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The Impact of Witnessing Domestic Violence on Hemoglobin A1C and C-Reactive Protein Levels in Children

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ABSTRACT

Objective: To investigate the impact of witnessing domestic violence (DV) on children's levels of high-sensitivity c-reactive protein (hs-CRP) and hemoglobin A1c (HbA1c). Further, to investigate whether DV exposure contributes to these outcomes above and beyond other child maltreatment (CM) or traumatic experiences.

Methods: The study analyzed data of 441 participants aged 8 to 13 years from the Child Health Study. The UCLA Posttraumatic Stress Disorder Reaction Index was used to evaluate youth self-reported experiences of traumatic events, including DV exposure and CM experiences. A peripheral blood draw was performed to allow for the assessment of HbA1c and hs-CRP.

Results: 31.1% of youth reported DV exposure, and of this subgroup about half (50.3%) of the participants reported DV exposure along with CM. DV exposure was significantly associated (B = 0.121, SE = 0.053, p = .024) with elevated hs-CRP but not HbA1c ($p > .40$) levels. When additionally including CM experiences or overall traumatic experiences, there was no longer a significant association between DV exposure and hs-CRP. With CM experiences and traumatic events considered, the association between DV exposure and HbA1c remained not significant.

Conclusion: DV exposure can impact hs-CRP levels in a similar way CM and trauma have previously been found to. Further research is necessary to investigate the impact of DV, CM, and trauma on CRP and HbA1c levels in youth so that a causal relation can be considered. This could allow the impacts of outside influences on the long-term consequences of witnessing DV to be better understood.

Key Words: domestic violence, c-reactive protein, hemoglobin A1c, child maltreatment

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Introduction

Child maltreatment, domestic violence, and physiological health outcomes

It has been long understood by researchers and medical professionals that adversity and trauma in childhood can have immediate and long-term consequences to an individual's physical, mental, and emotional wellbeing. In 1998, the Adverse Childhood Experiences (ACE) Study published groundbreaking research associating childhood adversity to numerous chronic diseases and leading causes of death in adulthood (Felitti et al., 1998). The study found that experiencing more forms of childhood adversity and household dysfunction led to a higher likelihood of experiencing adverse health consequences in adulthood. These consequences in adulthood include, but are not limited to, increased risk of severe obesity, ischemic heart disease, liver disease, cancer, alcoholism, depression and suicide attempts (Felitti et al., 1998). Of the numerous ACEs evaluated, two ACEs related to this study, child maltreatment (CM) and exposure to physical violence against the individual's mother, were found to have profound impacts on a child (CDC-Kaiser ACE Study, 2020).

Across the world, hundreds of millions of children witness domestic violence (DV), or intimate partner violence, in their homes (Behind Closed Doors, 2006). DV involves coercive or assaultive actions against an individual's intimate partner and can include physical, sexual, or emotional attacks (Behind Closed Doors, 2006). Examples of these attacks include biting, kicking, threatening with objects, forced sexual contact, isolation, humiliation, and coercion (Flury et al., 2010). Children witnessing DV involves any child that resides in the home witnessing the physical, sexual, or emotional attack on a caregiver, which can involve hearing or

seeing the incident. In the U.S., children's exposure to DV is often not considered a form of CM; an estimated 3.2 million children in the United States are exposed to DV each year (Siles, 2002).

Legal definitions of CM vary by state, but broadly speaking, the World Health Organization defines CM as any form of abuse or neglect to an individual under 18 years of age (Child maltreatment, 2020). It is important to acknowledge that information regarding DV, CM, and trauma is frequently underreported (Korbin & Krugman, 2014). However, based on previous research and findings that will be presented in this study, witnessing DV can have many similar long-term consequences compared to CM.

The exposure to violence in childhood can lead to children experiencing physical and mental health problems (Tsavoussis et al., 2014). The mental health problems associated with witnessing DV include anxiety, depression, and self-harm behaviors. While the present study does not focus on mental health, it is important to acknowledge because poor mental health can have consequences on physical health. In terms of physical health, CM is associated with type 2 diabetes in adulthood due to high glycated hemoglobin (Danese et al., 2009). CM is also associated with cardiovascular disease in adulthood due to high levels of inflammation seen in increased high-sensitivity CRP (hs-CRP) (Danese et al., 2009). This same study found that CM was one of three of the most influential ACEs on physical health. CM caused an increase in inflammation and metabolic risk markers, indicating the physical health consequences of cardiovascular disease, diabetes, obesity, and atherosclerosis. Existing studies suggest that there is an association between witnessing DV and physical problems (epileptic episodes, failure to thrive, and somatic complaints) (Kolbo, et al., 1996). One literature review included witnessing DV as a form of CM and found associations between the exposure and cardiovascular disease and type 2 diabetes in adulthood (Basu et al., 2017). Other research suggests that DV exposure

does not have a physical consequence on that individual, but rather an intergenerational consequence for the individual's offspring (Forke et al., 2019). Often, research on the impacts of children's exposure to DV focused on psychological consequences, but there is a need for further research on physiological consequences (Mohr & Fantuzzo, 2008).

Some children exposed to DV experience negative health outcomes, but many children do not due to resiliency and protective factors (Siles, 2002). Children that expressed resilience after DV exposure most often were not exposed to maternal depression, presented with easy temperament, and had familial support which acted as protective factors to early adversity (Martinez-Torteya et al., 2009). A need for early prevention and intervention strategies has been discussed in the literature to prevent adverse experiences from impacting chronic disease risk markers and changes to the inflammatory response associated with the chronic elevation of CRP in maltreated children (Gonzalez, 2013).

Some physiological markers have been found to be impacted by experiences of CM, such as changes in the levels of the biomarkers HbA1c and CRP. Levels of HbA1c and CRP are associated with an increased disease risk, such as diabetes, in regard to HbA1c (Pradhan et al., 2001) and coronary artery disease, in regard to CRP (Visser et al., 1999).

Associations between CM and DV and CRP

The long-term consequences of cardiovascular disease and diabetes occur because of underlying mechanisms involving inflammation and metabolic markers. A specific mechanism is the relation between CRP levels and obesity and heart disease (Visser et al., 1999). Serum CRP levels are used to indicate systemic inflammation (Visser et al., 1999). CRP is relevant to an

individual's long-term health because elevated levels have been associated with chronic conditions such as coronary heart disease and increased risk of stroke (Visser et al., 1999). Inflammation as a result of elevated CRP has also been associated with diabetes (Pradhan et al., 2001) and cardiovascular disease (Sin & Man, 2003). A systematic review of 20 studies found that individuals exposed to CM had desensitized hypothalamic-pituitary-adrenal axis responses resulting in overactivation of the inflammatory response leading to an overproduction of CRP (Coelho et al., 2013). Another study, which followed participants from birth to age 32, found that CM can increase inflammation in adulthood (Danese et al., 2007).

Specifically, CRP has been shown to be increased among adult CM survivors (Hepgul et al., 2012). Studies have found that both children who experienced maltreatment and adults with a history of maltreatment in childhood can present with elevated levels of CRP (Gonzalez, 2013). Different forms of CM, for example physical, emotional, and sexual abuse, impact the elevation of CRP levels to different degrees. One study found that individuals with official reports of CM did experience elevated CRP levels, while no association between CM and CRP levels were found for adults who retrospectively self-reported CM (Osborn & Wisdom, 2020). Previous research has found elevated levels of CRP in adolescents due to victimization in childhood (Baldwin et al., 2018). In this study, several measures of childhood victimization were utilized, including witnessing DV, peer bullying, and maltreatment committed by an adult (Baldwin et al., 2018). In regard to CM, increased CRP levels, as well as higher BMIs, are associated with the maltreatment exposure (Hepgul et al., 2012). Although several studies now show associations between CM and inflammation, it is less clear whether witnessing DV is similarly associated with inflammation.

Current evidence suggests that levels of CRP for maltreated children can vary and are impacted by characteristics of the child. For example, children who express more internalizing symptoms (withdrawal, somatic complaints, and anxiety/depression) tend to present with higher CRP levels in close proximity to maltreatment exposure (Cicchetti, 2015). Changes to this chronic disease risk marker and inflammatory marker present the link between childhood adversity and negative adult health consequences (Coelho et al., 2013). These studies add to the body of literature which connects stressful life events in youth to higher inflammation which can be seen in elevated levels of CRP and can therefore lead to higher cardiovascular disease risk in adulthood. A clear link has not been established in the association between DV exposure and CRP. There is a potential association between witnessing DV and elevated levels of CRP which then could increase risk of cardiovascular disease. Based on prior research, it is suggested that experiencing stress is associated with increased inflammation (Black & Garbutt, 2002). Long-term, the elevated inflammation increases risk for cardiovascular disease and other diseases of aging (Black & Garbutt, 2002). Due to this, we expect DV exposure to have a similar effect on CRP and overall physical health.

Associations between CM and DV and HbA1c

The biomarker HbA1c can also be used to assess health implications of witnessing DV, specifically in relation to type 2 diabetes risk. The glycated HbA1c test provides a two-to-three-month blood glucose concentration average, which can be used to screen for type 2 diabetes (Bennett, Guo, & Dharmage, 2007). Elevated levels of HbA1c are problematic at 5.7% but indicate a diagnosis of diabetes at or above 6.5% (Type 2 diabetes in children, 2020). This can be

used to indicate whether there is chronic elevation of blood glucose and the ability of the body to control these levels. Chronic elevation of blood glucose indicates dysregulation of the metabolic system (Snieder et al., 2001).

Experiences of physical abuse and neglect have been linked to elevated levels of HbA1c, leading to poor glycemic control when following children utilizing a prospective cohort design (Korbin & Krugman, 2014). ACEs such as CM have a long-term impact on metabolic activity and have been linked to the development of type 2 diabetes (Danese & McEwen, 2012). Another study found that when all other forms of abuse and neglect were controlled for, it was sexual abuse experienced by men in their childhood that was associated with diabetes in adulthood (Duncan et al., 2015). Specifically, men with a history of sexual abuse had a 3.63 greater chance of developing diabetes compared to control individuals (Duncan et al., 2015). For women, although no association between CM and diabetes was found, they were at a greater risk for prediabetes when there was a history of neglect in childhood (Duncan et al., 2015). This broadly supports the association of CM and diabetes risk, but more research is needed because the role of sex differences is not yet well understood. When one study investigated the association between childhood adversity and obesity in adulthood, it found that experiences such as CM and witnessing abuse raised obesity rates from 20% to 50% (Thomas, Hyppönen, & Power, 2008). The link to obesity led to elevated glycated hemoglobin levels which increases the risk for type 2 diabetes in adulthood (Thomas, Hyppönen, & Power, 2008). There is a need for a better understanding whether DV exposure also impacts HbA1c in ways similar to CM. A clear link has not been established in the association between DV exposure and HbA1c. There is a potential association between witnessing DV and elevated levels of HbA1c which then could increase risk of diabetes.

The Current Research

The goal of the present study is to investigate whether DV exposure in youth has adverse effects on physiological markers of disease risk. A main caveat of existing research is that most study designs rely heavily on retrospective recall of childhood experiences among adults. The studies often do not look at the health consequences until years after the maltreatment has occurred. This study improves on existing research because it gathers data close in time to when the maltreatment occurred to evaluate the health outcomes associated with physiological markers of disease risk.

We set out to answer four research questions. First, to determine the prevalence of DV exposure in this sample of youth participants from the Child Health Study and how many of the participants report only DV exposure or DV exposure in addition to CM. Second, we sought to test whether exposure to DV is associated with a child's levels of HbA1c and/or CRP, whether CM predicts a child's levels of HbA1c and/or CRP, and whether overall trauma exposure more generally predicts a child's levels of HbA1c and/or CRP. To this end, we hypothesized that if a child witnesses DV they will have increased levels of HbA1c and CRP compared to children who have not reported DV exposure. We also hypothesized that a child exposed to CM or overall trauma would have increased levels of HbA1c and CRP compared to children who did not report CM or trauma exposure. Third, whether exposure to DV is associated with HbA1c and CRP levels in participants after additionally taking into account CM. We hypothesized that if a child is exposed to DV and CM, then DV exposure specifically will no longer predict higher levels of HbA1c and CRP. Fourth, we sought to test whether exposure to DV is associated with HbA1c and CRP levels in children after additionally taking into account all other reported trauma. To

this end, we hypothesized that if a child is exposed to DV and other trauma, then DV exposure specifically will no longer predict higher levels of HbA1c and CRP.

Methods

Participants

The participants in this study were 441 youth between the ages of 8 and 13 years who were recruited for the Child Health Study. These children were recruited from 23 counties across Pennsylvania between August 2017 and March 2020. The youth with reported CM exposure were contacted within 12 months of a Children and Youth Services (CYS) investigation for sexual abuse, physical abuse, or neglect; this was not relevant to the comparison youth. Youth included in the study had to have lived with their primary caregiver for 3 months prior to the visit date. The youth who experienced maltreatment and the comparison youth, without a reported history of maltreatment, were matched in terms of sociodemographic information (age, sex, minority status, family income, and region of the state). The comparison youth were carefully screened to ensure that they had no past involvement with CYS. All youth participants were excluded if they presented with serious chronic health problems or developmental delays. The data included 213 (48.3%) female participants, 224 (50.8%) male participants, and two participants who identified as transgender, but for the purposes of data analyses were coded in accordance with their biological sex (both female), due to the absence of undergoing hormonal treatments at the time of the visit. Caregiver informed consent was required, and English must have been the first language used in the home. Participants 11 years of age and older provided assent to the study. The recruited individuals were primarily Caucasian and identified as non-Hispanic; details of race and ethnicity can be found in Table 1. For further details regarding participant characteristics, see Table 1.

Procedure

The participating youth attended an all day visit with their caregiver at the Penn State (University Park, PA) campus. Youth and caregivers arrived the night prior and stayed in a local hotel. If the family was local, they arrived the morning of the study. Once written consent was received, the child and caregiver went through a day of data collection, while also being provided breakfast and lunch. Following consent, the child first participated in a fasting blood draw performed by a trained phlebotomist, and the caregiver answered forms regarding demographic and health information about themselves and the child. Prior to the blood draw, the participant had the option to apply a topical anesthetic to their arm to numb and alleviate discomfort during the blood draw. The child and caregiver then privately completed questionnaires in adjacent rooms regarding their own feelings and life experiences with trained research assistants. Participants also completed an MRI scan and multiple other questionnaires via an iPad and paper measures. These measures were not relevant to the focus of the present paper. The UCLA Posttraumatic Stress Disorder Reaction Index (UCLA PTSD RI) was administered by a trained research assistant. The visit concluded with a debrief and craft activity for the youth. Participants are to be reassessed every two years, but this paper focuses on the analyses from visit one data. This study was approved through the University's Institutional Review Board (IRB) and is funded by the National Institutes of Health (NIH). Participants received a participation incentive of $160 each visit as a reimbursement for their time.

Measures

Trauma history

UCLA Posttraumatic Stress Disorder Reaction Index. The youth participant completed the UCLA PTSD RI (Steinberg et al., 2013). This measure is in line with the DSM-5 to evaluate trauma during childhood and adolescence, i.e., before the age of 18. The measure includes 23 items total with questions about different traumatic events. Each question yields a yes or no answer, which was coded as yes, it did happen (1) or no, it did not happen (0). Due to the complexity of the measure, a trained interviewer helped the youth participant through the 23 items in a structured interview manner, marking down the exact youth report. For the purpose of this study, we operationalized DV exposure, CM, and other trauma as follows: of the 23 items, one question assessed DV, and seven items reflected on other forms of CM. The report for the one DV exposure item was the total DV score and could have totaled either 0 or 1. For the DV exposure item, n=5 (1.1%) participants' data were missing. The sum of the seven items was reported as the CM score, which could have had a total sum of 0 to 7. The other trauma exposure score was a sum of 22 items regarding all trauma, excluding the one item reporting DV exposure. The other trauma exposure score could total 0 to 22.

Outcome Measures

The blood samples were picked up and delivered via same-day courier by Quest Diagnostics, a clinical laboratory. The results were typically returned to the study staff within 24 hours. Youth participants were instructed to fast overnight prior to arrival.

HbA1c

Whole blood was collected into a 4ml Ethylenediaminetetraacetic acid (EDTA) tube and then HbA1c was measured in the blood. This blood sample was refrigerated immediately upon draw until pick-up. HbA1c serum samples were assayed by Quest Diagnostics utilizing enzymatic methodology. For children, an HbA1c test level of 6.5% or higher indicates type 2 diabetes (Type 2 diabetes in children, 2020). An HbA1c level below 5.7% is considered normal, while 5.7% to 6.4% is considered prediabetic (Rooney et al., 2021). HbA1c blood draw results were missing for n = 54 participants.

Hs-CRP

Whole blood was collected into a serum separator tube (SST) and then hs-CRP was measured in the serum. This blood sample had to rest for 30 minutes to allow for clotting. The sample was then centrifuged to separate the serum. The sample rested at room temperature until pick-up. Hs-CRP serum samples were assayed by Quest Diagnostics using immunoturbidimetric assay. Hs-CRP assays were utilized as it can accurately detect lower levels of CRP (Windgassen et al., 2011). As supported by the American Heart Association: an optimal level of hs-CRP is below 1 mg/L, a level ranging from 1-3 mg/L presents moderate risk, and any value above 3 mg/L presents high risk for potential cardiovascular health consequences (Ridker, 2003). These values were based on the collection of hs-CRP and are an important indicator for risk of cardiovascular disease and type 2 diabetes (Ridker, 2003). Hs-CRP blood draw results were missing for n = 47 participants.

Covariates

Sociodemographic information including sex, race, ethnicity, age, and income were reported by the caregiver in regard to the youth participant. Children's age- and sex-adjusted BMI percentiles were assessed using the CDC growth charts based on height and weight measurements collected during the study, without shoes and outerwear (Clinical Growth Charts, 2017). In the morning, the youth participant's weight was measured using a standing scale, and height was measured using a wall mounted tape measure. This measure defined a BMI above the 85th percentile as overweight, and any BMI above the 95th percentile as obese (Clinical Growth Charts, 2017).

Statistical Analyses

For the analyses, HbA1c and hs-CRP were the outcome variables with DV exposure, CM, and other trauma exposure acting as the predictor variables. The covariates included in the regression analyses were age, sex, race, ethnicity, total family income, and BMI percentile. HbA1c and hs-CRP values were log-transformed to reduce skewness, before the linear regression was analyzed. After the log transformation, the hs-CRP data was no longer positively skewed, but for the HbA1c data there were five values still more than three standard deviations away from the mean. The analyses were not rerun without the outliers because their inclusion did not change the results and therefore, were elected to be kept in the analyses. Linear regressions were run to assess the main research questions addressed in this study. The first linear regression run was to assess the impact of DV exposure on hs-CRP and HbA1c. Hs-CRP and HbA1c analyses were run in separate models. Additional linear regression models were run. First, DV

exposure and CM were simultaneously considered to address the impact on hs-CRP and HbA1c. Second, DV exposure and other trauma were simultaneously considered to address the impact on hs-CRP and HbA1c. These linear regressions aimed to identify the independent effects of DV exposure when considered at the same time as other adverse childhood experiences. Results were considered to be statistically significant if the p-value was less than 0.05. IBM SPSS Statistics version 26 was used to analyze the data.

Results

Sample Descriptives

The sample consisted of youth participants with an average age of 11.47 years. Among the children in the study, the most common form of maltreatment was physical abuse, which 38.8% of youth participants had experienced. In addition, 13.2% reported sexual abuse, 33.6% reported neglect, and 14.5% were matched comparison participants who did not have prior CYS involvement. For enrollment purposes, each participant was assigned to one main category of maltreatment based on the CYS report, but many participants had experienced multiple forms of CM. The sample came from largely lower income families, with 59.8% of participants reporting family incomes below $39,999. Refer to Table 1 for more details regarding the distribution of sample descriptives among the participants.

Reported prevalence of adverse experiences

Based on the UCLA PTSD RI, 31.1% of youth endorsed DV. Among those who did endorse DV, 50.3% also endorsed at least one of the seven CM exposure items. Of the seven items indicating CM, on average youth endorsed 0.53 items with a standard deviation of 0.91. Of the 22 items indicating trauma, on average youth endorsed 3.67 items with a standard deviation of 2.61. Refer to Table 1 for more details regarding the prevalence of adverse experiences.

Main effects of domestic violence exposure

Hs-CRP

DV exposure was significantly associated with hs-CRP (B = 0.121, SE = 0.053, p = 0.024). This indicates that youth who reported past DV exposure had higher hs-CRP levels than youth who did not report DV exposure. Refer to Table 2 for more details regarding the results of the linear regression models.

HbA1c

DV exposure was not significantly associated with HbA1c ($p > 0.4$), indicating that youth who reported past DV exposure did not have significantly different levels of HbA1c. Refer to Table 2 for more details regarding the results of the linear regression models.

Independent effects of domestic violence and child maltreatment exposure

Hs-CRP

When simultaneously considering the effect of witnessing DV and CM, neither was associated with hs-CRP levels (DV exposure: B = 0.098, SE = 0.055, p = 0.074; CM exposure: B = 0.043, SE = 0.028, p = 0.129), indicating that youth's reports of DV exposure and CM did not affect hs-CRP levels when considered together. Refer to Table 2 for more details regarding the results of the linear regression models.

HbA1c

When simultaneously considering the effect of witnessing DV and CM, neither was associated with HbA1c levels (DV exposure: B = 0.003, SE = 0.003, p = 0.441; CM exposure: B = -0.001, SE = 0.002, p = 0.683), indicating that youth's reports of DV exposure and CM did not affect HbA1c levels when considered together. Refer to Table 2 for more details regarding the results of the linear regression models.

Independent effects of domestic violence and overall trauma

Hs-CRP

When simultaneously considering the effect of witnessing DV and all other trauma items, neither was associated with hs-CRP levels (DV exposure: B = 0.106, SE = 0.056, p = 0.060; Trauma exposure: B = 0.008, SE = 0.010, p = 0.414), indicating that youth's reports of DV exposure and all other trauma items did not affect hs-CRP levels when considered together. Refer to Table 2 for more details regarding the results of the linear regression models.

HbA1c

When simultaneously considering the effect of witnessing DV and all other trauma items, neither was associated with HbA1c levels (DV exposure: B = 0.001, SE = 0.003, p = 0.693; Trauma exposure: B = 0.000, SE = 0.001, p = 0.434), indicating that youth's reports of DV exposure and all other trauma items did not affect HbA1c levels when considered together. Refer to Table 2 for more details regarding the results of the linear regression models.

Discussion

This study aimed to investigate the prevalence of witnessing DV and CM within the sample and evaluate how the presence of DV exposure, CM, and trauma exposures impacted HbA1c and/or hs-CRP levels. A substantial minority of youth reported having experienced DV, and this was associated with one of the two chronic disease markers studied. The present study found that witnessing DV was associated with increased hs-CRP levels. However, the majority of other findings were not statistically significant. The present research is important because past studies have mainly focused on the psychological and behavioral effects of witnessing DV, rather than physiological effects (Siles, 2002).

Evaluating the first research question, the prevalence of witnessing DV was about 31% for this sample of youth participants, indicating that almost one in three children had reported exposure to DV. This aligns with other studies, which had estimated up to 1/3 of children are exposed to DV before the age of 18 (Carlson, 2000). The estimates indicating the prevalence of youth exposed to DV have been criticized as too conservative (Carlson, 2000). Another study analyzed data which reported that 42% of youth participants had indicated DV exposure in an ACE screener (Heard-Garris et al., 2020).

The present study's data for the second hypothesis provides statistically significant evidence for an association between reported DV exposure and increased hs-CRP levels in youth participants. This finding is in line with earlier research indicating that experiences such as witnessing DV can lead to increased levels of CRP (Baldwin et al., 2018). Recent research, which also recruited children immediately upon reported maltreatment, did find an association between CM and CRP, but only in females (Entringer et al., 2020). In comparison, another study challenges that claim by stating a significant association between DV exposure and other

individual ACEs and CRP at age nine was not found (Heard-Garris et al., 2020). The study followed a prospective cohort design like the previous two studies but differed in the way DV exposure was measured and in the sample population that was followed. These differences could have impacted the contradicting findings. The study did note that there was potential for an association between DV exposure and elevated CRP later in life even though the data did not indicate an immediate impact on CRP.

The second portion of the second hypothesis was not supported because DV exposure did not impact HbA1c levels in this study. While HbA1c is linked to diabetes, inflammation related to elevated CRP levels could be the mechanism explaining diabetes in individuals with a history of CM and DV exposure (Pradhan et al., 2001). It is also possible that data collection was too close in time to DV exposure to indicate a change in HbA1c levels (Forke et al., 2019). This could also be due to the limitations of the study which are described below.

The third hypothesis was supported in that exposure to DV, when simultaneously considering CM, no longer impacted hs-CRP and still did not impact HbA1c. When CM is added to the model, the study finds that DV exposure is no longer significantly related to hs-CRP, but rather becomes marginally significant for hs-CRP levels. CM is not associated with hs-CRP, and DV exposure no longer significantly predicts elevated hs-CRP levels in this model. This is seen when CM and DV exposure are analyzed together, in that it is not merely DV exposure impacting hs-CRP and HbA1c.

Finally, the fourth hypothesis was supported in that exposure to DV when simultaneously considering all other trauma exposures also did not impact hs-CRP or HbA1c. This poses interesting questions surrounding the strength of each of the relations. Further research is needed to evaluate which forms of trauma have the greatest impact on increasing disease risk due to the

elevation of inflammatory and metabolic markers. This is important so it is better understood exposure to which traumatic experiences have the largest impact on overall health, which could lead to the implementation of prevention and intervention strategies (Gonzalez, 2013).

The constant in each regression for both hs-CRP and HbA1c was either significant or marginally significant. These p-values indicate that there are outside factors which were not controlled for that impact hs-CRP and HbA1c levels other than DV, CM, trauma, and the covariates. An outside factor not considered was exercise. The present study did not control for exercise, but exercise is a health behavior that has been associated with lower CRP and decreasing risk of cardiovascular disease and type 2 diabetes (Owen et al., 2010). The significance of the constant could also indicate a problem with the validity of the measure.

When a child is exposed to DV they are at an increased risk of experiencing CM, specifically when the CM exposure consists of sexual or physical abuse (Hornor, 2005). The CM exposure could have acted as a mediating factor. This mediating factor could explain why witnessing DV was not significantly associated with HbA1c and hs-CRP when CM was considered. In addition, the youth that indicated only DV exposure could have been exposed to CM and did not report that experience.

It is important to acknowledge that the data in this study is based on the youths' reported experiences and is a primary strength of the study. The selection of youth reported UCLA PTSD RI poses benefits to the study due to the self-reported experience. The child report was selected for analyses over caregiver report because the caregiver might fear reporting due to judgement. Also, the caregiver might be unaware of a child's exposure to different events that constitute trauma. The UCLA PTSD RI evaluates whether the experiences in each item have occurred within the individual's first 18 years of life. For the youth in this study, these questions evaluate

if the exposure had occurred at any point in their lifetime. Many youth can struggle to determine life events within a specific time. Therefore, the UCLA PTSD RI is beneficial because it captures all events within the youth's life and allows them to more accurately report their experiences.

Overall, this study is unique in its ability to collect data through a prospective cohort design. The study is gathering participant data in close proximity to the trauma exposure. This means that the data on the physiological markers were collected shortly after the CYS report. Studies that rely on recall years into adulthood have the potential to be confounded by a multitude of other factors that can greatly influence health outcomes, such as diabetes and cardiovascular disease (Danese et al., 2009). Systematic reviews of the literature have found that retrospective studies found evidence for inflammation in adulthood, specifically elevated levels of CRP in relation to CM (Kerr et al., 2020). There is inconsistent evidence in regard to statistically significant associations between CM and inflammatory markers in adulthood, primarily due to smaller sample sizes. The systematic review also expressed the strength of prospective studies to show the association between CM and elevated CRP levels both in childhood and adulthood (Kerr et al., 2020). For future research, the Child Health Study plans to follow the youth participants and will collect further data which will have the capacity to investigate the impact of witnessing DV on hs-CRP and HbA1c levels in youth participants. This is important because past studies suggest that an increase in CRP and HbA1c can be seen overtime and into adulthood (Kerr et al., 2020).

The utilization of the UCLA PTSD RI child report is limited to the child's understanding of trauma, which could pose as a limitation because the youth might not understand or know that they were exposed to DV, CM, or trauma. The child is guided by the interviewer in explaining

the questions of the UCLA PTSD RI, but a lack of clarity or understanding could still be present. The youth could have also been exposed early in development and be unable to remember the experience, compared to the caregiver who would be able to more accurately report.

Another limitation of the UCLA PTSD RI is that it did not allow this study to determine frequency, severity, and recency of the exposure. The participant is merely endorsing whether that item has ever happened or not. This is problematic because studies have found that coinciding experiences of acute and chronic stressors can moderate the outcome of physiological consequences (Boyce et al., 1995). For example, a participant who heard a violent encounter between their caregivers once compared to a participant who saw their caregiver violently abused over the course of months or years both endorsed DV exposure once. These experiences differ in frequency, severity, and recency and therefore could have very different impacts on hs-CRP and HbA1c, but this study analyzes the events as being equal.

The design of the study could also have impacted the null results. These cross-sectional analyses evaluated youth once, between the age of eight and thirteen years old. It is quite possible that to find significant results for levels of HbA1c there must be a follow up with these individuals later in life (Basu et al., 2017). Due to the retrospective design of most childhood trauma studies, measures of CRP and HbA1c are often taken in adulthood. While some results (for CRP) were seen, the data collection in this study could be too immediate to show results at the time of the participants' evaluation. Forke and colleagues (2019), found that exposure to DV in childhood did not affect participants' physical health, but was associated with intergenerational consequences on their child's health. This finding suggests that DV exposure may have negative consequences that can be far reaching and take years to be detectable.

Due to the ethical implications of assigning youth the CM or DV exposure, causality of the relation between CM exposure and CRP can be difficult to prove, presenting another limitation to the present study design (Danese et al., 2007). There are many different factors that could have impacted this study: quality of the measures, recruitment of sample participants, and time between the adverse exposure and recruitment to the study. Study procedures took a full day which could be tiring, complicated, or overwhelming for the youth participants. At the same time, a one-day study limited the measures that could be included for data collection. The participants were only from Pennsylvania, and recruitment from other regions would diversify the sample. Finally, although there are benefits to collecting data close in time to trauma exposure, it could take months or years for significant data on health consequences to appear (Felitti et al., 1998). For these reasons, follow up studies using a prospective cohort approach should be considered.

Future research would benefit from investigating the numerous other influences that could be impacting CRP and HbA1c levels in youth who have experienced adversity. Research on other influences could include gender, race, and total family income. This is evident in how the literature can differ in the outcomes for other influences such as gender (Entringer et al., 2020). However, it is evident that DV exposure and CM individually impact hs-CRP levels and further research into this association is necessary. This is necessary so causality can be determined between DV exposure and hs-CRP levels.

Conclusion

The present study evaluated the impact of children's exposure to DV on hs-CRP and HbA1c, physiological markers for chronic disease risk. The results suggest that DV exposure was associated with increased levels of hs-CRP. DV exposure and HbA1c were not significantly associated. DV exposure when simultaneously considering CM and DV exposure and when simultaneously considering overall trauma were not significantly associated with hs-CRP and HbA1c levels. These findings present important information on the impact of child witnessed DV on hs-CRP and HbA1c and the long-term health consequences that could be associated with such exposure. Thus, it might be important to consider DV exposure alongside other more 'traditional' forms of CM because witnessing DV too can have negative effects on later health. Further research is necessary to better understand this association and therefore, more effectively implement prevention and intervention strategies to better protect vulnerable children (Carlson, 2000).

Appendix A

Table 1. Sample Descriptives (N=441)

Variables	n (%)	M (SD)
Age		11.5 (1.5)
Sex		
Male	224 (50.8)	
Female	213 (48.3)	
Race		
White/Caucasian	307 (69.6)	
Black/African American	66 (15.0)	
American Indian/Alaskan Native	2 (0.5)	
Asian/Pacific Islander	1 (0.2)	
Multiracial	44 (10.0)	
Other	16 (3.6)	
Ethnicity		
non-Hispanic	381 (86.4)	
Hispanic	55 (12.5)	
Total Family Income		
<$10,000	64 (14.5)	
$10,000-$19,999	71 (16.1)	
$20,000-$29,999	84 (19.0)	
$30,000-$39,999	45 (10.2)	
$40,000-$49,999	35 (7.9)	
$50,000-$59,999	25 (5.7)	
$60,000-$69,999	24 (5.4)	
$70,000-$79,999	23 (5.2)	
$80,000-$89,999	15 (3.4)	
$90,000-$99,999	4 (0.9)	
$100,000-$120,000	20 (4.5)	
>$120,000	27 (6.1)	
BMI Percentile		69.1 (30.6)
Child Maltreatment Group		
Comparison	64 (14.5)	
Maltreatment	377 (85.5)	
Primary Abuse Reported to CYS at Study Enrollment		
Physical	171 (38.8)	
Sexual	58 (13.2)	
Neglect	148 (33.6)	
Comparison	64 (14.5)	
Health Outcome Measures		
HbA1c (log)		.79 (.03)
CRP (log)		-.18 (.51)
Self-Report on UCLA PTSD RI		
# of Youth Reported DV Exposure	137 (31.1)	
# of Youth Reported DV and CM Exposure	73 (50.3)	
CM Items Endorsed		.53 (.91)
Trauma Items Endorsed		3.7 (2.6)

Table 2. Linear Regression Models of Childhood Trauma Exposure on hs-CRP and HbA1c Levels

	hs-CRP			HbA1c		
	B	SE	*p*	B	SE	*p*
Domestic Violence						
Constant	**-0.425**	**0.209**	**0.043***	**0.761**	**0.012**	**0.000***
Age	-0.017	0.016	0.310	0.001	0.001	0.161
Sex	-0.048	0.050	0.335	0.005	0.003	0.127
Race	0.000	0.017	0.991	**0.003**	**0.001**	**0.007***
Income	-0.005	0.008	0.517	0.000	0.000	0.317
BMI	**0.006**	**0.001**	**0.000***	**0.000**	**0.000**	**0.019***
DV Exposure	**0.121**	**0.053**	**0.024***	0.003	0.003	0.492
Child Maltreatment						
Constant	-0.361	0.208	0.083**	**0.762**	**0.012**	**0.000***
Age	-0.020	0.017	0.236	0.001	0.001	0.152
Sex	-0.047	0.050	0.347	0.004	0.003	0.128
Race	-0.001	0.017	0.965	**0.003**	**0.001**	**0.010***
Income	-0.007	0.008	0.381	0.000	0.000	0.348
BMI	**0.006**	**0.001**	**0.000***	**0.000**	**0.000**	**0.019***
CM Exposure	**0.056**	**0.027**	**0.040***	0.000	0.002	0.833
Trauma						
Constant	-0.384	0.208	0.066**	**0.762**	**0.012**	**0.000***
Age	-0.021	0.017	0.216	0.001	0.001	0.234
Sex	-0.040	0.050	0.430	0.005	0.003	0.106
Race	-0.002	0.017	0.883	**0.003**	**0.001**	**0.007***
Income	-0.005	0.008	0.477	0.000	0.000	0.307
BMI	**0.006**	**0.001**	**0.000***	**0.000**	**0.000**	**0.024***
Sum of Trauma Items w/o DV	0.015	0.010	0.134	0.001	0.001	0.335
CM + DV						
Constant	-0.402	0.209	0.055**	**0.761**	**0.012**	**0.000***
Age	-0.019	0.017	0.242	0.001	0.001	0.149
Sex	-0.047	0.049	0.341	0.005	0.003	0.127
Race	0.002	0.017	0.890	**0.003**	**0.001**	**0.008***
Income	-0.005	0.008	0.484	0.000	0.000	0.311
BMI	**0.006**	**0.001**	**0.000***	**0.000**	**0.000**	**0.017***
DV Exposure	0.098	0.055	0.074**	0.003	0.003	0.441
CM Exposure	0.043	0.028	0.129	-0.001	0.002	0.683
Trauma + DV						
Constant	**-0.421**	**0.209**	**0.044***	**0.762**	**0.012**	**0.000***
Age	-0.019	0.017	0.248	0.001	0.001	0.227
Sex	-0.043	0.050	0.387	0.005	0.003	0.109
Race	0.001	0.017	0.959	**0.003**	**0.001**	**0.006***
Income	-0.005	0.008	0.555	0.000	0.000	0.296
BMI	**0.006**	**0.001**	**0.000***	**0.000**	**0.000**	**0.023***
DV Exposure	0.106	0.056	0.060**	0.001	0.003	0.693
Trauma Exposure	0.008	0.010	0.414	0.000	0.001	0.434

Significant ($p \leq .05$) associations are in bold and indicated with *; marginally significant ($p \leq .10$, $p > .05$) associations indicated with **; all analyses controlled for age, sex, race, income, and BMI (included in Table 1).

Note. B = unstandardized beta-coefficient, SE = standard error, *p* = p-value, CM = child maltreatment, DV = domestic violence, hs-CRP = high-sensitivity c-reactive protein, HbA1c = hemoglobin A1c

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ACADEMIC VITA

SARAH STITZEL

EDUCATION

The Pennsylvania State University — University Park, PA
B.S. in Biobehavioral Health, College of Health and Human Development — Date of Graduation: May 2021

- *Biobehavioral Health takes a holistic approach to health by examining an array of factors that contribute to health and health disparities across the human lifespan and within communities.*

Minor: Child Maltreatment and Advocacy Studies

OBJECTIVE

Compassionate and dedicated student with significant patient care experience wanting to make a difference in the overall health of individuals and community while advocating for vulnerable populations and the betterment of healthcare.

HONORS/AWARDS

Schreyer Honors College — University Park, PA
Awarded by Penn State — 2018 – Present

- Must meet minimum GPA requirements, honors course and credit requirements, and submission deadlines for senior thesis to obtain a prestigious honors education

Dean's List 7/7 Semesters — University Park, PA
Awarded by Penn State Health and Human Development — 2017 — Present

- Awarded to students who achieve a cumulative semester GPA of at least 3.50

President's Award — University Park, PA
Awarded by Penn State — 2017 – 2018 Academic Year

- Maintaining a 4.0 GPA for the student's first year of admission

Woman of the Year — University Park, PA
Awarded by Penn State — 2019

- Pi Beta Phi Outstanding Member of the Year Awarded by Penn State Panhellenic

QUALIFICATIONS

- **Emergency Medical Technician Certification**
- **American Heart Association CPR Certification**

PATIENT CARE EXPERIENCE

The Highlands at Wyomissing Continuing Care Facility — Wyomissing, PA
Personal Care Assistant — May 2019 – Present

Penn State Health St Joseph's Medical Center — Wyomissing, PA
Clinical Nursing Assistant — June 2019 – Present

- **PAWS Up Award**: Awarded for providing compassionate care

VOLUNTEER/LEADERSHIP

The Child Health Study — State College, PA
Research Assistant — June 2019 – Present

- The Child Health Study, sponsored by the NIH, conducts high-quality, well-controlled research that contributes innovative data on the effects of child maltreatment and trauma
- Research Assistant (2019-2020): work directly with high-risk youth and their caregivers that have been involved with Child Protective Services as well as code data associated with the study
- Conduct research based on The Child Health Study data to synthesize senior thesis and contribute to growing literature regarding child maltreatment

Penn State IFC/Panhellenic Dance Marathon (THON) University Park, PA
THON 2021 Special Events Captain 2017 – Present
Diversity, Equity, and Inclusion Committee (2020-2021)
THON 2020 Dancer Relations Captain
Dancer Relations Committee Member and Weekend Warrior (2018-2019)

Pennsylvania Epsilon Organization (Pi Beta Phi Fraternity for Women) University Park, PA
Vice President of Philanthropy (2018-2019) 2018 – Present
- Planned and Organized Philanthropy and Community Service Events for a group of over 200 women

THON Family Relations Chair (2020)
Leadership and Nominating Committee (LNC)
- Appointed to select senior leadership for the chapter
- LNC members have a comprehensive understanding of the chapter's needs and mission and cultivate interest and skills for future chapter leaders

Member and Community Service Chair (2018)

Mortar Board National Honor Society, Archousai Chapter University Park, PA
Member Present
- Work with a diverse team if student leaders to better serve the community and engage with alumni
- A highly selective national honor society which recognizes members of the senior class who exhibit the pillars of leadership, scholarship, and service

American-Caribbean Experience Medical Mission Trip Saint Mary, Jamaica
Medical Volunteer Summer 2019
- Served the people of St. Mary Parish by assessing patients at local clinics
- Triaged patients and documented all vitals
- Distributed and explained medication instructions to low health literacy in the pharmacy