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Patterns of Adverse Childhood Experiences and Cardiovascular Risk Factors in U.S. Adults

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Abstract

Adverse Childhood Experiences (ACEs) are associated with poor health yet, we know little about how distinct patterns of ACE types are associated with cardiovascular (CVD) risk factors. The current study 1) examined associations of latent ACE classes with modifiable CVD risk factors including high cholesterol, smoking, diabetes, hypertension, high triglycerides, physical inactivity, overweight/obesity, and lifetime depression; and 2) examined the impact of socioeconomic status-related (SES) factors on these relationships. Using a cross-sectional analysis of the NESARC-III (n=36,309) data, four latent classes of ACEs were previously identified: 1) low adversity, 2) primarily household dysfunction, 3) primarily maltreatment, and 4) multiple adversity types. We examined the association of these classes with CVD risk factors in adulthood and subsequently, the same model accounting for SES-related factors. Tobacco smoking, overweight/obesity, and

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lifetime depression were each associated with higher odds of being in classes 2, 3, and 4 than class 1, respectively. These relationships held after adjusting for SES-related factors. Class 4 was associated with the most CVD risk factors, including high triglycerides and high cholesterol after controlling for SES-related factors. The consistent associations between tobacco smoking, overweight/obesity, and lifetime depression with each adverse ACE profile, even after controlling for SES, suggest behavioral CVD prevention programs should target these CVD risk factors simultaneously.

Keywords

Cardiovascular risk factors; Adverse childhood experience; Tobacco smoking; Depression; Obesity

Cardiovascular disease (CVD) is the leading cause of death in the U.S., accounting for about one in four deaths annually (Centers for Disease Control and Prevention (CDC), 2018). According to the American Heart Association (AHA), major non-modifiable and hereditary risk factors for CVD include older age, male sex, and certain racial and ethnic minority groups including African American/Black, Mexican-American, Native American, and some Asian-American groups (American Heart Association, 2016). AHA-defined major modifiable risk factors for CVD include clinical factors such as hypertension, high cholesterol, high triglycerides, type 2 diabetes, and being overweight or obese, as well as related behavioral risk factors of tobacco smoking, and physical inactivity. In addition, depression also has been identified as a strong risk factor for CVD (Lichtman et al., 2014).

Poor health outcomes in adulthood are associated with early exposure to negative life events, such as sexual abuse, physical abuse, physical neglect, emotional abuse, emotional neglect, and growing up in a family with violence, mental health issues, or substance use before the age of 18 (Centers for Disease Control and Prevention [CDC], 2020a), collectively known as adverse childhood experiences (ACEs; Doom et al., 2017; Jakubowski et al., 2018; Vig & Paluszek, 2019). Prevalence rates indicate ACEs are common, with 61.6% of people experiencing at least one ACE type and 15.8% experiencing four or more ACEs (Merrick et al., 2018). Literature supports both a dose-response and a threshold-response relationship between ACEs and poor health outcomes, such that experiencing more cumulative ACEs and meeting a threshold of four or more ACEs are each associated with increased risk for poor health outcomes (Hughes et al., 2017). In terms of CVD specifically, meta-analytic evidence shows that cumulative ACEs have been associated with an increased risk for CVD clinical outcomes (e.g., coronary heart disease, stoke) and metabolic outcomes (Jakubowski et al., 2018). Although some studies examined modifiable CVD risk factors (hypertension, diabetes), the bulk of studies have focused on cardiometabolic disease itself (Jakubowski et al., 2018).

Fewer studies have focused specifically on CVD risk factors. Prior research examining ACEs and CVD risk factors has examined cumulative ACEs (Danese et al., 2009) or a threshold of 4 or more ACEs. For example, a meta-analysis showed a threshold of experiencing four or more ACEs was associated with adult health outcomes, including small or modest positive associations with several CVD risk factors – diabetes, overweight

or obesity, physical inactivity, and tobacco smoking (Hughes et al., 2017). This approach assumes that all ACE types have an equal impact on adult health and does not consider that combinations of ACEs may commonly co-occur or interact with each other to result in poor health outcomes.

Other research suggests there are positive associations between specific types of ACEs and health outcomes relevant to CVD (Campbell et al., 2016; Felitti et al., 1998). For example, a meta-analysis by Huang et al. (2015) found both combined and differential influences of various types of ACEs on type 2 diabetes risk, such that overall exposure to ACEs was associated with increased odds of type 2 diabetes, with neglect having the strongest influence, followed by sexual abuse, then physical abuse (Huang et al., 2015). Campbell et al. (2016) found that diabetes, obesity, tobacco smoking, and depression were each differentially associated with different individual measures of verbal abuse, sexual abuse, substance abuse, and parent separation/divorce. Further, overweight/obesity has been positively associated with a combination of both childhood physical abuse, sexual abuse, and neglect (Ruiz & Font, 2020).

One way to better understand these patterns of specific ACE types is latent class analysis (LCA), a statistical approach used to categorize individuals based on their patterns of experiences, to identify unmeasured class membership. Further, by defining several homogeneous subgroups, LCA allows for the examination of the relationship between different patterns of ACE types and modifiable CVD risk factors. We are aware of only one study that examined latent classes of ACEs and cardiovascular outcomes. Salas et al. (2019) investigated ACEs, depression and cardiometabolic disease (defined as having diabetes or heart attack or angina/coronary heart disease) and found that membership in the “high adversity” class in those with depression was positively associated with cardiometabolic disease. The “sexual abuse” class was positively associated with diabetes independent of depression. However, this study included a singular outcome of cardiometabolic disease while controlling for potentially comorbid health conditions and behaviors, limiting the ability to compare among health conditions/behaviors or to identify health outcomes and risk factors that could be simultaneously targeted by behavioral medicine interventions.

There are additional gaps in prior examinations of the association between ACEs and CVD risk. For example, while profiles of ACEs have been examined in several populations, none have explored patterns of ACE types and major modifiable risk factors for CVD in a nationally representative U.S. sample. Given the potentially complex interplay between ACEs, depression, and CVD (Birk et al., 2019; De Venter et al., 2013; Iob & Steptoe, 2019; Merrick et al., 2018; Nemeroff & Goldschmidt-Clermont, 2012; Polanka et al., 2018; Seligman & Nemeroff, 2015), any examination of CVD risk factors should account for the role of depression either as an independent risk factor for CVD or as a control variable. To our knowledge, there are no studies that have examined the relationship between ACE classes and all AHA-defined major modifiable CVD risk factors together with depression. Further, existing studies examining relationships between ACEs and health outcomes are mixed in terms of adjusting for socioeconomic status (SES) factors (Hughes et al., 2017). Given established associations between SES and CVD risk (Mestral & Stringhini, 2017) and SES and ACEs (Merrick et al., 2018), it is difficult to interpret and compare relationships

across studies that vary in their inclusion of SES-related covariates. Additionally, it is unclear to what degree ACEs are associated with CVD risk factors above and beyond SES-related factors.

The current study builds upon a previous study that identified latent classes of ACEs in a nationally representative U.S. sample (Tynan et al., 2022). Latent classes were identified from nine categories of ACEs (sexual abuse, physical abuse, physical neglect, emotional abuse, emotional neglect, household member in prison, household substance use, witnessing interpersonal violence [IPV], and household member mental illness). The analysis yielded four classes of ACEs, which we labeled as 1) low adversity, 2) primarily household dysfunction, 3) primarily maltreatment, and 4) multiple adversity types. The study also showed SES factors such as income, education, occupation, and Veteran status were associated with membership in the more adverse classes. In the present study, we sought to evaluate whether these patterns of ACE exposure were associated with modifiable CVD risk factors including hypertension, high cholesterol, high triglycerides, diabetes, overweight/obesity, tobacco smoking, physical inactivity, and lifetime depression before and after accounting for SES factors. We expected that the multiple adversity types class would have the strongest relationship to individual CVD risk factors. No other specific hypotheses were formed given the lack of prior research with LCA of ACEs and modifiable CVD risk factors.

Method

Data and Sample

Data were obtained from the National Epidemiologic Survey of Alcohol and Related Conditions-III (NESARC-III), supported by the National Institute on Alcohol Abuse and Alcoholism (NIAAA). The target population was the non-institutionalized adult population 18 years or older living in the United States. Multistage probability sampling was used to collect the data from a representative U.S. sample in terms of age, sex, gender, race/ethnicity, and education of 36,309 individuals and is described elsewhere (Grant et al., 2014). Data were collected from participants via a computer-assisted personal interviewing system by a trained interviewer using the NIAAA'S Alcohol Use Disorder and Associated Disabilities Interview Schedule (AUDADIS-5), a structured interview that assesses alcohol, drug, and mental disorders according to DSM-5 criteria (American Psychiatric Association, 2013). Data were obtained through a Data Use Agreement with National Institute on Alcohol Abuse and Alcoholism and the study was approved by the institutional review board and the Research and Development Committee at VA San Diego Health Care System approved this secondary analysis study (Protocol #: N170149).

Measures

ACE Latent Class—Based on a prior study (Tynan et al., 2022), from 9 ACE indicators, each participant was classified into one of 4 latent ACE classes. The ACE indicators included sexual abuse, physical abuse, physical neglect, emotional abuse, emotional neglect, witnessing interpersonal violence (IPV), adult substance use in the home, adult mental health issues in the home, and household member in prison. The identified latent

classes were: 1) Low adversity (75.3%), 2) primarily household dysfunction (9.0%), 3) primarily maltreatment (10.7%), and 4) multiple adversity types (5.1%). Class distribution is consistent with recommendations for including classes the comprise at least 5% of the sample and 50 cases (Weller et al., 2020). The low adversity class was characterized by a low probability of experiencing all ACE indicators, and the multiple adversity types class was characterized by a having the highest probability of experiencing each ACE. The primarily household dysfunction and primarily maltreatment classes each had more moderate probabilities of all ACEs, with the 'household dysfunction' class experiencing a relatively higher probability of each of the household dysfunction indicators (household member in prison, household substance use, witnessing IPV, household member mental ill), and the primarily maltreatment class having relatively higher probabilities of experiencing maltreatment (sexual abuse, physical abuse, emotional abuse, emotional neglect). More information about specific items and procedures for conducting the LCA is provided in Tynan et al. (2022).

Non-Modifiable Cardiovascular Risk Factors and other sociodemographic variables—Sociodemographic variables relevant to the current study were participants' age, sex, race/ethnicity, education, employment, household income, and Veteran status. These variables were selected either because they represent a major non-modifiable CVD risk factor (age, sex, race/ethnic minority status), they were associated with latent ACE class membership in our previous study (Veteran status, sex), and/or are an SES factor relevant to CVD or ACEs (Veteran status, education, employment, household income). Being a Veteran, and being female were each associated with membership to the more adverse ACE profiles (Classes 2, 3, 4) compared to the low adversity class (Tynan et al., 2022). For primary analyses, age was used as a continuous variable. Sex, race/ethnicity, and Veteran status were used as categorical variables. Race/ethnicity were coded as (1) racial/ethnic minority (0) White, non-Hispanic.

Modifiable Cardiovascular Risk Factors

Diagnosed Conditions.: Cardiovascular risk factors that require a diagnosis were assessed by asking participants to self-report if they had each condition "in the last 12 months" and if a "doctor or other health professional confirmed the diagnosis." These conditions included: hypertension, high cholesterol, high triglycerides, and diabetes.

Overweight/Obesity.: Body Mass Index (BMI) was calculated from height and weight data. Per the Center for Disease Control (CDC) Guidelines, a BMI less than 18.5 kg/m^2 falls within the underweight range, 18.5 to < 25 falls into the normal weight range, 25 to < 30 falls into the overweight range, and 30.0 or higher falls into the obese range. For the current study, BMI was coded as (1) overweight or obese (0) underweight or normal weight.

Tobacco Smoking.: Smoking status was assessed using a single item inquiring about tobacco use status (current smoker, former smoker, non-smoker). Respondents were coded as (1) smoker if they selected "current smoker" and (0) non-smoker if they indicated "former smoker" or "non-smoker".

Physical Inactivity.: Respondents reported average frequency of both vigorous and moderate physical activity in the past year and an average duration of each physical activity session in minutes. The mean duration of weekly moderate and vigorous physical activity was calculated by multiplying the average duration per session by the frequency of moderate/vigorous physical activity per week. CDC physical activity guidelines recommend 150 minutes of moderate physical activity or 75 minutes of vigorous activity per week (Centers for Disease Control and Prevention [CDC], 2020c). Taking these guidelines into account and consistent with prior NESARC studies (Dakwar et al., 2012; Udo & Grilo, 2020), physical inactivity was coded yes (1) when respondents reported less than one day per week of engaging in moderate or vigorous PA and (0) when respondents reported activity levels above this cut-off.

Lifetime Depression.: Lifetime depression was assessed using the AUDADIS-5 (Grant et al., 2015), A dichotomous lifetime depression variable was coded as (1) if respondents indicated having a major depressive disorder, major depressive episode, or dysthymic disorder currently, in the past year, or prior to the past year. Respondents who did not endorse the aforementioned conditions were coded as (0).

Analytic Plan

We used the complex samples module in IBM SPSS (Version 27) to calculate descriptive statistics and frequencies. Our previously reported latent class analyses (Tynan et al., 2022) was conducted in Mplus (Version 7.31) (Muthén & Muthén, 1998-2017). Multinomial regression analyses for the current study were conducted in Latent Gold (Version 6.0). All analyses accounted for a complex sample design by adjusting for sampling weights, clustering, and strata (see supplemental File 1 for Mplus code). The NESARC-calculated AUDADIS full-sample weight was applied to account for participant nonresponse and oversampling of certain ethnic and demographic groups as recommend by Grant et al. (2014). Specifically, sample weight refers to the value used to compensate for variable probabilities of selection, differential nonresponse rates, and possible deficiencies in the sampling frame, strata, refers to the percentage of the population in the segment who were Hispanic, Black, or Asian, and cluster refers to individual counties grouped as “high-minority,” “moderate minority,” or “low minority (Grant et al., 2014).”

Results, including fit statistics, for our previously reported LCA (Tynan et al., 2022) are summarized in Supplemental Table 1. Considering all fit indices and examining profiles associated with different models, the 4-class model demonstrated the best fit. Entropy, which represents the overall precision of group classification (range=0-1), with values closer to 1 indicating higher precision was .77 for the final 4-class solution. This entropy value is similar to that reported in other LCAs of ACEs (Barboza, 2018; Roos et al., 2016). Probability estimates (Supplemental Table 2) were used to interpret the classes. Class 1 (Low adversity; 75.1%) demonstrated low probability of any form of maltreatment or household dysfunction. Class 2 (Primarily household dysfunction; 9.0%) exhibited moderate probabilities of all ACEs and higher probabilities of household dysfunction indicators, especially household substance use. Class 3 (Primarily maltreatment; 10.8%) represented high probability for maltreatment indicators and moderate to low probability for household

dysfunction. Class 4 (Multiple adversity types; 5.2%) demonstrated high probability of all ACE types.

Chi-Square Tests of Independence, accounting for the complex sample design, were used to examine the association between class membership, key non-modifiable CVD risk factors (i.e., age, sex, race/ethnicity) and key SES-related factors (employment, income, education, and Veteran status) and individual CVD risk factors (i.e., hypertension, high cholesterol, high triglycerides, diabetes, tobacco smoking, overweight/obesity, tobacco smoking, physical inactivity, and lifetime depression). Standardized residuals were used to assess the strength of the difference between observed and expected values for the prevalence of each CVD risk factor among the 4 ACE classes. Standardized residuals greater than and less than 2, which represent 2 standard deviations from the mean, were considered statistically significant.

To examine the association between CVD risk factors and class membership, we conducted multinomial regression analyses using the R3step method in Latent Gold. The R3step method makes it possible to conduct the LCA and regression analyses in the same model, thus reducing statistical error by allowing the LCA to maintain its formation and meaning when covariates are introduced (Asparouhov & Muthén, 2014; Zhu et al., 2017). In the first step of the R3step model, we replicated the 4-class LCA described in Tynan et al. (2022). In the second step, the posterior distribution calculated in the first step was used to create a most likely class membership variable. In the final step, the most likely class membership variable was regressed on the covariates (CVD risk factors). We conducted two R3step models. The first model included the non-modifiable CVD risk factors (age, sex, race/ethnicity) as covariates in addition to the modifyable CVD risk factors. The second model included the non-modifiable risk factors and SES-related factors (Veteran status, education, employment, household income) as covariates in addition to the modifyable CVD risk factors. In these models, the low adversity class served as the reference class. We used Wald statistics to determine whether covariates in the models could discriminate between classes in a statisically significant way. We also used Z statistics to determine statistically significant associations between a covariate and the latent class. Z statistics that are less than −3 or greater than 3 are considered to be at least three standard deviations below or above the mean and therefore statistically significant at $p < .01$.

Results

The majority of participants in the total sample reported being female (51.9%), non-Hispanic White (66.2%), and employed (65.9%); substantial minorities reported having a household income below $19,999 (41.2%) and having a college degree or higher (28.1%). Participants were on average 46.2 (SE = 0.2; range = 18 to 90) years old. Of the total sample, 9.6% were Veterans (See Table 1).

Prevalence rates for modifiable CVD risk factors for the overall sample and by latent ACE class are presented in Table 1. Chi-Square Test of Independence indicated a significant association between class membership with all individual modifiable CVD risk factors, except for being physically inactive ($X^2 = 7.76$, df = 2.91, $p = 0.144$). Standardized residuals

indicated a higher than expected prevalence of each individual modifiable CVD risk factor other than physical inactivity for classes 3 (primarily maltreatment) and 4 (multiple adversity types). Results were similar for class 2 (primarily household dysfunction), with the additional exceptions of high triglycerides and diabetes. The low adversity class (1) had a lower than expected prevalence of most modifiable CVD risk factors, with the exception of overweight/obesity (no relationship) and physical inactivity where there was a higher than expected prevalence.

Results of the R3step multinomial logistic regression models are presented in Tables 2a and 2b.[1] The first model indicated that after accounting for non-modifiable CVD risk factors, all modifiable CVD risk factors except diabetes and inactivity were significantly associated with class membership. Specifically, compared to individuals in the low adversity class (class 1): those who reported high cholesterol were significantly more likely to be in the multiple adversity types class (class 4); those who reported hypertension, were significantly more likely to be in the primarily household dysfunction (class 2) and multiple adversity types classes (class 4); those who reported high triglycerides were significantly more likely to be in the multiple adversity types class (class 4); those who reported overweight/obesity, tobacco smoking, or lifetime depression were significantly more likely to be in all three adverse classes (primarily household dysfunction, primarily maltreatment, and multiple adversity types; See Table 2a). The second multinomial logistic regression model which accounted for non-modifiable CVD risk factors and SES-related factors, showed a similar pattern of results. However, those in the multiple adversity types class (class 4) and the primarily household dysfunction (class 2) were no longer more likely to report hypertension.

Discussion

To our knowledge, this is the first study to examine ACE patterns in relation to individual major modifiable CVD risk factors. Results showed a consistent pattern that, of major modifiable CVD risk factors, overweight/obesity, tobacco smoking, and lifetime depression were related to the more adverse profiles (classes 2, 3, 4). There was a relatively stronger relationship between membership in the multiple adversity types class and individual modifiable CVD risk factors than other classes of adversities. However, distinct patterns in associations between the more adverse profiles (classes 2, 3, 4) and individual modifiable CVD risk factors indicated differential associations between specific ACE classes and specific CVD risk factors. The associations identified between individual modifiable cardiovascular risk factors and each adverse ACE profile reduced but showed an overall similar pattern after controlling for SES-related factors, suggesting these relationships are independent of SES-related factors.

Of the three classes with higher reported adversity, the multiple adversity types class (class 4) was associated with the most individual CVD risk factors and was most strongly associated with overlapping CVD risk factors among classes (overweight/obesity, tobacco smoking, and lifetime depression). The multiple adversity types class was additionally

[1]Ns for the four classes computed in Mplus (reported in Table 1) differ very slightly from those computed in Latent Gold (reported Supplementary Tables 1 and 2).

associated with high hypertension (prior to controlling for SES-factors), cholesterol, and high triglycerides. This finding is consistent with previous research showing relationships between latent ACE classes with the most ACE types being associated with worse substance use and mental health outcomes (Bryant et al., 2020; Hughes et al., 2017), and extends this accumulating evidence to include major modifiable CVD risk factors. Even though LCA was used to group together unique profiles of ACEs, this finding does lend some support to a dose-response relationship between ACEs and CVD risk factors.

In our study mean number of ACE types does increase in each of the 4 classes. While there is a large discrepancy in the mean number of ACE types between classes 1 and 4, there was a similar mean number of ACE types for classes 2 and 3. Thus, similarity in mean number of ACE types between classes 2 and 3, and differences between classes in associations with modifiable CVD risk factors suggest a more nuanced relationship between ACE types and modifiable CVD risk factors. The positive association between the multiple adversity class (class 4) and high cholesterol and high triglycerides, not identified with other classes, suggests the cumulative effect of multiple ACE types and perhaps this combination of ACEs is related to the most detrimental long-term physiological impact. Multiple biological mechanisms linking ACEs with health outcomes have been proposed. For example, psychosocial stress, such as that from ACEs, may lead to dysregulation of the limbic-hypothalamic-pituitary-adrenal axis and subsequently impact childhood brain development (De Bellis & Zisk, 2014). Additionally, ACEs may impact neuroendocrine functioning by triggering a chronic low-grade inflammatory response that may lead to metabolic dysregulation and subsequently brain circuitry dysregulation such that individuals are predisposed to substance use and high-fat diets (Nusslock & Miller, 2016).

Further, membership in the primarily household dysfunction class (class 2) was associated with greater likelihood of tobacco smoking than was the primarily maltreatment class (class 3). Conversely, membership in the primarily maltreatment (class 3) was associated with greater likelihood of having lifetime depression than the primarily household dysfunction (class 2). Discrepancies in results between classes 2 and 3 suggest specific associations between household dysfunction such as witnessing household substance use, and tobacco smoking, as well as specific associations between maltreatment and greater likelihood of experiencing depression. Further, prior to controlling for SES-factors, hypertension was associated with the primarily household dysfunction class (class 2) but not primarily maltreatment (class 3), perhaps representing different underlying physiological responses between these two adverse experiences. Household dysfunction often represents a longstanding, chronic stressor, whereas maltreatment may be more episodic and acute.

Of all modifiable CVD risk factors, our findings demonstrate that tobacco smoking, overweight/obesity, and lifetime depression had the strongest relationships to all latent ACE classes compared to the reference group. The relatively strong relationships between ACEs and tobacco smoking and lifetime depression in particular, are consistent with prior research demonstrating strong relationships between ACEs and substance use and mental health in adults (Hughes et al., 2019). Further, the association of more adverse ACE classes and tobacco smoking, overweight/obesity, and lifetime depression, lends support to the behavioral pathway associating ACEs with poor health in adulthood (Solís et al., 2015).

For example, tobacco use and overeating may function as avoidance strategies following potentially traumatic experiences (Feldner et al., 2007).

Some of our results were in contrast to those identified in prior studies examining dose-response relationships between ACEs and health-related factors. Our result that physical inactivity was not related to any of the adverse ACE profiles, deviates from previous meta-analytic research showing that a threshold of four or more ACEs was associated with physical inactivity, but had the weakest association with ACEs among the health outcomes examined (Hughes et al., 2017). Contrary to their hypothesis, a previous study using data from the NESARC wave 2 and using the same physical activity items as the current study found that vigorous physical activity was associated with a higher prevalence of psychiatric diagnoses (Dakwar et al., 2012), suggesting that these unexpected findings may be related to the limitations of self-reported physical activity and sedentary behavior in general and in the current study (Steene-Johannessen et al., 2016).The self-reported prevalence of physical inactivity in our sample was lower than other nationally representative reports (e.g., Centers for Disease Control and Prevention [CDC], 2020), further indicating reports of physical activity may be inflated in our sample. Additionally, prior studies have been mixed in terms of associations between diabetes and ACE types (Huffhines et al., 2016); however, diabetes was not associated with adverse ACE class in the current study. This may be explained by inconsistency in covariates, particularly other modifiable CVD risk factors.

Our results also have implications for clinical interventions in terms of both childhood prevention and adult risk management. Given that cardiovascular disease is the leading cause of death in the United States (Ahmad & Anderson, 2021), prevention of ACEs, such as through home visitation programs (Jones et al., 2020) could have a substantial public health impact. Further, prevention interventions in childhood could focus on cardiovascular risk and promoting optimal health behaviors starting from an early age. In adults, multiple health behavior change interventions show some promise, but results have been mixed for CVD prevention (Prochaska and Prochaska 2011). Findings from the current study suggest interventions that target weight, smoking, and depression simultaneously may be particularly beneficial for individuals with a significant history of ACEs of any type. Further, transdiagnostic approaches, such as Acceptance and Commitment Therapy may be appropriate for improving health behaviors and psychological distress simultaneously (e.g., Spatola et al., 2014). Our results also highlight the importance of screening for ACEs in primary care in addition to mental health settings to identify individuals who may need to receive more targeted risk management or prevention interventions. Further, the strong associations among ACEs and modifiable CVD risk factors suggest the need for healthcare professionals working with patients with high CVD risk be trained in trauma-informed care principles, such as understanding the impact of childhood adversity and trauma and avoiding practices that may re-traumatize individuals and impede access to care (Piotrowski, 2019). Further, individuals who have experienced household dysfunction may particularly benefit from screening and intervention for tobacco use and individuals who have experienced maltreatment may benefit from screening and intervention for depression.

Our study had several limitations. While the NEASRC-III data offers a large nationally representative sample, it is cross-sectional, and we were not able to draw inferences

about causality or temporal relationships. Reports of ACEs are subject to recall bias, with adults retrospectively reporting their experiences of ACEs from childhood. Additionally, our ACE measures did not take into account severity ratings or chronicity (e.g., occurred one time versus continuously) of ACEs, which may impact the strength of associations (O'Leary et al., 2010). Further, the multiple adversity types class (class 4) represented a relatively small percentage of participants relative to the other class. However, we believe this class makes conceptual sense as there are generally fewer individuals with multiple ACEs types than with one ACE type (Merrick et al., 2018). Health behaviors and health outcomes were self-reported. While not as ideal as alternative objective measures or medical record data, self-report of hypertension, diabetes, and high cholesterol have been shown to be reasonably accurate in the context of population-based research (Martin et al., 2000). Our measure of diabetes did not specify diabetes type. While it can be assumed in a nationally-representative sample that about 95% of diabetes cases refer to type 2 diabetes (Bullard et al., 2018), more precise assessment of health conditions and clinical indicators is recommended (e.g., more specific diagnoses, electronic health records, laboratory data). Future research should include longitudinal studies that focus on the temporal relationship between ACEs, modifiable CVD risk factors including depression to gain additional insight into explanatory mechanisms. More robust assessment of physical activity and sedentary time, using accelerometry, would also improve the rigor of future studies. Additionally, while we accounted for a range of sociodemographic factors, a more fine-grained examination of the impact of race and ethnicity is recommended for future work. Lastly, we did not assess protective factors, such as social support, that may attenuate our identified relationships (Roh et al., 2015).

In sum, the current study demonstrated an association between distinct ACE profiles and individual modifiable CVD factors with and without accounting for SES-related factors. Associations among ACE classes and individual CVD risk factors, suggest the strongest association with tobacco smoking, overweight/obesity, and lifetime depression, which informs directions for development of comprehensive or integrated behavioral CVD prevention and intervention strategies. Given that CVD is the leading cause of death in United States, the relationship between ACEs, several major modifiable CVD risk factors, and CVD underscores the importance of prevention and intervention efforts toward ACEs. Recommendations for future inquiry include examining mechanisms underlying the associations among ACE history, modifiable CVD risk factors, and depression as well as improving our understanding of potential protective factors using prospective designs (Lopez et al., 2021).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data accessibility statement:

Data for the current study was obtained from National Institute on Alcohol Abuse and Alcoholism per a data use agreement. See https://www.niaaa.nih.gov/sites/default/files/procedures_for_obtaining_datasets_vbw_edited_Final_4_23_2019.pdf for their procedures for obtaining the dataset.

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Table 1.

Demographic characteristics and modifiable cardiovascular risk factors across total sample and within each latent class

	Total Sample (N = 36,190)	**Class 1 Low Adversity (n = 26,679)**	**Class 2 Primarily household dysfunction (n = 3,430)**	**Class 3 Primarily maltreatment (n = 4,085)**	**Class 4 Multiple adversity types (n = 1,996)**	**χ^2 (df)**
	n,% (SE) /M (SE)	**n,% (SE) /M (SE)**	**n,% (SE) /M (SE)**	**n,% (SE) /M (SE)**	**n,% (SE) /M (SE)**	
Age	46.5 (0.2)	46.9 (0.2)	43.2 (0.4)	47.8 (0.4)	44.6 (0.4)	
Female	20387, 51.9 (0.3)	14661, 50.3 (0.3)	2158, 59.7 (1.0)[a]	2289, 53.2 (0.9)	1279, 59.5 (0.9)[b]	153.08 (2.96)*
Veteran	3111, 9.6 (0.3)	2211, 9.2 (0.3)	258, 8.4 (0.6)	442, 12.8 (0.7)	200, 11.6 (1.1)	63.39 (2.76)*
Racial/ethnic minority	17052, 33.8 (0.8)	12481, 33.6 (0.8)	1687, 35.0 (1.2)	1987, 35.1 (1.2)	897, 31.9 (1.4)	8.36 (2.84)*
Lower income	19592, 44.4 (0.7)	13994, 42.6 (0.7)[b]	2046, 51.3 (1.2)[a]	2264, 45.9 (1.2)	1288, 55.5 (1.7)[a]	194.84 (2.86)*
Lower education	15224, 38.7(0.8)	10956, 73.4 (0.6)[b]	1592, 44.3 (1.1)[a]	1691, 39.0 (1.1)	985, 48.5 (1.3)[a]	138.01 (2.97)*
Unemployed	11121, 34.1 (0.6)	7999, 33.1 (0.6)[b]	1042, 34.3 (1.2)	1347, 37.4 (1.1)[a]	733, 41.1 (1.6)[a]	61.64 (2.99)*
Hypertension	8984, 24.9 (0.4)	6398, 24.1 (0.5)[b]	848, 24.1 (1.0)[a]	1174, 29.3 (0.8)[a]	564, 30.0 (1.3)[a]	76.41 (2.86)*
High cholesterol	6719, 19.9 (0.4)	4728, 19.1 (0.4)[b]	620, 18.5 (0.8)[a]	914, 23.7 (0.8)[a]	457, 26.3 (1.2)[a]	95.91 (2.98)*
High triglycerides	2563, 8.4 (0.2)	1740, 7.8 (0.3)[b]	245, 8.0 (0.6)	364, 10.7 (0.6)[a]	214, 13.0 (0.8)[a]	87.95 (2.73)*
Diabetes	3518, 9.3 (0.2)	2451, 8.7 (0.3)[b]	337, 9.5 (0.6)	504, 11.8 (0.7)[a]	226, 12.2 (1.0)[a]	57.81 (2.74)*
Overweight/obesity	11270, 30.2, (0.5)	7826, 28.4 (0.5)	1208, 34.1 (1.1)[a]	1480, 35.8 (0.9)[a]	756, 37.7 (1.2)[a]	92.07 (2.92)*
Tobacco smoking	9979, 27.1 (0.5)	6571, 24.0 (0.4)[b]	1189, 35.6 (1.1)[a]	1314, 32.7 (1.1)[a]	905, 45.5 (1.3)[a]	631.76 (2.89)*
Physical inactivity	5487, 13.8 (0.4)	4205, 14.1 (0.4)[a]	439, 12.8 (0.7)	563, 12.8 (0.6)	280, 13.5 (0.9)	7.61 (2.82)
Lifetime depression	8029, 22.4 (0.4)	4493, 17.2 (0.4)[b]	1099, 33.5 (1.0)[a]	1436, 35.7 (1.0)[a]	1001, 50.8 (1.5)[a]	1900.46 (2.82)*

Note. M = Estimated population mean, SE = Standard Error

*Chi-square tests of independence (χ^2) statistically significant at $p < 0.001$

[a]Standardized residuals > 2

[b]Standardized residuals < −2

Table 2a.

Multinomial Regression Model examining the Association Between Latent Class and Cardiovascular Risk Factors

	Primarily Household Dysfunction			**Primarily Maltreatment**			**Multiple Adversity**				
	Coefficient	**SE**	**Z-Value**	**Coefficient**	**SE**	**Z-Value**	**Coefficient**	**SE**	**Z-Value**	**Wald Test**	**P-Value**
Intercept	−1.3009	0.0911	−14.2833	−2.5127	0.0859	−29.2504	−2.8797	0.1189	−24.2122	1503.385**	<.001
Covariates											
Age	−0.0218	0.0025	**−8.772**	0.0044	0.0016	2.8304	−0.0165	0.0021	**−7.9654**	125.8856**	<.001
Female	0.4676	0.0636	**7.3472**	−0.1588	0.0687	2.3126	−0.6065	0.0773	**7.8468**	115.2314**	<.001
Veteran	0.3935	0.1205	**3.2659**	0.5992	0.0999	**5.9953**	0.6626	0.1537	**4.3115**	69.8127**	<.001
Racial/Ethnic Minority	0.0659	0.0582	1.1312	0.3305	0.0633	**5.2194**	−0.107	0.0743	1.4392	29.4413**	<.001
Hypertension	0.2521	0.0789	**3.197**	0.0527	0.0767	0.6871	0.3019	0.0987	**3.0597**	18.4156**	0.00036
High cholesterol	0.1208	0.0938	1.2882	0.1005	0.0759	1.3234	0.3741	0.1065	**3.5118**	15.9014*	0.0012
High triglycerides	0.0151	0.1439	0.1046	0.1674	0.114	1.4693	0.3944	0.116	**3.3997**	11.9558*	0.0075
Diabetes	0.1317	0.1173	1.1223	0.2112	0.0939	2.2483	0.2244	0.1417	1.5836	8.6099*	0.035
Overweight/Obesity	0.2278	0.0703	**3.2391**	0.3384	0.0646	**5.2414**	0.2766	0.0747	**3.7015**	49.3894**	<.001
Tobacco smoking	0.718	0.0621	**11.5554**	0.4334	0.0656	**6.6076**	1.1289	0.0658	**17.1437**	448.8382**	<.001
Physical inactivity	−0.1457	0.0909	−1.6024	−0.1876	0.0821	−2.2845	−0.1099	0.093	−1.1824	7.7499	0.051
Lifetime depression	0.9112	0.0632	**14.4086**	1.1954	0.0677	**17.6525**	1.6545	0.08	**20.6813**	721.1606**	<.001

Note. SE = Standard Error

* $p < .05$

** $p < .001$; Bolded values represent Z statistics that are less than −3 or greater than 3, which are considered to be at least three standard deviations below or above the mean and therefore statistically significant at $p < .01$.

Table 2b.

Multinomial Regression Model examining the Association Between Latent Class and Cardiovascular Risk Factors Controlling for SES-Factors

	Primarily Household Dysfunction			Primarily Maltreatment			Multiple Adversity				
	Coefficient	**SE**	**Z-Value**	**Coefficient**	**SE**	**Z-Value**	**Coefficient**	**SE**	**Z-Value**	**Wald Test**	**P-Value**
Intercept	−1.1442	0.1210	−9.4576	−2.4707	0.1316	−18.7697	−2.6014	0.1392	−18.693	729.9919**	<.001
Covariates											
Age	−0.0226	0.0025	**−8.929**	0.0038	0.0017	2.2469	−0.0196	0.0020	**−9.5974**	141.4851**	<.001
Female	0.4570	0.0636	**7.1843**	0.1801	0.0699	2.5767	0.5589	0.0776	**7.2051**	107.8373**	<.001
Veteran	−0.4284	0.1195	**3.5849**	0.6031	0.1021	**5.9088**	0.7023	0.1602	**4.3850**	70.8497**	<.001
Racial/ethnic minority	−0.0184	0.0619	0.2967	0.3497	0.0676	**5.1763**	0.0480	0.0755	−0.6364	27.1099**	<.001
Lower income	0.1934	0.0541	**3.5745**	−0.0031	0.0594	−0.053	0.4205	0.0888	**4.7350**	43.2846**	<.001
Lower education	0.3231	0.0567	**5.7023**	0.0459	0.0731	−0.6280	−0.4436	0.0791	**5.6048**	54.8186**	<.001
Unemployed	0.0700	0.0823	0.8503	−0.0439	0.0774	0.5543	−0.2889	0.0791	**3.6516**	13.5055*	0.0037
Hypertension	0.2170	0.0771	2.8148	0.0663	0.0812	0.817	0.1863	0.1050	1.774	11.1083*	0.011
High cholesterol	0.1083	0.0967	1.1206	0.0693	0.0778	0.8909	0.3460	0.1071	**3.2301**	12.9297*	0.0048
High triglycerides	0.0551	0.1378	0.3997	0.2368	0.1123	2.1089	0.5233	0.1202	**4.3530**	20.5223**	0.00013
Diabetes	0.0877	0.1153	0.7608	0.2151	0.0945	2.2762	0.1264	0.1399	0.9032	6.2604	0.1
Overweight/obesity	0.2321	0.0713	**3.2530**	0.3565	0.0653	**5.4596**	0.2910	0.0726	**4.0055**	54.0943**	<.001
Tobacco smoking	0.6321	0.0621	**10.1754**	0.4262	0.0653	**6.5267**	0.9868	0.0645	**15.2927**	373.0975**	<.001
Physical inactivity	−0.2161	0.0938	−2.3032	−0.2008	0.0856	−2.3472	−0.2015	0.0926	−2.1753	13.4668*	0.0037
Lifetime depression	0.9294	0.0644	**14.4407**	1.1777	0.0686	**17.1789**	1.6941	0.0813	**20.8354**	708.8414**	<.001

Note. SE = Standard Error

* $p < .05$

** $p < .001$; Bolded values represent Z statistics that are less than −3 or greater than 3, which are considered to be at least three standard deviations below or above the mean and therefore statistically significant at $p < .01$.