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The Link Between Adverse Childhood Experiences and Diabetes

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Abstract

Exposure to adversity in childhood (ACEs) is linked to a number of chronic diseases in adulthood, yet there is limited research examining the impact of ACEs on diabetes. The current review sought to examine the association between ACEs, other trauma exposure or posttraumatic stress disorder (PTSD) diagnosis, and risk for diabetes. Thirty-eight studies are reviewed. Unlike in other diseases, several studies in diabetes show a threshold-response versus a dose-response relation, while other studies show a relation between greater abuse severity and diabetes risk. There were mixed results for studies examining abuse type and frequency. Chronic or comorbid PTSD was also related to increased diabetes risk among veterans, but in community samples, only trauma exposure predicted diabetes risk. While the research is still limited, diabetes researchers and clinicians should consider screening for ACEs and examine severity and frequency across abuse type as a predictor of both diabetes and poor diabetes outcomes.

Keywords

adverse childhood experiences; maltreatment; PTSD; diabetes

Introduction

Childhood adversity presents a major public health challenge. Exposure to abuse, neglect, and family dysfunction in childhood not only curtails healthy emotional, behavioral, and physical development, but contributes to morbidity and mortality in adulthood [1–3]. The Biological Embedding of Childhood Adversity Model provides an explanation for this phenomenon [4]. Specifically, this model posits that childhood stress arising from poverty or maltreatment programs cells with pro-inflammatory tendencies, causing exaggerated cytokine response to challenge and decreased sensitivity to inhibitory hormonal signals and

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Compliance with Ethics Guidelines

Conflict of Interest

Lindsay Huffhines, Amy Noser, Susana R. Patton declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent

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hormonal dysregulation leading to problematic behaviors (e.g., impaired self-regulation, unhealthy lifestyle choices). These factors, together with other exposures and genetic liabilities, provoke chronic disease in adulthood. For example, exposure to childhood adversity has been linked to obesity; autoimmune disease; heart, lung, and liver disease; skeletal fractures; and cancer [1]. Yet, the effect of childhood adversity on both the development and control of type 1 (T1DM) and type 2 diabetes mellitus (T2DM) is rarely considered in either research or practice. Although identifying factors linked to diabetes and suboptimal glycemic control is a priority for the field [5], exposure to childhood adversity has largely been excluded as a potential predictor due to the difficulty of comparing and interpreting findings across multiple disciplines and differing methodologies. As such, there remain a number of gaps in the literature and a need for research into this relation.

The purpose of this review was to provide an overview of the association between adverse childhood experiences (i.e., abuse, neglect, family dysfunction, and other potentially traumatic events) and risk for diabetes. Due to the small number of studies conducted in this area, and the potential of studies examining posttraumatic stress disorder (PTSD) to bring insight to the child adversity/diabetes connection, participants who experienced war, combat, or an unspecified adverse event were also included. Twenty-two studies investigating adversity, maltreatment or exposure to war in childhood and 16 studies examining PTSD were identified and are discussed more extensively below (see also Table 1 for review of recent studies).

Prevalence of ACEs

Results of a large national sample indicated that one in four children in the United States experience some type of child maltreatment in their lifetimes [6]. Specifically, in 2012, the data reveal that 678,810 U.S. children were victims of substantiated maltreatment [7], although this is likely an underestimate of the true number. Moreover, of those whose cases were substantiated, 75% experienced neglect, 18.3% experienced physical abuse, and 9.3% experienced sexual abuse, while some children experienced multiple types of abuse [7]. When analyzed based on adverse childhood experiences (ACEs) one study found 67% of children served by an urban health center reported at least 1 ACE and 12% reported 4 or more ACEs [8]. Another study found 44%–52% of adults reported at least 1 ACE prior to age 18 and between 6%–15% reported 4 or more ACEs [1, 13, 15]. These findings demonstrate that ACEs are prevalent in the broader population and if applied to diabetes suggest ACEs may be at least as prominent in the lives of people with diabetes as depression (14% of youths and 12–13% of adults) [9–11] and low socioeconomic status (14–19% of T1DM families) [12]. Thus, suspected high rates of ACEs and the likelihood of detrimental, lifelong problems provide the impetus for examining abuse, neglect, family dysfunction, and other traumatic events in the context of persons with diabetes.

ACEs and Risk for Diabetes

Interest in chronic health conditions of adults maltreated as children has burgeoned in recent years, beginning with the landmark Adverse Childhood Experiences (ACE) Study [1]. This study and subsequent studies asked participants about exposure to multiple types of

childhood adversity (see Table 2). Participants received a score of 1 if they experienced 1 or more events in the selected category; the highest ACE score possible being 7, which would indicate exposure to an event in all 7 categories. Overall, results found that as the number of ACEs increased, so did patients' risk for obesity, heart disease, cancer, autoimmune disorders, and depression; however, there was no dose-response relation for any diabetes (incorporating T1DM or T2DM, as the study did not specify diabetes type). Instead, patients experienced a higher risk of any diabetes once they endorsed at least 4 ACEs (OR = 1.6; 95% CI = 1.0–2.5) with no change in risk despite increasing reports of ACEs.

These results have been duplicated by other large trials. For example, in a study completed in England, findings demonstrated that endorsing 4 or more ACEs significantly increased the odds of any diabetes (OR = 2.99; 95% CI = 1.90–4.72), while endorsing less than 4 did not [13]. Endorsing 4 or more ACES was related to significantly greater odds of any diabetes in Saudi Arabian adults as well (OR = 2.1; 95% CI = 1.0–4.5); however, the odds ratios for less than 4 ACEs were not reported, so it is unknown if less exposure was also related to diabetes [14]. Similarly, in a study of 10 countries, experiencing 1or 2 ACEs did not significantly increase the odds of any diabetes, but 3 or more ACEs did (HR = 1.59, 95% CI = 1.20–2.09) [15]. In a large study, researchers found that endorsing 1 to 3 or 4 to 6 ACEs was associated with significantly greater odds of any diabetes compared to those who endorsed 0 ACEs, but endorsing 7 to 9 ACEs was not [16]. Interestingly, this argues against a threshold response relation between ACEs and diabetes, as those adults who endorsed the greatest number of ACEs had lower odds of diabetes. However, it should be noted that while the increased odds of diabetes in people with 7 to 9 ACEs was not significant at the .05 level, the 95% confidence interval was 1.0–2.1, suggesting a trend toward significance. Moreover, this nonsignificant finding may also have been due to the smaller sample size in the group who endorsed 7 to 9 ACEs (i.e., only 2.6% of the sample, compared to 40.6%, 44.1%, and 12.7% who endorsed 0, 1 to 3, and 4 to 6 ACEs, respectively).

Finally, in an expansion of the ACE model, Husarewycz and colleagues asked adult participants about 27 categories of trauma exposure [17] and found that experiencing a greater number of traumatic events, or injurious trauma, psychological trauma, or witnessing trauma significantly increased the odds of any diabetes in models adjusted for demographics, mental disorders, and the other trauma (e.g., controlling for injurious trauma in psychological trauma model). This was one of the few ACE studies to control for abuse-related variables. Unfortunately, exposure in childhood was not differentiated from exposure in adulthood, therefore it is impossible to ascertain whether number of adverse events endorsed or developmental period in which the adversity took place contributed to outcomes.

ACE studies have traditionally examined multiple chronic conditions, but several diabetes-specific investigations allow greater insight into the relation between ACEs and diabetes. One study that included youths with T1DM (M age = 10.73 years, SD = 3.62 years) and a control group of youths (recruited during a hospital encounter for an acute event) [18], asked parents to complete a negative life events questionnaire. The authors found a higher number of negative life events reported by parents of children in the T1DM group versus parents of controls. But in this study, only parental abuse was significantly associated with diabetes in

the multivariate model (OR = 2.63, p < .05) until timing of adversity was included (OR = 1.93, p = .18). Thus, study findings provide further insight into the relationship between ACEs and diabetes by suggesting that parental abuse, more so than other adversities, may place susceptible youth at an increased risk for developing T1DM.

In a study examining the incidence of cardiovascular disease (CVD) in African American adults with T1DM, findings showed a significant association between the number of trauma categories endorsed and a 6-year incidence of any CVD after adjusting for other risk factors (i.e., age, body mass index, blood pressure) [19]. In fact, each additional type of childhood trauma endorsed resulted in an increase in the odds of CVD. However, there was no significant association between number of ACEs and participants' hemoglobin A1c (HbA1c), insulin dose, or retinopathy severity, suggesting that ACEs do not affect glycemic control in adults, which may be related to other factors that are closer in time or relevance to diabetes (e.g., adherence). In the future, a study examining the effects of ACEs on glycemic control in children, adolescents, and adults is needed, as well as a model that includes well-studied predictors of glycemic control in order to parcel out the unique effects on glycemic control related to childhood adversity.

One study examined T2DM in relation to ACEs using a low-income minority sample of patients in a primary care clinic (86.7% Black; 50% with >4 ACEs) [20]. While none of the ACE subscales were individually associated with T2DM, the total ACE score was found to be a strong predictor of a T2DM diagnosis, even over the impact of age (b =.104, p = 0.28; OR = 1.109; 95% CI = 1.01–1.22). This finding again suggests that cumulative trauma exposure is more important than specific trauma type, particularly for T2DM, and is consistent with the previously mentioned Biological Embedding of Childhood Adversity Model [4]. Alternatively, because trauma exposure is known to increase risky health behaviors, which in turn may translate into obesity and other medical conditions at lower thresholds, it is possible obesity mediates the relation between maltreatment and diabetes [21], explaining why diabetes is not observed until greater levels of trauma exposure are reported.

Abuse Categories and Diabetes Risk

In contrast to the ACE research, a number of studies have surveyed participants about discrete categories of abuse (e.g., sexual abuse only). The first study asked adults in a primary care clinic to self-report whether they had received a diabetes diagnosis and whether they had been sexually or physically abused as a child, or experienced domestic violence as an adult [22]. One-hundred and thirty adults participated, with 65 reporting abuse/violence and 4 reporting a diabetes diagnosis. Patients with a history of abuse were significantly more likely to report any diabetes ($\chi^2 = 4.13$, p = 0.042). However, patients with diabetes more commonly reported a history of domestic violence versus childhood abuse, suggesting risk of diabetes could increase with more recent stressors. Yet, this study was limited due to its small number of individuals with diabetes, the use of only self-report for diabetes diagnosis, and the cross-sectional methodology, leading to some reservations regarding its generalizability.

A more representative, prospective study assessed presence of abuse through Child Protective Services case file reports, and found that having an abuse history predicted any diabetes in adulthood (i.e., HbA1c ≥ 6) (OR = 1.93; 95% CI = 1.12, 3.32) and continued to be predictive of diabetes even after controlling for age, race, and gender [23]. Furthermore, when abuse categories were examined separately, physical abuse and neglect were related to greater odds of HbA1c ≥ 6, but not sexual abuse. In another study, adults who had experienced emotional abuse (OR = 3.4; 95% CI = 1.9–6.4) physical abuse (OR = 2.8; 95% CI = 1.2–6.4) and severe physical abuse (OR = 3.4; 95% CI = 1.2–9.4) by their mother had significantly higher rates of any self-reported diabetes [24] than adults reporting none of these.

Although not specific to abuse, one study found the incidence of T1DM in youths significantly increased in the northern region of Israel following the Second Lebanon War compared to the incidences in pre-war years and in non-war zones [25], thus giving some credence to the importance of investigating the impact of trauma on T1DM development. Similarly, in two studies of children in Belgrade, “severe stressful life events” and “minor stressful life events” were significantly related to increased risk for T1DM; however, the categorization of events into these categories were highly subjective, potentially casting some doubt on the association between trauma and diabetes [26, 27].

To date, two studies have failed to find a relation between abuse and diabetes altogether [28, 29] and two have found differing results by gender [30, 31]. Notably, these studies measured discrete abuse categories versus cumulative trauma, which is suspected to have a greater effect on diabetes risk, thus rendering the negative findings less surprising. One study examined a number of chronic diseases in a sample of adults who had been physically abused as children, but this study found no relation between physical abuse and any diabetes [29]. Another study found that physical and sexual abuse were not related to greater odds of any diabetes, although exposure to neglect was (OR = 2.2; 95% CI = 1.1–4.4) [28]. In another study, men who reported having a substance-using father had significantly greater risk for diabetes (i.e., T2DM or HbA1c ≥ 6) after adjusting for socioeconomic status, smoking, drinking, diet, physical activity, and adiposity than men who did not report a substance-using father [30]. Uniquely, in this study, no other forms of abuse or neglect were related to diabetes in men or women. In a sample of adults recruited from primary care (53% diagnosed with anxiety disorder), participants were surveyed about 9 trauma types [31]. Similar to the Husarewycz study, the survey did not differentiate between childhood and adulthood exposure but the study found significantly increased odds of diabetes in men who endorsed any trauma or any assaultive trauma, save sexual trauma, and no association between trauma and diabetes for women.

Abuse Categories with a Focus on Severity, Frequency, and Timing

Moving beyond measuring whether a certain type of abuse did or did not occur, a handful of studies have inquired about severity (i.e., how bad an abuse event was) or frequency (i.e., how many times the abuse event happened). As an example of the former, female participants were surveyed about the occurrence of child sexual abuse (CSA), further defined by severity (6 levels, ranging from non-contact abuse to sexual intercourse), as well

as the occurrence of child physical abuse and the occurrence of adult physical or sexual abuse [32]. The researchers found the odds of any diabetes were significantly greater for women who experienced genital-contact CSA when compared to a group that comprised women reporting either non-genital CSA or no CSA (OR =0.38, CI = 0.33–0.43, p = 0.02), but no effect when diabetes was examined in relation to the frequency of abuse events.

Severity of abuse emerged as an important factor in another study examining physical (CPA) and sexual abuse (CSA) in childhood and risk of T2DM in adulthood [33]. Specifically, while mild CPA was not associated with increased risk of T2DM, moderate and severe CPA was associated with increased risk of diabetes and mild, moderate, and severe CSA was associated with higher risk. Interestingly, after controlling for adult BMI, smoking, and alcohol use, the researchers only found severe CSA to be significantly associated with increased risk for diabetes. But in the case of women who had experienced both CPA and CSA, the risk of diabetes was highest even after adjusting for covariates. The authors suggest that it may be that individuals who experience both CPA and CSA may also suffer more severe abuse. Taken together, study findings suggested that severity of CPA and CSA may have dose response associations with risk of T2DM in women and that this relationship may be especially evident for CSA after controlling for various health risk behaviors.

In addition to abuse severity, the frequency of abuse may also be related to diabetes risk. For example, in one study men who reported experiencing CSA 3 or more times had 3.63 times greater odds of any diabetes than men who did not report sexual abuse (95% CI = 1.53–8.62) [34]. Further, the magnitude of the association remained similar after adjusting for other forms of child maltreatment and covariates. Although there was no significant association for women, experiencing 1 to 2 occurrences of neglect incurred greater risk of prediabetes, even after covariates and BMI were added to the model. Thus, it appears that recurrent CSA among men may be a potential risk factor of diabetes in adulthood.

Finally, one study examined the timing of adversity exposure. In this study [18], researchers found a higher risk for T1DM if any adverse event occurred within the two years prior to the T1DM diagnosis. However, when the negative events were grouped by category, only parental abuse was found to be significantly more common among youths with T1DM than controls and no difference was found if timing was included in this model. These findings suggest an association between timing of adversity exposure and T1DM. Future research may consider the role of developmental timing in the association between adversity exposure and diabetes onset, given that developmental maturity may influence individuals' interpretation and emotional understanding of an event.

In short, the studies of severity and frequency of abuse largely mirrored the ACE findings: more adversity, whether it be due to multiple categories of abuse events, more severe abuse, or more frequent abuse, was associated with greater risk for diabetes. Future studies should examine these three constructs concurrently, as well as timing of adverse events and other abuse-related variables, such as the individual's relationship to the perpetrator(s), appraisal of adverse events, and coping in response to the events to determine how adversity affects a person's diabetes risk.

PTSD and Diabetes Risk

Posttraumatic stress disorder (PTSD) has been reported to affect 5–10% of the U.S. population during their lifetime [35, 36] and has been linked to numerous health problems including the development or exacerbation of diabetes [37, 38]. PTSD is thought to be a risk factor for diabetes by prolonging activation of the body's stress response system (i.e., the hypothalamic-pituitary-adrenal [HPA] axis, nervous system, and immune system) [38, 39]. Further, numerous health risk behaviors such as poor sleep, obesity, sedentary behaviors, and substance use are thought to contribute and/or exacerbate the development of diabetes among individuals with PTSD [37].

Interest in the relationship between PTSD and diabetes has focused primarily on veteran populations and has generally demonstrated that PTSD symptoms serve as an important risk factor of diabetes [40–45]. For example, a prospective study following U.S. military services members reported a diabetes (type 1 or type 2) incidence of 3 per 1,000 persons/years and results further revealed that, after accounting for demographic characteristics and numerous psychiatric conditions, baseline PTSD symptoms was the only significant predictor of diabetes [45]. Research has also shown in a large retrospective study of Vietnam veterans that among those veterans with PTSD, depression was the best predictor of poor glycemic control [43]. Finally, studies have shown a mediating role for risky behaviors, including sedentary behavior, alcohol and drugs, and overweight, in explaining the relation between PTSD and any diabetes (primarily type 2) among veterans [43, 44].

Numerous epidemiological studies have also documented an association between PTSD and diabetes in community samples. The vast majority of these studies either focused on adults with T2DM [46, 47] or failed to specify the diabetes type [48–51]. However, similar to studies of veterans, findings showed an association between PTSD and diabetes [46, 50]. For instance, Pietrzak et al. found individuals with PTSD symptoms were more likely to have a diagnosis of any diabetes compared to those with partial or no symptoms of PTSD [50]. Yet, this association diminished when total lifetime trauma exposure was examined, suggesting that lifetime trauma exposure may be a better indicator of subsequent diabetes onset than PTSD among community samples.

More recently, researchers have started to explore whether findings relating PTSD to diabetes risk from community samples extend to unique populations (e.g., racial minorities, [52]; Southeast Asian refugees, [53]; women, [54]; asylum seekers, [55]). Results of these studies have been largely consistent with previous research, suggesting that PTSD is associated with an increased risk for any diabetes and the association is stronger when PTSD is chronic [54] or comorbid [55]. However, no association between PTSD and diabetes was found among Southeast Asians refugees [53], a discrepancy which could be explained by the assessment of trauma symptoms versus PTSD, and which did not allow the authors to differentiate among those with full and partial symptoms of PTSD. Still, the findings from Pietrzak et al.'s study ultimately point toward the importance of more severe or chronic trauma in dictating diabetes risk [50].

Conclusion

Adverse childhood experiences are common and may be linked to the development of a number of chronic conditions in adulthood as well as some conditions in childhood. Links between ACEs, cardiovascular problems, and obesity have been widely explored. Diabetes, however, as one of the most common diseases in children and adults, must also be examined. Further, understanding risk factors related to the development of diabetes and poor glycemic control is an important goal for the field and child adversity may be one such risk factor.

The ACE studies provide evidence for the Biological Embedding of Stress model, or the notion that stress accumulates in the body from cumulative abuse or stress, and disease emerges once a certain threshold has been reached. In these studies, it was persons who experienced the greatest number of ACE categories who were at greater risk for diabetes versus persons who experienced no adversity, or less adversity. In contrast, other studies supported the notion of a discrete category of abuse (e.g., sexual abuse only) increasing the risk of diabetes, contradicting the theory that there is a threshold to the number of abuse categories needed to be experienced before the odds of diabetes are increased. However, these results are mixed, and vary by type of abuse examined or gender of participant.

Two studies failed to find a significant relation between a discrete category of abuse and diabetes altogether, perhaps because they did not account for the overlap with other types of abuse. That is, many youths exposed to adversity are often exposed to more than one kind of adversity, and cumulative risk likely confers greater probability for poor outcomes than does type of abuse [56].

Finally, the few studies that included severity, frequency, and timing of abuse in their predictive models of diabetes demonstrated support for a cumulative risk model. Consistent with the ACE findings and the maltreatment literature [57], in these studies greater severity was related to increased risk of diabetes. Future studies should emulate these more complete models by measuring severity and frequency across abuse type. Null results may again be explained by examining the severity or frequency of only one abuse type rather than accounting for multiple exposures.

Generally mixed results have also been found when examining the relation between PTSD and diabetes. Although associations were found between these constructs, ACEs may have greater impact on diabetes risk than PTSD diagnosis in community samples, as not all maltreated children develop PTSD [58, 59]. Instead, problems arising from adversity may manifest in different ways for different individuals (e.g., through poor health outcomes). These findings emphasize the importance of asking about exposure to adversities rather than relying on a PTSD diagnosis. It also signifies that pathways from abuse to diabetes may be driven by underlying problems in the stress-response system or through obesity, rather than through mental health problems. However, it is important to note that having chronic PTSD or PTSD comorbid with another disorder had the largest effect on diabetes. In one study, those with partial PTSD symptoms were not at greater risk for diabetes again mirroring ACE findings and the cumulative risk model.

Overall, the literature examining the relation between ACEs and diabetes point to the need for more specialized methodology. In future studies, careful attention is needed to define the sample, the type of adverse event(s), the severity, frequency, and timing of adverse events in relation to diabetes, and the presence of PTSD or other mental disorders (e.g., depression). Studies should use a common ACEs measure, as this would allow for comparisons across studies. Moreover, studies should include both medical records and markers of glycemic control, clarifying diabetes types, and diabetes-related covariates as these will be essential for understanding exactly what the effects of ACEs are on patients' diabetes risk. Finally, a number of moderators and mediators should be included, as well as mechanisms explaining the pathway between the experience of ACEs and trauma (e.g., obesity versus stress-related changes to the endocrine system).

Despite the limitations of the studies reviewed, and the need for longitudinal studies to determine causation, ACEs appear to be a construct relevant to diabetes care. For example, the current findings indicate that practitioners, particularly those in pediatrics, should assess for abuse history with every patient(for every patient? who should do this?) and work to minimize risky health behaviors and increase stress management techniques to reduce the risk of developing diabetes in children and adults who have experienced adversity. The studies included in this review provide the foundation for future research to explore the mechanisms underlying pathways from ACEs to diabetes (e.g., risky health behaviors, obesity, stress response system dysfunction) allowing for development of more specific targets for intervention. Understanding the association between adverse childhood experiences and diabetes may aid in prevention and intervention efforts, ultimately reducing the high rates of mortality and morbidity associated with trauma exposure.

Finally, diabetes practitioners should assess for ACEs in their patients to better understand potential contributors to the disease, and to have more complete information about the individual's social environment, as childhood adversity could be related to problematic diabetes outcomes (e.g., worse adherence, higher HbA1c values). In addition to more common screening assessments of depression or anxiety, diabetes practitioners might also assess for PTSD, specifically in individuals who endorsed ACEs, as presence of the disorder could worsen diabetes outcomes or complicate treatment. Only one study to date has examined specific diabetes outcomes in relation to abuse, therefore, more research is needed to determine whether associations exist, particularly in children. These studies may identify new targets for treatment, including greater support for daily self-care, family and individual psychotherapy, and frequent clinic-based contact.

References

Papers of particular interest, published recently, have been highlighted as:

• Of importance

•• Of major importance

1. Felitti VJ, Anda RF, Nordenberg D, Williamson DF, Spitz AM, Edwards V, … Marks JS. Relationship of childhood abuse and household dysfunction to many of the leading causes of death

in adults: The Adverse Childhood Experiences (ACE) Study. American journal of preventive medicine. 1998; 14(4):245–258. [PubMed: 9635069]

2. Kim-Spoon J, Cicchetti D, Rogosch FA. A longitudinal study of emotion regulation, emotion lability-negativity, and internalizing symptomatology in maltreated and nonmaltreated children. Child development. 2013; 84(2):512–527. [PubMed: 23034132]
3. Ayoub CC, O'Connor E, Rappolt-Schlichtmann G, Fischer KW, Rogosch FA, Toth SL, Cicchetti D. Cognitive and emotional differences in young maltreated children: A translational application of dynamic skill theory. Development and Psychopathology. 2006; 18(03):679–706. [PubMed: 17152396]
4. Miller GE, Chen E, Parker KJ. Psychological stress in childhood and susceptibility to the chronic diseases of aging: moving toward a model of behavioral and biological mechanisms. Psychological bulletin. 2011; 137(6):959–997. [PubMed: 21787044]
5. Gary-Webb TL, Suglia SF, Tehranifar P. Social epidemiology of diabetes and associated conditions. Current diabetes reports. 2013; 13(6):850–859. [PubMed: 24085624]
6. Turner HA, Ormond R, Hamby SL. Violence, crime, and abuse exposure in a national sample of children and youth: An update. JAMA Pediatrics. 2013; 167(7):614–621. [PubMed: 23700186]
7. US Department of Health and Family Services. Child maltreatment. 2012. retrieved from http://www.acf.hhs.gov/sites/default/files/cb/cm2012.pdf
8. Burke NJ, Hellman JL, Scott BG, Weems CF, Carrion VG. The impact of adverse childhood experiences on an urban pediatric population. Child abuse & neglect. 2011; 35(6):408–413. [PubMed: 21652073]
9. Barnard KD, Skinner TC, Peveler R. The prevalence of co-morbid depression in adults with Type 1 diabetes: systematic literature review. Diabetic Medicine. 2006; 23(4):445–448. [PubMed: 16620276]
10. Lawrence JM, Standiford DA, Loots B, Klingensmith GJ, Williams DE, Ruggiero A, Liese AD, Bell RA, Waitzfelder BE, McKeown RE. SEARCH for Diabetes in Youth Study. Pediatrics. 2006; 117(4):1348–58. [PubMed: 16585333]
11. Cooper MN, O'Connell SM, Davis EA, Jones TW. A population-based study of risk factors for severe hypoglycaemia in a contemporary cohort of childhood-onset type 1 diabetes. Diabetologia. 2013; 56(10):2164–2170. [PubMed: 23832082]
12. Valenzuela JM, Seid M, Waitzfelder B, Anderson AM, Beavers DP, Dabelea DM. … SEARCH for Diabetes in Youth Study Group. Prevalence of and disparities in barriers to care experienced by youth with type 1 diabetes. The Journal of pediatrics. 2014; 164(6):1369–1375. [PubMed: 24582008]

13••. Bellis MA, Hughes K, Leckenby N, Hardcastle KA, Perkins C, Lowey H. Measuring mortality and the burden of adult disease associated with adverse childhood experiences in England: a national survey. Journal of public health. 2014:1–10. This paper has an important impact because it demonstrated a threshold effect for ACES and diabetes; the odds of diabetes were higher with at least 4 ACEs, and there was no dose-response relation.

14. Almuneef M, Qayad M, Aleissa M, Albuhairan F. Adverse childhood experiences, chronic diseases, and risky health behaviors in Saudi Arabian adults: A pilot study. Child abuse & neglect. 2014; 38(11):1787–1793. [PubMed: 24974249]
15. Scott KM, Von Korff M, Angermeyer MC, Benjet C, Bruffaerts R, De Girolamo G, … Kessler RC. Association of childhood adversities and early-onset mental disorders with adult-onset chronic physical conditions. Archives of General Psychiatry. 2011; 68(8):838–844. [PubMed: 21810647]

16•. Gilbert LK, Breiding MJ, Merrick MT, Thompson WW, Ford DC, Dhingra SS, Parks SE. Childhood adversity and adult chronic disease: an update from ten states and the District of Columbia. American journal of preventive medicine. 2015; 48(3):345–349. This paper is of importance because it demonstrated that 1–3 or 4–6 ACEs, but not 7–9 ACEs, increased the odds of diabetes, which is contrary to previous ACE studies. [PubMed: 25300735]

17••. Husarewycz MN, El-Gabalawy R, Logsetty S, Sareen J. The association between number and type of traumatic life experiences and physical conditions in a nationally representative sample. General hospital psychiatry. 2014; 36(1):26–32. This paper is important given that it was one of the few that adjusted for numerous covariates, included a large number of adverse events, and

found that both adversity type and exposure to cumulative events resulted in greater odds of diabetes. [PubMed: 24183489]

18. Karavanaki K, Tsoka E, Liacopoulou M, Karayianni C, Petrou V, Pippidou E, … Dacou-Voutetakis C. Psychological stress as a factor potentially contributing to the pathogenesis of Type 1 diabetes mellitus. Journal of endocrinological investigation. 2008; 31(5):406–415. [PubMed: 18560258]
19. Roy A, Janal MN, Roy M. Childhood trauma and prevalence of cardiovascular disease in patients with type 1 diabetes. Psychosomatic medicine. 2010; 72(8):833–838. [PubMed: 20668287]
20•. Lynch L, Waite R, Davey MP. Adverse childhood experiences and diabetes in adulthood: support for a collaborative approach to primary care. Contemporary Family Therapy. 2013; 35(4):639–655. This paper was significant for the field given that it was one of the first to establish a relation between ACEs and T2DM. Specifically, with every 1 point increase in ACE score, patients had 11% greater likelihood of T2DM.
21. Danese A, Tan M. Childhood maltreatment and obesity: systematic review and meta-analysis. Molecular psychiatry. 2014; 19(5):544–554. [PubMed: 23689533]
22. Kendall-Tackett KA, Marshall R. Victimization and diabetes: An exploratory study. Child abuse & neglect. 1999; 23(6):593–596. [PubMed: 10391516]
23. Widom CS, Czaja SJ, Bentley T, Johnson MS. A prospective investigation of physical health outcomes in abused and neglected children: new findings from a 30-year follow-up. American Journal of Public Health. 2012; 102(6):1135–1144. [PubMed: 22515854]
24. Goodwin RD, Weisberg SP. Childhood abuse and diabetes in the community. Diabetes care. 2002; 25(4):801–802. [PubMed: 11919145]
25. Zung A, Blumenfeld O, Shehadeh N, Dally Gottfried O, Tenenbaum Rakover Y, Hershkovitz E, … Shalitin S. Increase in the incidence of type 1 diabetes in Israeli children following the Second Lebanon War. Pediatric diabetes. 2012; 13(4):326–333. [PubMed: 22151880]
26. Vlajinac H, Šipetić S, Marinković J, Bjekić M, Kocev N, Sajić S. The Belgrade childhood diabetes study–comparison of children with type 1 diabetes with their siblings. Paediatric and perinatal epidemiology. 2006; 20(3):238–243. [PubMed: 16629698]
27. Sipetic S, Vlajinac H, Marinkovi J, Kocev N, Milan B, Ratkov I, Sajic S. Stressful life events and psychological dysfunctions before the onset of type 1 diabetes mellitus. Journal of Pediatric Endocrinology and Metabolism. 2007; 20(4):527–534. [PubMed: 17550217]
28. Goodwin RD, Stein MB. Association between childhood trauma and physical disorders among adults in the United States. Psychological medicine. 2004; 34(03):509–520. [PubMed: 15259836]
29. Shaw BA, Krause N. Exposure to physical violence during childhood, aging, and health. Journal of aging and health. 2002; 14(4):467–494. [PubMed: 12392001]
30. Thomas C, Hyppönen E, Power C. Obesity and type 2 diabetes risk in midadult life: the role of childhood adversity. Pediatrics. 2008; 121(5):e1240–e1249. [PubMed: 18450866]
31. Norman SB, Means-Christensen AJ, Craske MG, Sherbourne CD, Roy-Byrne PP, Stein MB. Associations between psychological trauma and physical illness in primary care. Journal of traumatic stress. 2006; 19(4):461–470. [PubMed: 16929502]
32. Romans S, Belaise C, Martin J, Morris E, Raffi A. Childhood abuse and later medical disorders in women. Psychotherapy and psychosomatics. 2002; 71(3):141–150. [PubMed: 12021556]
33. Rich-Edwards JW, Spiegelman D, Hibert ENL, Jun HJ, Todd TJ, Kawachi I, Wright RJ. Abuse in childhood and adolescence as a predictor of type 2 diabetes in adult women. American journal of preventive medicine. 2010; 39(6):529–536. [PubMed: 21084073]
34•. Duncan AE. Relationship Between Abuse and Neglect in Childhood and Diabetes in Adulthood: Differential Effects By Sex, National Longitudinal Study of Adolescent Health. Preventing chronic disease. 2015; 12:E70, 1–14. This paper was important in providing evidence for a threshold effect, given that greater odds of diabetes were only evident for men who were sexually abused three or more times. [PubMed: 25950577]
35. Brewin CR, Andrews B, Valentine JD. Meta-analysis of risk factors for posttraumatic stress disorder in trauma-exposed adults. Journal of Consulting and Clinical Psychology. 2000; 68:748–766. [PubMed: 11068961]
36. Ozer EJ, Best SR, Lipsey TL, Weiss DS. Predictors of posttraumatic stress disorder and symptoms in adults: A meta-analysis. Psychological Bulletin. 2003; 129:52–73. [PubMed: 12555794]

37. Dedert EA, Calhoun PS, Watkins LL, Sherwood A, Beckham JC. Posttraumatic stress disorder, cardiovascular, and metabolic disease: A review of the evidence. Annals of Behavioral Medicine. 2010; 39:61–78. [PubMed: 20174903]
38. Pacella ML, Hruska B, Delahanty DL. The physical health consequences of PTSD and PTSD symptoms: a meta-analytic review. Journal of Anxiety Disorders. 2013; 27:33–46. [PubMed: 23247200]
39. Friedman, MJ., McEwen, BS. Posttraumatic stress disorder, allostatic load, and medical illness. In: Schnurr, PP., Green, BL., editors. Trauma and health: Physical health consequences of exposure to extreme stress. Washington, DC: American Psychological Association; 2004. p. 157-188.
40. Boscarino JA. Posttraumatic stress disorder and physical illness: results from clinical and epidemiologic studies. Annals of the New York Academy of Sciences. 2004; 1032(1):141–153. [PubMed: 15677401]
41. Boyko EJ, Seelig AD, Jacobson IG, Hooper TI, Smith B, Smith TC. … Millennium Cohort Study Team. Sleep Characteristics, Mental Health, and Diabetes Risk A prospective study of US military service members in the Millennium Cohort Study. Diabetes care. 2013; 36(10):3154–3161. [PubMed: 23835691]
42. David D, Woodward C, Esquenazi J, Mellman TA. Comparison of comorbid physical illnesses among veterans with PTSD and veterans with alcohol dependence. Psychiatric Services. 2004; 55(1):82–85. [PubMed: 14699207]
43. Trief PM, Ouimette P, Wade M, Shanahan P, Weinstock RS. Post-traumatic stress disorder and diabetes: co-morbidity and outcomes in a male veterans sample. Journal of behavioral medicine. 2006; 29(5):411–418. [PubMed: 16865552]
44. Vaccarino V, Goldberg J, Magruder KM, Forsberg CW, Friedman MJ, Litz BT, … Smith NL. Posttraumatic stress disorder and incidence of type-2 diabetes: a prospective twin study. Journal of psychiatric research. 2014; 56:158–164. [PubMed: 24950602]
45. Boyko EJ, Jacobson IG, Smith B, Ryan MA, Hooper TI, Amoroso PJ. … Millennium Cohort Study Team. Risk of diabetes in US military service members in relation to combat deployment and mental health. Diabetes care. 2010; 36:3154–3161.
46. Lukaschek K, Baumert J, Kruse J, Emeny RT, Lacruz ME, Huth C, … Ladwig KH. Relationship between posttraumatic stress disorder and type 2 diabetes in a population-based cross-sectional study with 2970 participants. Journal of psychosomatic research. 2013; 74(4):340–345. [PubMed: 23497837]
47. Rao MN, Chau A, Madden E, Inslicht S, Talbot L, Richards A, … Neylan TC. Hyperinsulinemic response to oral glucose challenge in individuals with posttraumatic stress disorder. Psychoneuroendocrinology. 2014; 49:171–181. [PubMed: 25108160]
48. Goodwin RD, Davidson JR. Self-reported diabetes and posttraumatic stress disorder among adults in the community. Preventive medicine. 2005; 40(5):570–574. [PubMed: 15749140]
49. Miller-Archie SA, Jordan HT, Ruff RR, Chamany S, Cone JE, Brackbill RM, … Stellman SD. Posttraumatic stress disorder and new-onset diabetes among adult survivors of the World Trade Center disaster. Preventive medicine. 2014; 66:34–38. [PubMed: 24879890]
50. Pietrzak RH, Goldstein RB, Southwick SM, Grant BF. Medical comorbidity of full and partial posttraumatic stress disorder in United States adults: Results from wave 2 of the National Epidemiologic Survey on Alcohol and Related Conditions. Psychosomatic medicine. 2011; 73(8): 697–707. [PubMed: 21949429]
51. Weisberg RB, Bruce SE, Machan JT, Kessler RC, Culpepper L, Keller MB. Nonpsychiatric illness among primary care patients with trauma histories and posttraumatic stress disorder. Psychiatric Services. 2014; 53(7):848–854.
52. Miller SA, Mancuso CA, Boutin-Foster C, Michelen W, McLean-Long C, Foote B, Charlson ME. Associations between posttraumatic stress disorder and hemoglobin A1 C in low-income minority patients with diabetes. General Hospital Psychiatry. 2011; 33:116–122. [PubMed: 21596204]
53. Wagner J, Burke G, Kuoch T, Scully M, Armeli S, Rajan TV. Trauma, healthcare access, and health outcomes among Southeast Asian refugees in Connecticut. Journal of Immigrant and Minority Health. 2013; 15(6):1065–1072. [PubMed: 22976796]

54. Roberts AL, Agnew-Blais JC, Spiegelman D, Kubzansky LD, Mason SM, Galea S, … Koenen KC. Posttraumatic stress disorder and incidence of type 2 diabetes mellitus in a sample of women: a 22-year longitudinal study. JAMA psychiatry. 2015; 72(3):203–210. [PubMed: 25565410]

55. Agyemang C, Goosen S, Anujuo K, Ogedegbe G. Relationship between post-traumatic stress disorder and diabetes among 105,180 asylum seekers in the Netherlands. The European Journal of Public Health. 2011; 22(5):658–662. [PubMed: 21953061]

56. Layne CM, Greeson JKP, Ostrowski SA, Kim S, Reading S, Vivrette RL, … Pynoos RS. Cumulative trauma exposure and high risk behavior in adolescence: Findings from the national child traumatic stress network core data set. Psychological Trauma: Theory, Research, Practice, and Policy. 2014; 6:S40–S49.

57. Jackson Y, Gabrielli J, Fleming K, Tunno AM, Makanui PK. Untangling the relative contribution of maltreatment severity and frequency to type of behavioral outcome in foster youth. Child abuse & neglect. 2014; 38(7):1147–1159. [PubMed: 24612908]

58. Shenk CE, Putnam FW, Rausch JR, Peugh JL, Noll JG. A longitudinal study of several potential mediators of the relationship between child maltreatment and posttraumatic stress disorder symptoms. Development and psychopathology. 2014; 26(01):81–91. [PubMed: 24444173]

59. Collishaw S, Pickles A, Messer J, Rutter M, Shearer C, Maughan B. Resilience to adult psychopathology following childhood maltreatment: Evidence from a community sample. Child abuse & neglect. 2007; 31(3):211–29. [PubMed: 17399786]

Table 1

Recent studies (2010–2015) examining adverse childhood experiences and diabetes

First author, year	Study sample	Main findings
Duncan et al., 2015	14,493 adults ages 24 to 34	Greater odds of diabetes (DM) for men who experienced CSA ≥3 times (OR = 3.63)
Gilbert et al., 2015	53,998 adults, ages 18 to ≥65	Greater odds of DM for 1–3 (OR = 1.2) or 4–6 ACEs (OR =1.4), but not 7–9 (OR = 1.4)
Almuneef et al., 2014	931 adults, ages 18 to ≥45	Greater odds of diabetes with at least 4 ACEs (OR = 2.1); dose-response unknown
Bellis et al., 2014	3,885 adults, ages 18 to 69	Greater odds of diabetes with at least 4 ACEs (OR = 2.99); no dose-response
Husarewycz et al., 2014..	34,653 adults (≥20 years)	Greater ACEs associated with greater odds of diabetes in all adjustment models (most stringent: OR = 1.04)
Lynch et al., 2013	801 adults, ages 19 to 82	Total ACE score predicted T2DM (OR = 1.11); with every 1 point increase in ACE score, patients had 11% greater likelihood of T2DM
Widom et al., 2012	598 adults with substantiated cases of abuse in childhood, ages 32 to 49	Exposure to overall abuse/neglect (OR = 1.93), physical abuse (OR = 2.35), or neglect (OR =1.91) associated with DM
Zung et al., 2012	All T1DM youth ages 0–17 reported to Israel Juvenile Diabetes Register (n = 1,822)	Post-war T1DM incidence increased in northern regions (rate ratio, RR = 1.27)
Scott et al., 2011	18,308 adults (≥18 years)	Greater risk of diabetes with at least 3 ACEs (HR = 1.59); no dose-response
Rich-Edwards et al., 2010	67,853 women ages 25 to 42; over 91% White	Dose-response for physical and sexual abuse. Greatest risk for both PA and SA (HR = 1.25)
Roy et al., 2010	444 African American adults (≥18 years) with T1DM	ACEs associated with CVD incidence; each additional trauma resulted in 23%–40% increase in odds of incident CVD. No association between ACEs and HbA1c, insulin dose, or retinopathy severity

Table 2

Measurement of adverse childhood experiences in recent review studies (2010–2015)

Author	ACEs/Abuse Categories or Measures
Duncan et al., 2015	5 abuse items: physical, sexual, & emotional abuse; physical & supervisory neglect
Gilbert et al., 2015	ACE module from Behavioral Risk Factor Surveillance System; 9 domains: physical, verbal, & sexual abuse; parental separation; exposure to domestic violence, mental illness, alcohol abuse, drug abuse, incarceration
Almuneef et al., 2014	ACE International Questionnaire (WHO and CDC); 5 domains: neglect, physical, sexual, & emotional abuse; family dysfunction, domestic, peer & community violence
Bellis et al., 2014	Short ACE tool (Kaiser Permanente and CDC); 9 domains: physical, verbal, & sexual abuse; parental separation; exposure to domestic violence, mental illness, alcohol abuse, drug abuse, incarceration
Husarewycz et al., 2014	6 domains: injurious trauma; psychological trauma; witnessing trauma; natural disaster; combat-related trauma; other trauma that was not explicitly listed
Lynch et al., 2013	Family Health History questionnaire (adapted from Conflict Tactics Scale, Child Trauma Questionnaire, and Wyatt); Health Appraisal questionnaire. 3 ACE subscales: abuse, neglect, and household dysfunction
Widom et al., 2012	Substantiated physical or sexual abuse, or neglect, in official records
Zung et al., 2012	War zone defined as 6 northern regions of Israel that were under missile attacks; non-war zone defined as other 14 central and southern regions of Israel
Scott et al., 2011	11 ACE domains: physical & sexual abuse; neglect; parental death, divorce, or other loss; parental mental disorder, substance use, criminal behavior, family violence, and family economic adversity
Rich-Edwards et al., 2010	Revised Conflict Tactics Scale; sexual abuse items from national survey conducted in 1995
Roy et al., 2010	Childhood Trauma Questionnaire; yields scores for emotional, physical, and sexual abuse; physical and emotional neglect