and encephalopathy, without any other indications of abuse. In fact, "by 2001, shaking as the primary or exclusive cause of the triad had been taught in the medical schools for decades, not as a

hypothesis but as scientific fact."[26] The diagnosis is traditionally based on a "differential diagnosis" that seeks to rule out alternative explanations for the observed symptoms.[27] In other words, as Dr. Medina testified (4T99-4 to 11; 5T63-22 to 64-13), AHT often is a diagnosis based on a process of elimination.[28]

But before determining whether a shaking-only AHT diagnosis may be appropriate, biomechanists are essential to answering the baseline question of whether it is even physically *possible* to shake an infant in a manner that can produce forces sufficient to cause the triad without other physical indications of abuse. In other words, biomechanics is brought to bear to determine whether the assumption that shaking a child unaccompanied by other physical trauma is even possibly capable of causing the triad of symptoms. It is for this reason that biomechanical experts, including *Amici*, frequently testify in cases considering AHT.[29]

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[26] Findley, *et al.*, *supra* note 4 at 232.

[27] Keith Findley & D. Michael Risinger, *The Science and Law Underlying Post-Conviction Challenges to Shaken Baby Syndrome Convictions: A Response to Professor Imwinkelried*, 48 Seton Hall L. Rev. 1209, 1220-21 (2018); *Creanga v. Jardal*, 185 N.J. 345, 355 (2005); *see, e.g.*, *Allison v. State*, 448 P.3d 266, 271-74 (Ak. Ct. App. 2019) ("A diagnosis of shaken baby syndrome or abusive head trauma can only be made if all other possible causes are ruled out.").

[28] Findley, *et al.*, *supra* note 4 at 224-26.

[29] *See, e.g.*, *Jones v. State*, 2021 Md. App. LEXIS 76, at *46-47 (Md. Ct. Spec. App. Feb. 2, 2021) (unpublished) (granting defendant new trial based on biomechanical expert's testimony "that modern research contradicts earlier SBS theories"); *People v. Bailey*, 144 A.D.3d 1562, 1564 (N.Y. App. Div. 2016)

As explained further in the next Section, much of the most oft-cited literature on AHT—and particularly shaking-only AHT—is published by experts in biomechanics. And this makes sense. Shaking an infant is a mechanical event; and so, in order to conduct a comprehensive analysis and determination of the forces of shaking on an infant, courts must necessarily view the diagnosis through a biomechanical lens.

The United States Court of Appeals for the Sixth Circuit recently warned about the consequences of ignoring the views of biomechanical experts in cases alleging child abuse. In *Ceasor v. Ocwieja*, 655 F. App'x 263, 265 (6th Cir. 2016) (unpublished), the defendant challenged, on habeas corpus, his conviction for shaking a baby to death despite his trial counsel's failure to research an expert to rebut the state's AHT theory. Observing that the defendant could have adduced evidence that "the biomechanical and forensic literature demonstrates that shaking without impact is unlikely to cause subdural hematomas or retinal hemorrhages," *id*. at 273, the panel remanded the case for an evidentiary hearing, *id*. at 286. The court described the fundamental importance of ensuring that the

(same); *Council v. State*, 98 So. 3d 115, 116-17 (Fla. Dist. Ct. App. 2012) (biomechanical expert may testify that a child could have sustained certain types of brain injuries from an accidental fall and that shaking would not have caused the observed injuries).

appropriate science—including biomechanical research—is brought to bear before an individual may be convicted based upon the triad of symptoms alone:

> The crux of the prosecution's proof that [defendant] knowingly or intentionally caused [the victim] serious physical harm—an element of first-degree child abuse that the prosecution was required to prove beyond a reasonable doubt—was [a physician's] expert testimony [about SBS]. At closing argument, the prosecution went out of its way to point out that this testimony was uncontroverted. [The victim's] injuries—a subdural hematoma and retinal hemorrhaging—were medically complex and beyond the easy comprehension of the jury. Further, no amount of cross-examination or lay witness testimony could have rebutted [the physician's] medical opinions that these injuries were medically consistent with abuse and inconsistent with an accidental fall. Thus, we acknowledge, as the [Michigan Supreme Court in *People v. Ackley*, 870 N.W.2d 858, 676 (Mich. 2015)] did, that in many SBS cases where there is no victim who can provide an account, no eyewitness, no corroborative physical evidence and no apparent motive to [harm], the expert *is* the case.
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> [*Id*. at 286 (quotations and citations omitted).][30]

Failing to consider the testimony and knowledge of experts in biomechanics, then, in cases like this one necessarily impairs the search for truth and justice.

[30] The state ultimately dismissed the charges against the defendant. The National Registry of Exonerations: Terry Ceasor, https://www.law.umich.edu/special/exoneration/Pages/casedetail.aspx?caseid=6043.

IV. THE CURRENT STATE OF BIOMECHANICAL RESEARCH DOES NOT SUPPORT THE VALIDITY OF SHAKING-ONLY AHT.

For years, it was prevailing wisdom in the medical community that the triad of symptoms—without evidence of a fall or other injurious event—could only be explained by AHT or its predecessor, SBS.[31] "In its classic formulation, SBS comes as close as one could imagine to a medical diagnosis of murder: prosecutors use it to prove the mechanism of death, the intent to harm, and the identity of the killer."[32] As Dr. Patrick Barnes, a pediatric radiologist and neuroradiologist, explained in 2017:

> During the first twenty years of my career, the triad was assumed to be due to nothing but abuse. I never questioned it. I marched in step, because I grew up in the authoritarian era, in which the older leaders and teachers told me this is the way it is. And it took me a while to grow up and start questioning these assumptions. . . .
>
> The SBS theory held that if you have the triad, that's abuse, just that simple. Or even just two of the triad. . .

[31] Papetti, *et al.*, *supra* note 5 at 303-11 (describing early history of SBS/AHT); Findley, *et al.*, *supra* note 4 at 223-245 (same); Walker, *supra* note 6 at 1-13 (same).

[32] Deborah Tuerkheimer, *The Next Innocence Project: Shaken Baby Syndrome and the Criminal Courts*, 87 Wash. U. L. Rev. 1, 5 (2009); Deborah Tuerkheimer, *Science-Dependent Prosecution and the Problem of Epistemic Contingency: A Study of Shaken Baby Syndrome*, 62 Ala. L. Rev. 513, 516 (2011).

> We just assumed all of these kids were otherwise well before the shaking event.[33]

However, it has become clear that these views were severely distorted by a number of fundamental methodological flaws.[34]

Most profoundly, because shaking-only AHT typically is a diagnosis based upon ruling out other possibilities, it is often applied when there is no direct evidence to prove the diagnosis is accurate.[35] Put another way, doctors and prosecutors have often argued that the triad of symptoms is a strong, if not

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[33] Patrick Barnes, *Symposium: Child Abuse—Nonaccidental Injury (NAI) and Abusive Head Trauma (AHT)—Medical Imaging: Issues and Controversies in the Era of Evidence-Based Medicine*, 50 U. Mich. J.L. Reform 679, 680, 685 (2017).

[34] *See generally* Papetti, *et al.*, *supra* note 5 at 312-63 (detailing shortcomings); Findley, *et al.*, *supra* note 4 at 273-98 (same); Tuerkheimer, *supra* note 32 at 10-22 (same); *Traumatic Shaking: The Role of the Triad in Medical Investigations of Suspected Traumatic Shaking—A Systematic Review*, Swedish Agency for Health Technology Assessment and Assessment of Social Services (2016) ("SBU Report") at 27 ("The research field is complex, but this does not excuse, for example, circular reasoning and inadequate presentation of data collection."), https://www.sbu.se/255e; Shalea Piteau, et al., *Clinical and Radiographic Characteristics Associated With Abusive and Nonabusive Head Trauma: A Systematic Review*, 130 Pediatrics 315, 316, 321 (2012) (reviewing the "best available evidence" and observing that studies in support of the diagnosis are "fraught with circular reasoning"); *see also Matter of Rihana J.H.*, 54 N.Y.S.3d 612 (N.Y. Fam. Ct. 2017) (unpublished) ("Even the names of the diagnoses, *i.e.* 'abusive head trauma' and 'shaken baby syndrome,' have been criticized as essentially self-fulfilling prophecies.").

[35] Findley, *et al.*, *supra* note 4 at 276-77 ("'Rule out' diagnoses are also known as diagnoses of exclusion or default diagnoses. . . . Because 'rule out' diagnoses cannot be confirmed, they run a significant risk of being wrong.").

conclusive, indicator of child abuse without any evidence that it is even biomechanically possible.[36]

Of course, "there is no dispute that shaking *with impact* can" cause the injuries associated with AHT.[37] But there is no biomechanical support for applying AHT in cases where there is no sign of impact. In fact, biomechanical studies have been unable to find reliable evidence that shaking alone—without the skull making contact with the body or another surface—generates the forces necessary to meet the injury threshold to cause the AHT triad of symptoms.[38] As a group of medical and legal scholars summarized in 2019, "virtually all of the

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[36] Findley, *et al.*, *supra* note 4 at 274-77 ("In study after study, doctors assume that, in the absence of a known medical explanation, subdural hemorrhages are caused by major trauma. Cases are then classified as abusive if the parents cannot describe a major trauma or substantiate a natural cause.").

[37] Keith Findley, *et al.*, *Feigned Consensus: Usurping the Law in Shaken Baby Syndrome/Abusive Head Trauma Prosecutions*, 2019 Wis. L. Rev. 1211, 1221 (2019) (emphasis in original).

[38] Werner Goldsmith & John Plunkett, *A Biomechanical Analysis of the Causes of Traumatic Brain Injury in Infants and Children*, 25 Am. J. Forensic Med. Pathol. 89, 94 (2004) ("Biomechanical studies have demonstrated that the head accelerations generated by shaking are below the thresholds for traumatic DAI [diffuse axonal injury], SDH [subdural hematoma], and even concussion," and shaking "simply does not generate accelerations that exceed any known injury tolerance values for traumatic brain injury." (citations omitted)); John Lloyd, *et al.*, *Biomechanical Evaluation of Head Kinematics During Infant Shaking Versus Pediatric Activities of Daily Living*, 2 J. Forensic Biomechanics 1, 8 (2011) ("[O]ur data indicate that neither aggressive nor resuscitative shaking is likely to be a primary cause of diffuse axonal injury, primary retinal hemorrhage, schisis or folds, or subdural hematoma in a previously healthy infant.").

biomechanical research has concluded that even the most vigorous shaking [alone] cannot generate sufficient forces to reach estimated brain injury thresholds."[39] In fact, as Dr. Van Ee testified in this matter (7T39-14 to 21), there is evidence that violent shaking would cause neck and spine injuries well before any injuries to the brain.[40]

Likewise, in 2016, the Swedish Agency for Health Technology Assessment and Assessment of Social Services appointed an academic panel to undertake a systematic review of medical literature to assess the strength of shaking-only AHT and the diagnostic value of the mere existence of the triad. After examining 3,773 medical papers (1,065 of which were deemed relevant),

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[39] Findley, *et al.*, *supra* note 37 at 1221 (citing studies); *see* Papetti, et al., *supra* note 5 at 313 (citing studies); *Commonwealth v. Epps*, 53 N.E.3d 1247, 1260-61 (Mass. 2016) (citing studies).

[40] *See*, *e.g.*, Waney Squier & Julie Mack, The Neuropathology of Infant Subdural Haemorrhage, 187 Forensic Sci. Int'l 6, 12 (2009) ("The forces required to cause bridging vein rupture would exceed the strength of the infant neck. . . . Any infant shaken sufficiently violently to produce SDH would be expected also to have injury to the bones and soft tissues of the neck and spinal cord."); A.K. Ommaya, *et al.*, *Biomechanics and Neuropathology of Adult and Pediatric Head Injury*, 16 Brit. J. Neurosurg. 220, 228-29 (2002) (biomechanical research demonstrates that, in the case of shaking, "the neck torque in the infant would cause severe injury to the high cervical cord and spine long before the onset of cerebral concussion"); Goldsmith & Plunkett, *supra* note 38 at 94 ("If one could 'shake' an infant or child, or an adult for that matter, vigorously enough to cause traumatic DAI or SDH, there will be significant structural neck damage, including the craniocervical junction. Shaking simply does not generate accelerations that exceed any known injury tolerance values for traumatic brain injury." (citation omitted)).

the Swedish Agency concluded that there was (1) "limited scientific evidence that the triad and therefore its components can be associated with traumatic shaking ([*i.e.*] low quality evidence)"; and (2) "insufficient scientific evidence on which to assess the diagnostic accuracy of the triad in identifying traumatic shaking ([*i.e.*] very low quality evidence)."[41]

At the same time, studies have also confirmed that there are multiple non-abusive accidental or natural causes that can produce the symptoms associated with shaking-only AHT.[42] For example, studies—including biomechanical re-creations—have demonstrated that short accidental falls may result in a child demonstrating the triad with no other physical evidence of injury.[43] For instance,

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[41] SBU Report, *supra* note 34 at 5; *see* Papetti, *et al.*, *supra* note 5 at 338-41 ("The Swedish Report is the first review by an independent scientific body with expertise in systematically reviewing evidence bases. Its findings are devastating to SBS[.]"); *see also* Findley, et al., *supra* note 37 at 1221.

[42] *See, e.g.*, Tuerkheimer, *supra* note 32 at 22 ("[T]he differential diagnosis for symptoms previously associated exclusively with SBS now contemplates a wide range of nontraumatic possibilities: medical or surgical interventions; prenatal, perinatal and pregnancy-related conditions; birth effects; infections; diseases; disorders; malformations; post-vaccinal conditions; re-bleeds; and hypoxia[.]"); *Epps*, 53 N.E.3d at 1264 (observing that "articles have been published in medical and scholarly journals questioning the diagnostic significance of the symptoms previously thought indicative of shaken baby syndrome").

[43] *See e.g.*, Papetti, *et al.*, *supra* note 5 at 314-18 ("As a matter of proven fact, short falls in infants and young children can and do cause subdural hemorrhage, retinal hemorrhages, retinal folds and schisis, and death. Accordingly, as a matter of forensic medicine, absent significant physical or investigatory evidence of abuse beyond the triad findings, there is no medical basis in such cases to rule out a short fall as an explanation for those findings." (citing

a 2003 study published by researchers at the University of Pennsylvania and Children's Hospital of Philadelphia subjected an anthropomorphic model of a 1.5 month old infant to shaking; inflicted impacts after shaking; and simulated falls from one foot, three feet, and five feet onto three surfaces of increasing hardness.[44] The study found that "[v]igorous shakes of this infant model produced rotational responses similar to those resulting from minor falls, but inflicted impacts produced responses that were significantly higher than even a 1.5-meter [*i.e.* 4.92 foot] fall onto concrete."[45] Dr. Van Ee found similar results in a 2015 study commissioned by the Washington Post in which he concluded that simulated "falls with a direct impact to the head produced far more acceleration than shaking": shaking recorded maximum force of six Gs; falls

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studies)); Findley, *et al.*, *supra* note 37 at 1221 ("[B]iomechanical research shows not only that shaking is an unlikely mechanism for these injuries, but also that even the most vigorous shaking generates one-fiftieth of the force of short-distance falls, such as accidental falls from furniture (beds, couches, changing tables, etc.)."); Findley, *et al.*, *supra* note 4 at 245-49 ("New research has restored some of the traditional nuance as videotaped and witnessed short falls have confirmed that short falls can be fatal and biomechanical studies have confirmed that the force of impact (including short falls) is much greater than the force of shaking." (citing studies)); *see Epps*, 53 N.E.3d at 1260 (recognizing "substantial scientific and medical literature that recognized the possibility that accidental short falls can cause serious head injuries in young children of the type generally associated with shaken baby syndrome." (citing studies)); *id*. at 1265 n.24 (citing additional studies).

[44] Michael T. Prange, *et al.*, *Anthropomorphic Simulations of Falls, Shakes, and Inflicted Impacts in Infant*s, 99 J. Neurosurgery 143, 144-45 (2003).

[45] *Id*. at 143-49.

from 18 inches recorded a maximum force of 112 Gs.[46] And these conclusions are further supported by studies describing videotaped or witnessed short falls.[47]

In light of this research, after years of recommending a presumption of child abuse whenever a child younger than one year suffers an intracranial injury,[48] the American Association of Pediatrics reversed its previous position and, for the first time, acknowledged in a 2009 policy statement that accidents can cause injuries associated with AHT:

> Few pediatric diagnoses engender as much debate as AHT, in part because of the social and legal consequences of the diagnosis. The diagnosis can result in children being removed from their homes, parents losing their parental rights, and adults being imprisoned for their actions. Controversy is fueled because the

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[46] Debbie Cenziper, *Engineers: Falls Could Be More Dangerous Than Shaking*, Washington Post (Mar. 20, 2015) https://www.washingtonpost.com/graphics/investigations/shaken-baby-syndrome/A-biomechanical-look-at-shaking.html (test conducted with 195-pound man vigorously shaking 22-pound crash test dummy).

[47] *E.g.*, Patrick E. Lantz & Daniel E. Couture, *Fatal Acute Intracranial Injury, Subdural Hematoma, and Retinal Hemorrhages Caused by Stairway Fall*, J. of Forensic Sci. (2011), at 1-5 ("This case report refutes a pervasive belief that childhood low-height falls are invariably trivial events and cannot cause subdural bleeding, fatal intracranial injuries, and extensive multilayered RHs"); Horace Gardner, *A Witnessed Short Fall Mimicking Presumed Shaken Baby Syndrome (Inflicted Childhood Neurotrauma)*, 43 Pediatr. Neurosurg. 433, 433 (2005) (concluding that "[v]iolent shaking is not necessary to produce these findings" of "subdural hematoma and retinal hemorrhages characteristic of presumed shaken baby syndrome").

[48] Findley, *et al.*, *supra* note 4 at 232-33 (citing Comm. on Child Abuse and Neglect, Am. Acad. of Pediatrics, *Shaken Baby Syndrome: Rotational Cranial Injuries—Technical Report*, 108 Pediatrics 206 (2001)).

> mechanisms and resultant injuries of accidental and abusive head injury overlap, the abuse is rarely witnessed, an accurate history of trauma is rarely offered by the perpetrator, there is no single or simple test to determine the accuracy of the diagnosis, and the legal consequences of the diagnosis can be so significant.[49]

Indeed, it is now understood that a number of underlying medical conditions can also cause symptoms that mimic the triad, including certain genetic conditions, physical disorders, and nutritional deficiencies.[50]

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[49] Cindy W. Christian, Robert Block, & Committee on Child Abuse and Neglect, *Abusive Head Trauma in Infants and Children*, 123 Pediatrics Vol. 1409, 1410 (American Academy of Pediatrics 2009); *see Epps*, 53 N.E.3d at 1265 ("The 2009 [AAP] policy statement no longer spoke of a presumption of child abuse[.]"); *Commonwealth v. Millien*, 50 N.E. 3d 808, 826 (Mass. 2016) (quoting 2009 AAP statement); Findley, *et al.*, *supra* note 4 at 241-42 ("While the [2009 AAP] policy statement noted that medical diseases can mimic AHT and that pediatricians have a responsibility to consider alternative hypotheses, it did not identify the alternatives or offer any assistance in distinguishing between accidental, nonaccidental and natural causes, leaving this up to individual pediatricians.").

In April 2020, the AAP released a new policy statement in which it "continue[d] to affirm the dangers and harms of shaking infants" and "continue[d] to embrace the 'shaken baby syndrome' diagnosis as a valid subset of the AHT diagnosis[.]" Sandeep K. Narang, *et al.*, *Abusive Head Trauma in Infants and Children*, 4 Vol. 145 (AAP 2020). But at the same time, the statement admitted that "there is not a particular pattern of cranial injury unique to AHT" and that "[b]iomechanical research forms an important adjunct to the growing body of knowledge on pediatric traumatic brain injury." *Id*.

[50] *See, e.g.*, Findley, *et al.*, *supra* note 4 at 215-16 (providing extensive list of alternative causes for the components of the triad); Cindy W. Christian & Alex V. Levin, *The Eye Examination in the Evaluation of Child Abuse*, Pediatrics Vol. 142 (AAP 2018) ("RHs have other etiologies, especially in critically ill children, including meningitis, leukemia, coagulopathy, and retinal disorders[.]"); James

In short, research increasingly renders the type of analysis employed by the State's expert here, which concludes that a child was abused based on the presence of the triad without any other indication of abuse, too simplistic to form the basis for an AHT diagnosis and abuse prosecution. As two legal scholars recently summarized:

> [B]iomechanical research does pose an enormous challenge to the SBS hypothesis, because the biomechanical research—using well-accepted research tools and methodologies—consistently shows that violent shaking of an infant by a human adult cannot generate accelerations that come anywhere close to estimated thresholds for brain injury or death. The research also consistently shows that, if shaking could generate sufficient accelerations, it would necessarily produce massive neck and spine injuries - which are not typical in SBS/AHT cases. Finally, the biomechanical research consistently shows that short-distance falls (such as falls off of furniture) produce many times more accelerations than the most vigorous shaking, and that they can produce accelerations that exceed estimated injury thresholds—thereby debunking one of the cardinal principles of the SBS dogma, which has consistently maintained that the medical findings and

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D. Anderst, *et al.*, *Clinical Report: Bleeding Disorders in Suspected Child Abuse*, 131 Pediatrics 1314, 1320-1321 (American Academy of Pediatrics 2013) (bleeding disorders can cause or aggravate findings that can be attributed to child abuse); A. Norman Guthkelch, *Problems of Infant Retino-Dural Hemorrhage with Minimal External Injury*, 12 Hous. J. Health L. & Pol'y 201, 204 (2012) (Complexities of infant brain mean "we should not expect to find an exact or constant relationship between the existence or extent of retino-dural hemorrhage and the amount of force involved, let alone the state of mind of the perpetrator. Nor should we assume that these findings are caused by trauma, rather than natural causes.").

> injuries used to diagnose SBS/AHT cannot be caused by accidental short-distance falls.[51]

In light of these developments, courts throughout the country continue to acknowledge the continuing scientific debate over the validity of AHT diagnoses. *See, e.g.*, *Gimenez v. Ochoa*, 821 F.2d 1136, 1145 (9th Cir. 2016) (observing "a vigorous debate about [SBS's] validity within the scientific community"); *Commonwealth v. Doe*, 68 N.E.3d 654, 656 n.3 (Mass. Ct. App. 2016) ("As noted in two recent opinions of the [Massachusetts] Supreme Judicial Court, shaken baby syndrome has been the subject of heated debate in the medical community." (citing *Epps*, 53 N.E.3d 1247; *Millien*, 50 N.E.3d 808)); *Vanek v. Wofford*, No. 14-CV-4427, 2016 U.S. Dist. LEXIS 158836, at *3 (C.D. Cal. July 26, 2016) (observing that "the scientific community ha[s] recognized a vigorous debate about the validity of a [SBS] diagnosis that . . . was based solely on a particular triad of symptoms"), *R&R adopted*, 2016 U.S. Dist. LEXIS 158822 (C.D. Cal. Nov. 15, 2016); *In re Yarbrough Minors*, 885 N.W.2d 878, 890 (Mich. Ct. App. 2016) ("The science swirling around cases of shaken baby syndrome and other forms of child abuse is highly contested" (quotations omitted)); *State v. Edmunds*, 746 N.W.2d 590, 596, 599 (Wis. Ct.

[51] Findley & Risinger, *supra* note 27 at 1216-18 (citations omitted); Findley, et al., *supra* note 4 at 213 ("[T]here is now widespread, if not universal, agreement that the presence of the triad alone—or its individual components—is not enough to diagnose abuse.").

App. 2008) (recognizing "legitimate and significant dispute within the medical community" and "shift in the mainstream medical community" on SBS/AHT); *see also Cavazos v. Smith*, 565 U.S. 1, 13 (2011) (Ginsburg, J., dissenting) (citing biomechanical studies and other research and observing that "[d]oubt has increased in the medical community [since defendant's 1997 trial] over whether infants can be fatally injured through shaking alone" (quotation omitted)); *id*. at 9 ("What is now known about shaken baby syndrome (SBS) casts grave doubt on the charge leveled against [defendant]"); *In re Pers. Restraint of Fero*, 409 P.3d 214, 239 (Wash. 2018) (McCloud, J., dissenting) (observing "evidence of a paradigm shift in the medical community [concerning SBS/AHT] that, if believed, undermines the State's entire shaken baby theory[.]").

Based on the forceful debate over the science of AHT, courts throughout the country "have ordered new trials in SBS/AHT cases based on the shifting science, either because the science is newly discovered, or because counsel was ineffective for failing to use it at trial, or because the defense was otherwise denied resources needed to challenge the medical evidence[.]"[52] In a particularly striking example, a federal court in 2014 granted habeas corpus relief to a daycare worker convicted of the murder of one of the children in her care on the

[52] *Id*. at 1226 n.58 (collecting cases).

basis of a 2005 SBS diagnosis. *Del Prete v. Thompson*, 10 F. Supp. 3d 907, 958 (N.D. Ill. 2014). Finding that new scientific evidence undermined key assumptions undergirding the SBS theory, the Court boldly concluded that these developments "arguably suggest[] that a claim of shaken baby syndrome is more an article of faith than a proposition of science." *Id*. at 957 n.10.

As well, a number of medical professionals—including some whose research has previously been cited to advance the SBS/AHT theories—now voice skepticism about the scientific validity of AHT diagnoses.[53] For example, Dr. A. Norman Guthkelch, a pediatric neurosurgeon who was one of the earliest and most prominent originators of the SBS hypothesis, recently warned that

> "[g]etting it right" requires that we distinguish between hypotheses and knowledge. SBS and AHT are hypotheses that have been advanced to explain findings that are not yet fully understood. There is nothing wrong in advancing such hypotheses; this is how medicine and science progress. It is wrong, however, to fail to advise parents and courts when these are simply hypotheses, not proven medical or scientific facts, or to attack those who point out problems with these hypotheses or who advance alternatives. Often,

[53] In 2016, the President's Council of Advisors on Science and Technology (PCAST) noted that "there are issues related to the scientific validity of . . . forensic evidence that . . . require urgent attention—including notably . . . abusive head trauma commonly referred to as 'Shaken Baby Syndrome.'" PCAST, *Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature—Comparison Method* (2016) at 23 n.15, https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_forensic_science_report_final.pdf.

> "getting it right" simply means saying, clearly and unequivocally, "we don't know."[54]

Although there may be some in the medical community who continue to stand by the shaking-only AHT theory and presume child abuse based on the presence of the triad of symptoms alone, there is little disagreement within the community of biomechanical experts that this position is unsupported by the biomechanical literature. Research continues to be underway, but because biomechanics has been unable to verify shaking-only AHT, the results thus far echo Dr. Guthkelch's fundamental premise: after decades of study, the shaking-only AHT diagnosis, based solely on the presence of the triad, remains an unproven and unverified hypothesis that has failed to gain a scientific consensus.

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[54] Guthkelch, *supra* note 50 at 207-08 ("Since the issue is not what the majority of doctors (or lawyers) think but rather what is supported by reliable scientific evidence, the evidence should be reviewed by individuals who have no personal stake in the matter, and who have a firm grounding in basic scientific principles, including the difference between hypotheses and evidence."); Findley, *et al.*, *supra* note 4 at 243 (summarizing Guthkelch's testimony that "Shaken Baby Syndrome is an undesirable phrase and that there was not a vestige of proof when the name was suggested that shaking, and nothing else, caused the triad. Dr. Guthkelch went on to say that a number of other conditions-natural and non-accidental-may lead to the triad, including metabolic disorders, blood clotting disorders, and birth injury, to name a few"); *see also* Sandeep Narang, *A Daubert Analysis of Abusive Head Trauma/Shaken Baby Syndrome*, 11 Hous. J. Health L. & Pol'y 505, 571 (2011) (proponent of SBS/AHT admitting "the mere presence alone of SDHs [subdural hematomas] and RHs [retinal hemorrhages] does not establish a diagnosis of AHT.").

In New Jersey courts, establishing reliability under *Frye*, 293 F. 1013, requires examination of the most updated scientific evidence and "entails the strict application of the scientific method, which requires an extraordinarily high level of proof based on prolonged, controlled, consistent, and validated experience." *Cassidy*, 235 N.J. at 492 (quotation omitted). But rather than offering the requisite "extraordinarily high level of proof," the testimony of the State's expert confirmed that there is no biomechanical evidence that shaking-only AHT is scientifically valid. Indeed, at best for the State, the debate about whether it has "gained general acceptance in the particular field in which it belongs," *J.L.G.*, 234 N.J. at 280 (quoting *Frye*, 293 F. at 1014), remains ongoing in the scientific community. And where that is the case, courts do not find—for obvious reasons—that the "general acceptance" standard has been met. *E.g.*, *id*. at 302 (holding that there was no general acceptance in the scientific community about retraction or false denial because "[e]xperts vary widely in their views about how often victims of child sexual abuse retract allegations or falsely deny them"); *State v. Moore*, 188 N.J. 182, 207 (2006) (holding that new scientific evidence demonstrated that the use of hypnotically refreshed testimony hypnotically cannot meet the general acceptance standard despite the fact that "the scientific community has not reached a definitive consensus on the issue"). Thus, the trial court correctly determined, after

examining the relevant scientific literature, that the State did not meet its heavy burden to demonstrate the validity, and therefore the admissibility, of shaking-only AHT evidence.

CONCLUSION

For the reasons set forth above, *Amici* respectfully urge this Court to affirm the trial court's order barring the State's proposed testimony concerning shaking-only AHT.

Respectfully submitted,

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