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Hair toxicology testing among children evaluated for physical abuse: evaluation of a practice change.

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Hair Toxicology Testing Among Children Evaluated for Physical Abuse:

Evaluation of a Practice Change

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8/02/2021



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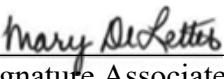
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Dedication

To my wife, for her constant love and support. You took care of everything at home so I could focus hard on an education. You are the reason it was possible. To my boys, for being the inspiration to pursue that education. You are the reasons for everything.

Acknowledgments

I would like to thank my DNP project team, Dr. Sara Robertson and Dr. Lynne Hall for your abundant patience, your steady encouragement, and your gentle ability to push me to give my best effort. I am honored and humbled that you both chose my project for your undertakings. I would also like to give a special thank you to Dr. Melissa Currie, division director of Pediatric Protection Specialists, for your constant support of educational advancement. You have my eternal thanks for saying “yes.” Lastly, to the entire team at Pediatric Protection Specialists, thank you all for being my village.

Abstract

Background: Despite a complete medical evaluation for child physical abuse, many suspected victims have indeterminate findings. The lack of a definitive diagnosis can impede child protection agencies' ability to protect those children at high risk for abuse, leaving them vulnerable to subsequent injuries and potentially escalating violence by caregivers. Oftentimes, allegations of child physical abuse are accompanied by concerns for substance abuse by the caregiver as well. While we know that children living in homes where caregivers use illicit substances are at substantially higher risk for physical abuse, drug testing children for environmental exposure to illicit substances is not yet widely accepted as part of the overall maltreatment evaluation. Drug testing has traditionally revolved around testing adult caregivers in the child's life. However, testing adults cannot determine whether the caregiver was intoxicated while in a caregiving role which is often necessary for investigators to prove risk of harm or neglect of the child. When hair testing is used in the evaluation of children, positive results can provide child protection agencies with concrete evidence of child drug endangerment, potentially changing the outcome of the maltreatment investigation.

Setting: This project was a retrospective review of cases using the database in a child abuse pediatrics sub-specialty office associated with a children's hospital in an urban area where approximately 1,100-1,200 children are evaluated yearly for physical abuse, sexual abuse, and neglect.

Purpose: The purpose of this project was to evaluate the yield of positivity for hair toxicology tests among children five years of age and younger who were evaluated for physical abuse over a 2-year period.

Procedure: The project used the current patient database to identify patients less than six years of age who were evaluated for maltreatment in 2019 and 2020 and underwent hair toxicology testing as part of the maltreatment evaluation.

Results: One hundred-fifty-five children met inclusion criteria for the study. Overall hair toxicology positivity rate was 91% for at least one illicit substance. Among children specifically evaluated for physical abuse, all children with injuries independently diagnostic for child physical abuse had positive hair tests. Among children with injuries that were inconclusive for physical abuse diagnostic criteria, 82.8% had positive hair tests.

Conclusions: Hair testing should be considered as an adjunct to the maltreatment medical work-up in cases of suspected abuse where there are family risk factors. If positive, hair testing can affect the outcome of the investigation by providing definitive proof of drug endangerment.

Keywords: hair toxicology testing, child maltreatment, physical abuse, indeterminate findings of physical abuse

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**Hair Toxicology Testing Among Children Evaluated for Physical Abuse:
Evaluation of a Practice Change**

Child physical abuse is a significant problem in our society. According to the most recent data from the U.S. Department for Health and Human Services (2020), Kentucky led the nation in the per capita child abuse rates in 2017 (22.2/1000), 2018 (23.6/1000), and 2019 (20.1/1000). Until 2019, these rates increased every year for the previous six years. In Kentucky, child physical abuse, including abusive head trauma, rank as the third most frequent cause of child fatalities and near-fatalities from caregiver maltreatment (Kentucky Child Fatality and Near-fatality External Panel (2020)).

While much has been published regarding testing recommendations for the medical evaluation of suspected victims of child maltreatment, oftentimes, especially with physical abuse, findings are inconclusive. In the setting of an abuse investigation, absent definitive medical evidence, child protective services (CPS) agencies must balance the rights of the parents to have access to their children against the risk calculation for maltreatment which is often based primarily on individual subjective assessment (CHFS, 2011; Church & Fairchild, 2017). Despite the involvement of child abuse pediatrics sub-specialty teams (CAPs) in guiding the medical evaluation and interpretation of findings, there is no crystal ball to determine which children will have the poorest outcomes. To more thoroughly evaluate abused and neglected children, in particular those with indeterminate findings, this CAP team associated with a children's hospital in Kentucky began including hair toxicology testing as part of some child abuse medical evaluations.

Background

Screening Tools in the Medical Evaluation of Physical Abuse

Within child maltreatment literature, there exists a canon of generally accepted procedures for screening children for occult injuries during the medical evaluation of physical abuse. The skeletal survey, first described in 1942 by radiologist John Caffey, is perhaps the most widely used and accepted medical test performed today in the evaluation of physical abuse in children under 2 years of age. Many studies have been published on the efficacy of skeletal surveys to detect occult fractures in this population. Wood et al. (2018) found that among a random chart sampling of 1,769 children evaluated for physical abuse with skeletal surveys, 24.6% of the youngest children (5 months and younger) and 3.6% of the oldest children (18-24 months) in the study had occult fractures. Blangis et al. (2020) found that initial skeletal surveys identified occult fractures in their population of children under 3 years to be 49% which increased another 9% when a second skeletal survey was performed 10-14 days after the initial, as is often customary, especially in the evaluation of non-mobile infants.

In another example, laboratory studies including transaminase, amylase, and lipase are now routinely used as screening tools to identify occult abdominal trauma. In one small study, Coant, Kornberg, Brody, and Edwards (1992) found that the use of these labs identified liver laceration in about 8% of children evaluated for concern of physical abuse who otherwise had no history of abdominal trauma and no external physical signs or symptoms. Herr and Fallat (2009) also published case studies illustrating the utility of these labs as a screening tool to detect occult abdominal injury. In yet another example of an abuse screening tool, Pierce et al. (2010) studied the cutaneous injuries of 95 children admitted to the PICU and found that based on the location of the bruises, those with bruising to the torso, ears, or neck as well as any bruising anywhere on

a non-mobile infant were found, with a 97% sensitivity and an 84% specificity, far more often among the abused rather than children without these bruising characteristics. These findings have since been updated and validated using in a sample of 2,123 children among 5 children's hospitals over a period of four years (Pierce et al., 2021).

Why Including Drug Endangerment Makes Sense

Missed signs of abuse have significant consequences. Peska et al. (2009) found that one-third of children in their study who were later determined to be abused had at least one medical visit with a provider who did not recognize those signs or symptoms of abuse. The delay in identification puts children at risk for additional and possibly more serious injuries as violence in the home continues unabated. In nearly half of Kentucky's child fatalities and near-fatalities, substance abuse by a caregiver was identified as a risk factor (Kentucky Child Fatality & Near-Fatality External Panel, 2020). The National Alliance for Drug Endangered Children (n.d.) defines drug endangered children as, "children who are at risk of suffering physical or emotional harm as a result of illegal drug use, possession, manufacturing, cultivation or distribution. They may also be children whose caretakers' substance misuse interferes with the caretaker's ability to parent and provide a safe and nurturing environment." While one may exacerbate the other, both physical abuse and living with a caregiver who abuses substances are each independently considered to be adverse childhood experiences (ACEs) according to the ground-breaking study published by Felitti et al. (1998). ACEs are associated with chronic stress and severe life-long consequences including long-term physical, mental, and behavior health disorders. The more ACEs a child experiences, the greater the risk to his or her health and well-being. For example, children with six or more ACEs live an average of 20 fewer years than children with no ACEs at

all. This held true even when researchers controlled for, among others, income, education, and current health behaviors (Felitti et al., 1998).

Children living with caregivers who abuse substances have nearly three times the risk of physical abuse (Wells, 2009). Petska et al. (2019) found that among 453 children younger than 5 years evaluated for physical abuse in their study, 5.1% had occult drug exposures detected by comprehensive urine drug testing at the time of their medical evaluations. Unfortunately, urine testing will only identify very recent exposures in quantities that reach their positivity threshold. While comprehensive urine drug screens are valuable in that they can detect very low thresholds of substances in the urine, they are also generally quite expensive. While immunoassay screens are much cheaper and can be performed at the point-of-care, the trade-off is that the positivity thresholds are usually much higher, with standards set to detect moderate to severe adult drug use (Hawks, Chiang, & National Institute of Drug Abuse, 1986). Overwhelmingly, studies indicated that immunoassay drug screens were rarely useful in hospital settings even for acute symptom management of ingestions (Christian et al., 2017; Tenebein, 2009; Wang & Drummer, 2015). Detecting remote exposure to drug use remains a limitation of all urine tests (Tenebein, 2009).

In a more recent study using hair toxicology testing for the detection of occult drug exposures, Howell, Bailey, and Coffman (2019) found that among children referred for evaluation of drug endangerment alone, 52% of the 1,150 children included in their study were identified as exposed to at least one illegal substance. Hair toxicology testing has a window of detection generally within the past three months. Even though hair toxicology testing has not been established as part of the canon of commonly accepted medical tests for child maltreatment evaluations, based on limited published data, hair toxicology testing has the potential to identify

drug endangerment which is, at minimum, diagnostic of environmental neglect. There is no established “safe” exposure of a child to any illicit substance, especially when considering that the child is dependent on an impaired adult caregiver. Among children who otherwise would have insufficient evidence for CPS mandated safety agreements, family service provision, or ongoing supervision and monitoring of compliance with case plans, identification of this often difficult to prove form of neglect could be life-changing.

Who to Test

Because there are no established practice standards by which to inform CAP physicians and nurse practitioners which children are at greatest risk for drug endangerment, understanding the available literature provides the only, albeit piece-meal, guidance. Oral et al. (2011) somewhat arbitrarily defined parameters for the types of cases that those authors considered for drug testing. These parameters included: 1. Caregiver history of domestic violence, 2. Caregiver history of substance abuse or substance abuse rehabilitation, 3. History of parental incarceration, and 4. Unusual or extreme injuries, extreme neglect or burn injuries regardless of the child’s age; however, children with “no or public insurance” increased the odds of a positive drug test by 4.49 times. Children with clinical presentations including injuries from physical abuse increased the odds of positive hair testing by 6.7 times. Children from homes where there was a reported presence of domestic violence increased the odds of positive hair testing by 2.81 times, and if the child had a parent with a drug use history, those odds for positive hair testing were increased by 3.42 times. Similarly, Howell, Bailey, and Coffman (2019) found that among those children they evaluated for maltreatment who had occult fractures, 100% (11/11) were positive for at least one illegal substance on hair toxicology tests. Both studies, reported an inverse relationship between the age of the child and positivity rates. Specifically, in the study of Howell et al.

(2019), children less than 2 years of age were 2.35 times more likely than children over 2 but less than 5 years of age and 7.42 times more likely than children over 5 years of age to test positive for at least one illicit substance by hair toxicology testing.

Choosing the Patient

Just as “photographs and x-rays or other appropriate medical diagnostic procedures may be taken or caused to be taken,” so may hair toxicology testing, “as a result of any report of suspected child abuse” under the authority of KRS 620.050 (14) without the consent of the parent. However, because hair toxicology testing does alter the child’s appearance, the CAP team requires a high level of suspicion for drug use by the caregiver. The decision to test and the number of panels within the test are ultimately the responsibility of the CAP attending physician (no nurse practitioners are currently employed in the CAP program), so no concrete methods for identifying appropriate (i.e., high risk) patients have been established. Generally accepted tenets, however, include:

- Referral for hair toxicology testing by CPS investigators or by court order
- History of substance abuse by a caregiver confirmed by CPS investigators through criminal background checks or previous CPS investigations
- History of substance abuse in the home reported by one caregiver about another
- Observable behaviors suspicious for caregiver intoxication by medical staff, police, or CPS investigators. These behaviors may include but are not limited to: falling asleep mid-sentence or while seated upright, difficulty to arouse from sleep to provide care for the child such as bottle or breast feedings, pressured speech, paranoid thinking, emotional disturbance, long absences from the hospitalized child without a substitute caregiver, and needle and/or “track” marks.

- Caregiver provided history that is incongruent with the injury or clinical presentation of the child.
- History of multiple previous CPS investigations, especially those involving reports of substance use by caregivers.
- History of permanent removal of other children from the child's current caregivers

The sample required for hair toxicology testing is typically a minimum of 100mg of hair, preferably about 1.5 inches or 3.8cm in length which provides the approximate 3-month window of exposure detection (USDTL, 2020). Therefore, children without enough hair must be excluded. All hair specimens are collected by CAP program RNs in accordance with procedures outlined by United States Drug Testing Laboratory (USDTL), the forensically certified laboratory used for hair toxicology testing purposes, and internal chain-of-custody procedures established at the children's hospital for both in-patient and outpatient tests. All hair toxicology tests were performed by USDTL which sets thresholds for positivity by initial immunoassay testing. Any "positive" test is then confirmed through the outside testing laboratory by either gas chromatography mass spectrometry or liquid chromatography tandem-mass-spectrometry instrumentation for confirmation purposes eliminating the possibility of "false-positive" results.

Purpose

The purpose of this retrospective chart review was to evaluate the yield of hair toxicology testing, a practice change implemented by one CAP team, among the population of children younger than 6 years of age who were evaluated for child maltreatment at the CAP evaluation center. The specific aim of the review was to identify potential patterns among drug-positive children including concurrent abuse or neglect findings, developmental and social characteristics,

and the most the commonly identified drugs of abuse. These findings could inform future practice.

One special subset of interest among the study population was children with physical abuse concerns for whom no concrete diagnosis was determined by the CAP team. Children in the diagnostic category for physical abuse often have stand-alone findings of maltreatment and therefore, child protective services investigators are able to substantiate or confirm the allegations. Substantiations are required to legally compel families to accept services such as parenting classes, substance use treatment, mental health treatment, or anger management therapy, which are designed to increase the parents' capacity to safely care for their children. In cases where maltreatment cannot be substantiated due to indeterminate medical findings, which is the majority, families are not required to accept services and children are often left vulnerable in high-risk situations. Hair testing for environmental exposure to illicit substances was implemented in an effort to narrow the gap between children who were protected by child protective services involvement and children who were not. This study sought to evaluate the yield of positive hair tests among children with indeterminate findings of maltreatment as a way to determine the efficacy of hair testing to change investigative outcomes by providing definitive evidence of drug endangerment regardless of the initial maltreatment concern.

Conceptual/Theoretical Framework

The conceptual theory used in the development of this project was a blend of King's Theory of Goal Attainment (1981) and the United Nations Universal Declaration of Human Rights (1948). Anyone familiar with King's work understands that the fundamental assumption is that of patient choice. King believed the patient's own goals, beliefs, and wishes related to his or her health are rational and in-keeping with the patient's values and role in society. It is,

therefore, the nurse's responsibility to assist, through communication and cooperative and supportive transaction with the patient, the attainment of the patient's goals. Because children, especially infants and pre-verbal toddlers, have not yet developed the depth of intellectual capacity and experience to make purposeful choices as they pertain to the quality of their own lives, the Universal Declaration of Human Rights (1948) was chosen as a proxy for the infant's own values. In particular, Article 25 was identified since it describes that, "Everyone has the right to a standard of living adequate for the health and wellbeing of himself and of his family, including food, clothing, housing, and medical care, and necessary social services and the right to security in the event...of circumstances beyond his control," as well as Article 22 which further delineates the "right to social security and is entitled to realization...of the economic, social, and cultural rights indispensable for his dignity and the free development of his personality."

Insomuch as it is accepted that physical abuse and living with a caregiver with substance use disorder are, each independently recognized as ACEs, the postulation is that children living in such environments have the right to protection from those adversities. Therefore, identification of potentially dangerous issues is paramount to maintaining the sanctity of the child's human rights.

Setting

This study took place in a CAP program office associated with a children's hospital located in an urban area of Kentucky using an existing database from which all information was extracted. The CAP program evaluates 1,000-1,200 children yearly for physical abuse, sexual abuse, or neglect concerns; the children are referred by the associated children's hospital, child protective services, police, county or commonwealth prosecutors, pediatricians, or other health

professionals and rarely, family members of the child suspected of having been abused. Not all children evaluated by the CAP program had hair testing for environmental exposure to illicit substances, however.

Methods

A retrospective chart review was completed using the CAP case database of children referred to the CAP program for evaluation of maltreatment in 2019 and 2020 after receipt of IRB approval. The database met all HIPAA requirements. The database is owned and maintained by University of Louisville on a secure, password protected server.

Target Population

The study population consisted of all children under 6 years of age referred to the CAP program in 2019 and 2020 for any concern of maltreatment who underwent hair toxicology testing as part of their medical evaluation for maltreatment concerns. Siblings evaluated as part of the risk of harm assessment as a result of the index child's findings were included if they also met the age restriction of under 6 years old. One child was evaluated twice, once in 2019 and once in 2020.

Procedures

The CAP database is used by the CAP team members to document on-going progress on the case evaluation including communication with investigators, pending information needed, status of the report, and to capture data for research purposes. According to CAP protocol, all cases referred to the CAP team for any reason are entered into the database.

The identification of potential cases included in this retrospective review consisted of two initial database searches conducted by the CAP program director using keywords: 1. "2019," "toxicity" and 2. "2020," "toxicity." An Excel spreadsheet was then created to further categorize

each case as described below. This spreadsheet was also stored on the secure server maintained by the university. Children were identified on the spreadsheet by their database assigned case number to maintain anonymity. The spreadsheet separated cases by their unique case numbers generated by the CAP database. No other identifying information was documented. Children not meeting the age restriction were removed from the spreadsheet.

Measures

For each case meeting the inclusion criteria, the following data were abstracted and categorized:

- Initial concern for maltreatment
 - Physical abuse (1)
 - Sexual abuse (2)
 - Neglect (3) *this includes medical and nutritional neglect as well as pediatric condition falsification
 - Drug endangerment (4) *this encompasses all children whose only concern is environmental drug exposure.
- Hair toxicology testing
 - Positive (1)
 - Negative (2)
- Substance in Positive cases
 - 6-MAM (heroin) (1)
 - Codeine/metabolite (2)
 - Hydrocodone/metabolite (3)
 - Methadone/metabolite (4)

- Buprenorphine/metabolite (5)
- Fentanyl/metabolite (6)
- Oxycodone/metabolite (7)
- Amphetamine (8) *not associated with concurrent positive for methamphetamine or suspicion for methamphetamine exposure
- Methamphetamine/metabolite (9)
- THC/metabolite (10)
- Cocaine/benzoylecgonine (11)
- Other (12)
- None (13)
- Poly Substance (more than one positive finding)
 - Yes (1)
 - No (2)
- Known or reported caregiver substance use disorder/drug history?
 - Yes (1)
 - No (2)
- Demographics
 - Race:
 - White Non-Hispanic (1)
 - Black Non-Hispanic (2)
 - Hispanic (3)
 - Other (4) *includes multi-race/ethnicity and unknown
 - Sex

- Male (1) *sex assigned at birth
 - Female (2)
 - Age
 - Non-mobile infant (1)
 - 6 months-<1 year (2)
 - 1 year-<2 years (3)
 - 2 years-<3 years (4)
 - 3 years-<4 years (5)
 - 4 year < 5 years (6)
 - 5 years < 6 years (7)
 - Zip code
 - Jefferson County, Kentucky (1)
 - Outside Jefferson County, Kentucky (2)

Was the exposure while the child was with a substitute caregiver?

*babysitter/non-custodial relative/school/daycare

 - Yes (1)
 - No (2)

- Was the hair testing performed while the patient was an inpatient at the hospital? *versus outpatient testing non-hospitalized patient
 - Yes (1)
 - No (2)
- Disposition and Final Determination
 - Discharge disposition

- With family (same caregivers) (1)
- Family with restrictions *supervision of parents or caregivers pending results of the CPS investigation (2)
- Kinship care *discharged to a relative's care (different caregiver and different environment)
- Foster care (4)
- Deceased (5)
- Unknown (6)
- Final Determination
 - Plausible (1) *history fits the injury
 - UD1 (2) *undetermined and concerning for abuse but not independently diagnostic
 - UD2 (3) *highly concerning for abuse, but not independently diagnostic
 - DA (4) diagnostic for inflicted injury and child maltreatment
 - Neglect (5)
 - Not enough information to determine (6)
 - Suspected sexual abuse (7)
- Among physically abused children with positive hair toxicology findings:
 - Type of injury
 - Skin (contusion/abrasion/laceration) (1)
 - Burn (2)
 - Fracture (3)

- Intracranial (4)
- Other (5)
- None (6)

Description of Variables

Diagnosis codes were used within the database to indicate the type of maltreatment concern for the case referral but may not reflect the actual diagnosis at the conclusion of the case evaluation. Diagnosis codes included “Physical abuse,” “Sexual abuse,” “Neglect,” and “Toxicity.” At the conclusion of the maltreatment evaluation in each case, a final determination is also coded. The final determination code refers to the level of certainty for the diagnosis. For example, among children in which “physical abuse” was the diagnosis code, one of six final determination codes is assigned. The first diagnosis code is “no injury” which may include medical conditions that mimic physical injuries, such as lichen sclerosis mistaken for genital injuries sustained from sexual abuse. The second is “plausible” meaning the injury was plausibly explained by the caregiver, such as a newly mobile infant being placed on an elevated surface such as a bed or couch, from which the infant rolled and sustained a simple linear parietal skull fracture without other concerning injuries. The third is “UD1,” indicating undetermined findings, a gray area of concern in which there is some characteristic of the injury, such as being unexplained, that raises concern for physical abuse, but does not meet diagnostic criteria. Generally speaking, “UD1” includes cases where the concern for abuse matches the likelihood for accidental injury and where neither can be excluded. The fourth diagnosis code category is “UD2” which is also considered indeterminate for abuse, but the level of concern is quite high though still not meeting criteria for the diagnosis of physical abuse. Finally, “DA” indicates that the injury is diagnostic for inflicted injury. This category includes cases in which the child is

unable to injure himself or herself due to developmental limitations such as multiple bilateral unexplained posterior rib fractures found on a non-mobile infant. This category is reserved for the greatest level of medical certainty for abuse.

Few, if any, children referred for sexual abuse also have hair toxicology testing. The CAP team is indirectly involved in sexual abuse cases, and generally only provided telephone support for medical work-up recommendations of the child at the initial presentation to the Emergency Department. A few of these children were captured in the data; however, a final determination is never reached by the CAP team because children with sexual abuse concerns are referred for follow-up to the Children's Advocacy Center (CAC), an off-site private entity that specifically serves this population. A diagnosis of neglect in sexual abuse cases would reflect the presence of positive hair toxicology findings.

The diagnosis code of neglect included medical neglect, nutritional neglect, or other/general such as uninhabitable housing, disease-causing sanitation problems, or access to deadly means such as firearms, or pediatric condition falsification. While neglect also encompasses environmental neglect, for the purposes of this retrospective review the environmental neglect diagnosis was only assigned to those cases in which the child had hair toxicology testing positive for at least one substance not otherwise explained.

Toxicity, for our purposes, was broadly defined as concern for drug exposure of some kind which includes environmental exposure to illicit drugs as well as acute ingestions of drugs or other toxic substances. Within the diagnosis code section, however, other qualifiers can be free typed into the space. As an example, this qualifier space allows the CAP members to further delineate which of these "toxicity" cases had hair, urine, or serum testing performed. Even if the

hair testing was ultimately determined to be negative, the diagnosis code of “toxicity” and the qualifier “hair” are used.

Oftentimes, children referred to the CAP team for maltreatment concerns also have siblings. Siblings are evaluated for maltreatment because of the risk of harm associated with being in an environment in which at least one child is suspected of being abused or neglected. As such, while there may be no obvious clinical indication of maltreatment, the associated risk and subsequent evaluation may also identify maltreatment in the sibling which are considered occult findings. Siblings who independently presented with concerns of physical abuse, sexual abuse, or neglect were not simply counted as “sibling at risk,” but rather as “index” cases.

Evaluation Plan/Data Analysis

This project sought to determine the yield of positive hair toxicology results among children evaluated for maltreatment by a CAP program in 2019 and 2020. Frequencies and percentages were used to describe the demographic characteristics of the sample, the different types of maltreatment, and occurrence of positive hair toxicology results. The overall yield of positivity was examined by type of presenting maltreatment and the final determination of the evaluation. Differences in proportions of maltreatment and positivity among population subsets were evaluated using frequencies and cross tabulations.

Consent

The researcher obtained a waiver of informed consent. This was a retrospective chart review so there were no opportunities to obtain informed consent. All data were entered into the medical record during the medical evaluation that took place during the hospital visit for the target population. The study involved no prospectively collected data. The results of the hair toxicology tests were previously shared with the medical provider of record in accordance with

continuity of care HIPAA standards. There was no risk to the patient during this review. The review had no direct impact on the patient's rights, welfare, or clinical care. Measures detailed below in the confidentiality section were implemented to minimize risk of data breach during record review and data collection.

This retrospective review benefits the general population by being able to document the yield of hair toxicology testing among young children referred to a CAP program for maltreatment concerns. Data from subpopulations within the whole provides adjunct understanding of the risk factors associated with environmental exposure to illicit substances.

Data Safety

The database used for this project was specific to this CAP program and was maintained on a private, password protected server by the University of Louisville. All patients were de-identified, referenced only by the case number assigned by the CAP team for the purposes of inclusion in the database. The database met HIPAA requirements.

Ethics

Testing children as a route to evaluate parental, specifically maternal substance abuse, is a practice now commonly adopted by obstetricians. Unfortunately, however, testing neonates is not universal; fewer than 25% of children born have any testing performed to evaluate for illicit substance exposure in utero (Wood, Smith, & Krasowski, 2017). While the American College of Obstetricians and Gynecologists (2015) does recommend "routine screening" of every woman for substance abuse, their recommendation falls short of endorsing the universal application of even qualitative tests of actual biological materials. Rather, obstetricians are encouraged to provide questionnaires to patients as the primary screening tool for substance abuse. In this instance, the absence of maternal self-report can hinder the identification of high-risk infants and

mothers. Therefore, suspicion of drug use often relies on the subjective opinion of medical providers may be heavily influenced by implicit or explicit biases. These sometimes very brief, opinion-based risk analyses may unfairly target certain marginalized groups while also overlooking other groups that do not conform to certain stereotypical characteristics of drug users. The existence of bias among healthcare workers has been reported in several studies (Cort, Cerulli, & He, 2010; Drake, Lee, & Jonson-Reid, 2009). In Kentucky, there are no legal barriers to medical performance of hair toxicology testing in the context of legitimate concern for and reporting of suspected child maltreatment.

Evidence of Benefit

While it seems intuitive that intervention for substance abuse among parents and caregivers would improve children's lives, there are a few caveats to consider. McLaughlin and Jonson-Reid (2017) compared, among all 50 states in the U.S., budgets for CPS agencies and found that when CPS and family budgets shrink, so do the number of substantiations for child abuse which implicates access to resources as a significant driver of outcomes for families. Without a substantiation of abuse or neglect, most, if not all, state CPS agencies cannot compel families to accept services for identified risk factors for ACEs (CHFS, 2011). Studies after the Felitti et al. (1998) ACEs study have since demonstrated the generational transmission of ACEs. Marie-Mitchell and Kostolansky (2019) found in their systematic review of randomized controlled trials that children of mothers who had experienced ACEs had poorer social and emotional scores than children of mothers without ACEs history. This risk is regardless of actual experienced ACEs of the mother's children, but that in-home services either through visiting nurses' programs or developmental intervention programs vastly improved outcomes for the families. Arria, Mericle, Meyers, and Winters (2012) found in their retrospective study involving

more than 5,000 adult participants who grew up with at least one substance abusing parent that among respondents whose fathers received substance abuse treatment, there was a lower risk for (respondent) substance abuse.

Results

In years 2019 and 2020, a total of 2,037 children were referred to the child abuse program for maltreatment concern. Among those, a total of 155 (7.6%) cases met study criteria (i.e., age 5 years old and younger and had hair toxicology testing that was coded as “toxicity” in the database). According to the child abuse program protocols, hair toxicology testing is considered in cases where the child’s injuries were severe or the child’s condition at hospital presentation was near-fatal (these included acute ingestion of illicit substances); the parent or caregiver appeared impaired or had a substance abuse history or concurrent allegations of substance abuse; a sibling living in the home tested positive for drugs; or the history or circumstances surrounding the patient’s presentation was unusual, bizarre, or otherwise did not make logical sense.

Table 1

Total Case Breakdown by Initial Referral Maltreatment Concern and Positivity Rate

Initial maltreatment concern prompting referral for medical evaluation	Number	Percentage of total	Positivity rate for at least one drug in hair
Physical abuse	41	26.4% (41/155)	85.4% (36/41)
Sexual abuse	5	3.2% (5/155)	100% (5/5)
General neglect	16	10.3% (16/155)	100% (16/16)
Substance use by caregivers <i>only</i>	93	83.5% (93/155)	90.3% (84/93)
Total	155	100% (155/155)	91% (141/155)

Of the five children included who were evaluated for sexual abuse, 100% had positive hair tests, findings that included methamphetamine (2/5), marijuana (2/5), and cocaine (1/5). Of the 16 children evaluated for neglect, 100% had positive hair tests. Marijuana was most commonly associated with neglect concerns (11/16), followed by methamphetamine (5/16),

buprenorphine (5/16) and cocaine (3/16). Of the 10 children classified as near-fatalities, 100% had positive hair tests. Of these children categorized as having a near-fatal presentation, marijuana was most highly associated (7/10), followed by methamphetamine (5/10), cocaine (2/10), buprenorphine (2/10), and fentanyl (2/10).

Overall characteristics involving entire study population

Only one child was included in the study twice. That particular child had two separate child abuse investigations at different time points, and therefore was included as two separate incidents. Hair toxicology testing panels were variable between 5-panel which included amphetamines, opiates, cocaine, CP, and cannabinoids to a 19-panel that also included benzodiazepines, barbiturates, methadone, propoxyphene, oxycodone, meperidine, tramadol, fentanyl, sufentanil, ketamine, buprenorphine, zolpidem, kratom, and gabapentin. Only one positive hair toxicology test (1/141) would not have detected at least one positive result using a 5-panel hair toxicology test (amphetamines, cocaine, cannabinoids, PCP, and *natural opiates).

Table 1-B

Frequency of drug findings among all study participants with positive hair tests

Drug	Number/141	Percentage of total	Found on Childguard 5 panel Toxicology (Y=YES; N=NO)
Methamphetamine	76	53.9%	Y
Marijuana	73	51.8%	Y
Cocaine	19	13.5%	Y
Buprenorphine	7	5%	N
Fentanyl	7	5%	N
Heroin	4	2.8%	Y
Oxycodone	3	2.1%	N
Hydrocodone	2	1.4%	Y
Methadone	2	1.4%	N
Amphetamine *not associated with methamphetamine exposure	1	0.7%	Y
Ketamine	1	0.7%	N

Table 2

Child & Family Characteristics among Positive Hair Tests

Characteristic	Number	Percentage of total	Positivity rate for at least one drug in hair
Child was with primary caregiver at the time of maltreatment evaluation	143	92.3% (143/155)	90.9% (130/143)
Child was in the care of a substitute caregiver at the time of maltreatment evaluation	12	7.74% (12/155)	91.7% (11/12)
Child lived within major metropolitan area at the time of maltreatment evaluation	36	23.2% (36/155)	88.9% (32/36)
Child lived in a community outside major metropolitan area at the time of maltreatment evaluation	119	76.7% (119/155)	91.6% (109/119)
Male	82	53% (82/155)	92.7% (76/82)
Female	73	47% (73/155)	89% (65/73)
Hospitalized at time of maltreatment evaluation	23	14.8% (23/155)	100% (23/23)
Child's condition at hospital presentation was classified as a near-fatality at the time of maltreatment evaluation	10	6.5% (10/155)	100% (10/10)
Race-white	101	65.2% (101/155)	88.1% (89/101)
Race-black	22	14.2% (22/155)	95.5% (21/22)
Ethnicity-Hispanic	6	3.4% (6/155)	100% (6/6)
Other-race/multi-racial/not indicated	26	16.8% (26/155)	96.2% (25/26)
Age <6 months	2	1.3% (2/155)	100% (2/2)
Age >6 months to <1 year	16	10.3% (16/155)	94% (15/16)
Age >1 year to <2 years	39	25.2% (39/155)	97.4% (38/39)
Age >2 years to <3 years	32	20.6% (32/155)	93.7% (30/32)
Age >3 years to <4 years	35	22.5% (35/155)	88.6% (31/35)
Age >4 years to <5 years	18	11.6% (18/155)	88.9% (16/18)
Age >5 years to <6 years	13	8.4% (13/155)	69.2% (9/13)

Case characteristics among children referred for physical abuse

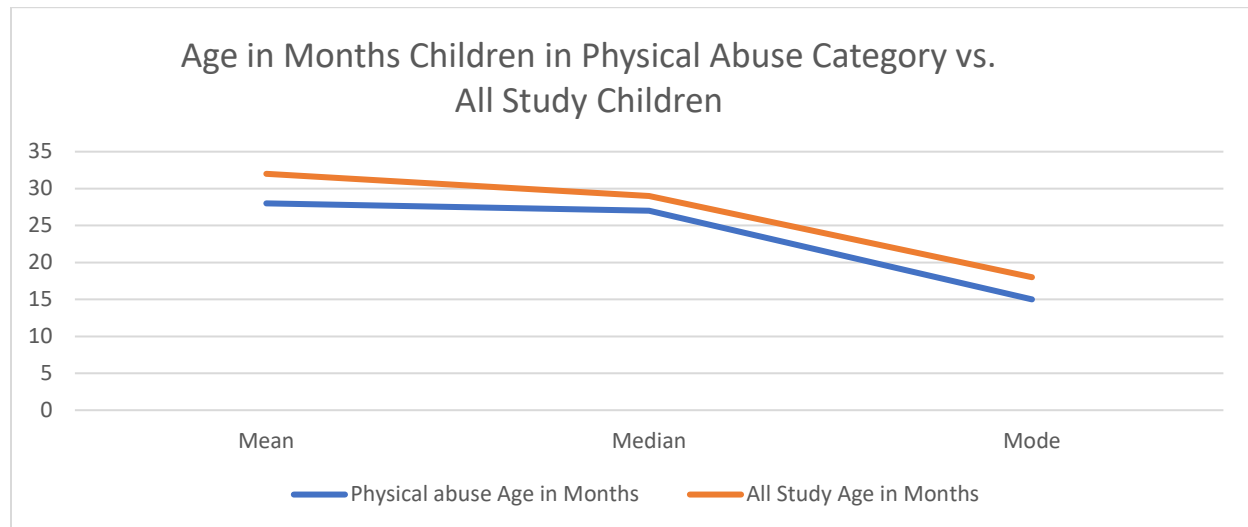
Of particular interest in this study was the subset of children initially referred for physical abuse symptoms ($n = 41$). Twelve of the children had injuries that were determined to be independently diagnostic for physical abuse, and therefore the addition of hair testing only added to the number of overall risk factors for the child but did not change the final determination of

abuse or neglect. However, all 12 children with injuries diagnostic for physical abuse also had hair tests positive for at least one drug. The remaining 29 children referred for physical abuse concerns either had no injuries at the time of maltreatment evaluation or injuries that, with varying degrees of likelihood, could have had other explanations and were considered indeterminate for abuse.

Of the 29 children with no injuries or non-diagnostic injuries, the overall positivity rate was 82.8% (24/29). Marijuana was the most common drug identified (12/29), followed by methamphetamine (10/29) and cocaine (4/29); though some hair tests were positive for more than one drug. Injuries in this subpopulation included bruising (19/29), burns (2/29), one intracranial injury (1/29), and the remainder had no injuries identified (7/29). Children evaluated for physical abuse were slightly younger; their a mean age was 28 months compared to children evaluated for all causes whose mean age was 32 months (see Figure 2). Among children evaluated for physical abuse, when the caregiver had an explicit allegation of substance abuse hair testing was positive in 90% of cases (27/30) while caregivers with no explicit allegation of substance abuse positive hair testing occurred 82% (9/11) of the time. Of note, among the entire study sample, alleged drug use by a parent or caregiver also had a 90% positivity rate (120/131).

Figure 2

Age in Months Children in Physical Abuse Category Verses All Study Children

**Discussion****Overall Study Observations**

The study sample was roughly equally divided between males (82/155) and females (73/155), and positivity rates were very similar (92.7% males vs. 89% females). Positivity rates grossly declined with increasing age, a phenomenon that was described in other studies (Pragst et al., 2019). Children who were documented as in the care of someone other than their primary caregiver, likewise, had near-equal positivity (91.7%) as children who were in the care of their primary caregivers (90.9%).

Toddlers over one year of age to less than four years of age made up the majority of the children (68.4%; 106/155). The youngest children in this study, (< 6 months) had a 100% positivity in hair tests (2/2); however, several factors can affect the interpretation of those results including whether the mother used any illicit substances during her pregnancy, what drugs may have been given at the hospital during the birth process, any medications provided to the neonate/infant, and whether the mother was prescribed any medications for pain or drug

dependency before, during, or after the child's birth. These factors should always be verified before interpretation of any hair tests in this age group can be reliably made.

Racial differences were confounded by the number of children whose race/ethnicity was not categorized. What was noticeable, however, was that while the majority of the children evaluated were white (65.2%), the urban area population is 69.92% white, while Kentucky as a whole is 87.5% white (United States Census Bureau, 2019). The percentage of white study participants was lower than the area population percentages, raising questions of potential biases in the selection of children that were tested. Additional contributing factors may also include hair color of the child, as brown hair color has been proposed to have a higher affinity for certain drugs, especially amphetamines and cocaine (Lewis, Moore, Morrissey, & Leikin, 1997). Adopting more concrete, less ambiguous indications for hair testing would likely decrease the potential for bias, but since children in racial and ethnic minority groups are still more likely to be reported for maltreatment concerns, bias would likely still exist (Cort, Cerulli, & He, 2010).

Potentially Clinically Useful Trends

Children with the highest positivity rates included children who were hospitalized (23/23) at the time the hair test sample was obtained as well as children with life-threatening or near-fatal conditions at hospital presentation (10/10). These findings support the child abuse pediatrics providers' assumptions that the more severe the child's clinical presentation the more likely the child is to have positive hair testing.

Children referred for general neglect (16/16) and children referred for sexual abuse (5/5) who were tested also had 100% positivity rates. While it may be understandable that the high degree of positivity for neglect is explained, at least in part, by caregiver drug use, hair drug positivity rates for children suspected of being sexually abused have previously been described

as quite low (Oral et al., 2011). While there were very few children referred for sexual abuse concerns who also had hair testing, the high positivity rate suggests that hair testing may be clinically useful in cases of suspected sexual abuse, especially if the child is pre-verbal. Stroud, Martens, and Barker (2000) found that the majority of sexual abuse cases that progress to criminal charges involve children over 4 years of age, suggesting that the ability to provide a verbal disclosure is one of the most, if not the most, significant evidentiary contribution to the decision to criminally prosecute suspected offenders.

Marijuana-Legalization Issues

Regardless of the initial referral concern, any child whose hair was positive for illicit drugs was diagnosed with neglect by the child abuse program providers. This is an important distinction since in areas where marijuana has been legalized, the designation of neglect may be less certain. Interestingly, among the 41 children evaluated for physical abuse, marijuana was the most frequently identified illicit drug in children's hair, closely followed by methamphetamine. All children with diagnostic injuries for physical abuse also had positive hair tests with marijuana being the most predominant of those, (8/12), with methamphetamine (7/12) followed closely behind. Among the remaining 29 children evaluated for physical abuse who had indeterminate findings, the addition of hair toxicology testing provided definitive proof of neglect in more than 82% (24/29) of those children, with 12 of those 29 being positive for marijuana followed by 10 of those 29 being positive for methamphetamine. Marijuana was also more frequently associated with near fatalities of children than any other drug (7/10). These findings are consistent with at least one other study (Freisthler, Gruenewald, & Price Wolf, 2015) in which parents who reported marijuana use within the past year engaged in physical abuse three times more frequently than parents who did not.

These results may represent regional trends and drug preferences. As more and more states legalize marijuana and push to decriminalize other drugs, the question of whether passive environmental exposure to marijuana, or other drugs, will continue to be considered neglect by child protection agencies and family courts will undoubtedly arise. More research is needed on the risks for maltreatment associated with caregiver use of marijuana in this new climate, especially where marijuana is no longer illegal, and substance use becomes less stigmatized.

Study Limitations

The number of participants (155) pales in comparison to the overall number of children evaluated for maltreatment over this 2-year period (2,037). While providers in the child abuse pediatrics program are generally very enthusiastic to offer hair testing as a part of the maltreatment evaluation, access to this service is severely limited to those families who are close to the hospital where the child abuse pediatrics program practices, have transportation, and adequate funds to travel. Few, if any, laboratories offer the type of Childguard testing performed by the child abuse pediatrics team, and fewer are willing to accept insurance payment for those services. Certainly, it is possible, indeed probable, that if hair testing were more accessible, then more children would have qualified for the study, thereby increasing the reliability of results.

Additional possible limitations of the study also include the very high overall test positivity rate (91%). These could represent skewed findings since the study authors relied upon the accuracy of identification of all children who underwent hair toxicology testing by the program through coding in the database. It is possible that some children with negative hair tests were not coded appropriately as “toxicity” in the database in the absence of drug findings.

CONCLUSION

The medical evaluation of child maltreatment is complex and multifaceted, yet there is no silver bullet that can accurately identify all cases of abuse or neglect. Failure to identify and intervene in child maltreatment can be costly, for the child, their families, and for society at large. Screening tools such as the use of skeletal surveys (2, 3), trauma labs (4, 5), and the TEN-4 and FACES bruising decision rule (6) have all been developed to increase the accuracy and likelihood of abuse recognition. The results of this study, while limited, do support the use of hair testing for drugs, especially among children who are pre-verbal, present with life-threatening or near-fatal conditions, or who have maltreatment concerns that are otherwise quite difficult to prove such as in instances of sexual abuse.

Only one case that had a positive result would not have been identified using a 5-panel hair toxicology test which includes amphetamines, cannabinoids, cocaine, PCP, and natural opiates. Even if we assume that the 14 negative tests may have had positive results for drugs that were not tested, the overall identification of at least one illicit substance in 90% of these cases supports the use of the less expensive 5-panel test (approximately \$65) unless there is a high level of concern for a specific drug that is not captured within this panel. Obviously, drug preferences may be regionally affected, so providers could consider developing relationships with law enforcement to help identify local and/or regional trends in illicit substances. Thus, hair testing can be more appropriately tailored to the community.

Accessibility to hair testing remains an obstacle to providing homogenous maltreatment evaluations across greater distances. Because the actual testing of hair is performed off-site at an outside forensically certified laboratory and because hair specimens do not require extreme temperature maintenance, nearly any medical practice has the capability of providing collection

procedures for hair sample testing. If child abuse pediatrics programs or other medical providers familiar with hair testing and the limitations of interpretation were to increase support services for interpretation, this could greatly increase access across the state to include more rural and more economically distressed areas.

Feasibility & Sustainability

According to the children's hospital laboratory, hair toxicology testing ranges from a cash price (sans insurance) of \$65 for a 5-panel test that includes amphetamines, cocaine, cannabinoids, *natural opiates and PCP, to approximately \$350 that includes a 16-panel test that adds benzodiazepines, barbiturates, methadone, propoxyphene, oxycodone, meperidine, tramadol, fentanyl, sufentanil, ketamine, and buprenorphine. The CAP program does not bill patients, patients' families, or insurance, but does receive financial support from the Kentucky Cabinet for Health and Family Services, Louisville Metro Police Department, and the University of Louisville and the associated children's hospital. Tests that are court ordered are paid for by the Kentucky Cabinet for Health and Family Services.

Dissemination

The final manuscript was presented to the *Journal of Pediatric Healthcare* and APSAC's publication, *Child Maltreatment*. The name of the hospital and the CAP program were not identified in any manuscript. Results of the project were shared with the CAP program director and clinical staff members. Results were also presented at the U of L SON poster presentation day and may be disseminated at a conference if selected.

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