Special Section: Latino Aging and Health: Original Research Article

# Association Between Adverse Childhood Events and Multimorbidity in a Racial and Ethnic Diverse Sample of Middle-Aged and Older Adults

**Elizabeth Vásquez, DrPH,[1,]\*** **Ana Quiñones, PhD,[2]** **Stephanie Ramirez, BS,[1]** **and Tomoko Udo, PhD[1]**

[1]Department of Epidemiology and Biostatistics, School of Public Health, University at Albany State University of New York. [2]Department of Family Medicine, Oregon Health and Science University, Portland.

\*Address correspondence to: Elizabeth Vásquez, DrPH, School of Public Health, University at Albany (SUNY) One University Place, Room 121, Rensselaer, NY 12144. E-mail: evasquez2@albany.edu

## Abstract

**Background and Objectives:** Adverse childhood events (ACEs) have been associated with increased health risks later in life. However, it is unclear whether ACEs may be associated with multimorbidity among diverse racial/ethnic middle-aged and older adults. We evaluated whether there were racial and ethnic differences in the association between ACEs and the number of somatic and psychiatric multimorbidity in a sample of U.S. middle-aged and older adults.
**Research Design and Methods:** Data from the 2012–2013 National Epidemiologic Survey on Alcohol and Related Conditions ($N = 10,727$; ≥55 years) were used to test whether the number of self-reported somatic conditions (i.e., heart disease, hypertension, stroke, diabetes, arthritis, cancer, osteoporosis, and chronic lung problems) as well as *DSM-5* psychiatric disorders (i.e., depression) during the past 12 months differed by history of ACEs while stratifying by age (i.e., 55–64 or ≥65) and racial/ethnic group (i.e., non-Hispanic White [NHW; $n = 7,457$], non-Hispanic Black [NHB; $n = 1,995$], and Hispanic [$n=1275$]).
**Results:** The prevalence of reporting more than two somatic conditions and psychiatric disorders was 48.8% and 11.4% for those with a history of ACEs, and 41.1% and 3.3% for those without a history of ACEs. Adjusting for sociodemographic and other health risk factors, ACEs was significantly associated with greater numbers of somatic multimorbidity among racial and ethnic middle-aged adults but this was not the case for older adults.
**Discussion and Implications:** Our findings suggest that middle-aged adults with a history of ACEs are more likely to suffer from somatic and psychiatric multimorbidity, highlighting the importance of screening for ACEs in promoting healthy aging.

**Translational Significance:** Adverse childhood events include physical, emotional, or sexual abuse or physical or emotional neglect. Adults who experienced one or more adverse childhood events have higher rates of chronic physical and psychiatric illnesses, than adults who did not experience adverse childhood events.

## Background and Objectives

Multimorbidity (i.e., simultaneous presentation of two or more chronic diseases) is a growing issue and poses a major challenge to health care systems around the world (Koroukian et al., 2017; Rocca et al., 2014; U.S. Department of Health and Human Services, 2010). One in four American adults has multimorbidity, and that number rises to three in four Americans aged 65 years and older (Lochner & Cox, 2013). Multimorbidity is an increasingly significant public health issue as it is associated with substantial health care expenditures over the past 20 years (Koroukian et al., 2017). Some studies have found that low socioeconomic status—such as childhood financial hardship, lower lifetime earnings, and lower educational levels—are associated with greater multimorbidity burden in older adults (Gijsen et al., 2001; Nagel et al., 2008; van Oostrom et al., 2016; Tucker-Seeley, Li, Sorensen, & Subramanian, 2011). In addition, underrepresented racial and ethnic minority groups are at higher risk of earlier multimorbidity development compared with non-Hispanic Whites (NHW) (Quiñones, Liang, Bennett, Xu, & Ye, 2011). However, less research has focused on malleable risk factors that may have occurred earlier in the life course. As the proportion of older adults in the population grows and multimorbidity becomes more ubiquitous, further identification of malleable risk factors is crucial to develop early prevention strategies during critical periods of the lifespan when multimorbidity development and progression may be averted, delayed, or compressed (Atun, 2015).

It has been well demonstrated that a history of adverse childhood events (ACEs) have profound impact on physical, emotional, and cognitive development in children, but also on one's physical and psychological health in adulthood (Felitti et al., 1998; Norman et al., 2012). One of the proposed pathways suggests that a history of ACEs may lead to disruptions in the neurobiological structure and functions that may persist into adulthood (Friedman, Karlamangla, Gruenewald, Koretz, & Seeman, 2015; Frodl et al., 2017; Tomasdottir et al., 2015). Furthermore, ACEs have been associated with increased risk for cardiovascular disease, certain types of cancer, among other life-threatening chronic somatic illnesses (Crowell et al., 2016; Ehrlich, Ross, Chen, & Miller, 2016; Levine, Cole, Weir, & Crimmins, 2015), as well as mental health issues in the general population (Kessler, Davis, & Kendler, 1997; Vannorsdall & Munro, 2017).

However, research on racial and ethnic differences in the prevalence of ACEs has produced mixed results. Some studies have reported higher prevalence of ACEs among underrepresented minorities (Merrick, Ford, Ports, & Guinn, 2018), whereas other studies have reported equivalent exposure to ACEs between racial and ethnic groups, particularly after adjusting for sociodemographic differences (Hussey, Chang, & Kotch, 2006). When evaluating specific ACEs domains such as parental substance abuse, exposure to violence, and being threatened or captive, non-Hispanic Black (NHB) and Hispanic adolescents report ACEs more frequently than NHW adolescents (Schilling, Aseltine, & Gore, 2007). Further, Schilling and colleagues (2007) found significant associations with depression, drug use, or anti-social behavior primarily in NHWs across different forms of adverse childhood events, but not in NHBs or Hispanics. While ACEs have been strongly associated with poor mental health outcomes and the risk of specific mental and psychiatric conditions (Vannorsdall & Munro, 2017), the role a history of ACEs exposure plays on the risk of developing multiple and interrelated coexisting conditions, or multimorbidity (hereafter) in middle-aged and older adults, has been largely unexplored.

Interest in multimorbidity is growing, signaling a continued shift away from considering diseases singly without consideration for the interactions between diseases. Yet, the possible role of ACEs in explaining differences in multimorbidity development and progression for underrepresented racial and ethnic middle-aged and older adults has not been fully investigated. While there are documented racial and ethnic disparities across the life span in the prevalence of psychiatric disorder in the general population, to the best of our knowledge, there are no studies that have investigated whether there are racial or ethnic differences in the relationship between ACEs and multimorbidity (somatic and psychiatric) among middle-aged and older adults. The aim of this study was twofold: (1) to examine the association between early exposures to ACEs and its health consequences in the form of multimorbidity among a nationally representative sample of middle-aged and older adults and (2) to examine whether age, racial, and ethnic differences exist in the relationship between ACEs and multimorbidity using the 2012–2013 National Epidemiologic Survey of Alcohol and Related Conditions III (NESARC-III).

## Research Design and Methods

### Sample

The NESARC-III is a national representative sample of 36,309 non-institutionalized U.S. adults 18 years and older (see Grant et al., 2014; Grant et al., 2016 for details on sampling procedure). The survey was designed to estimate the prevalence and correlates of alcohol and other drug use disorders in the U.S. adults. All participants completed computer-assisted face-to-face personal interviews at the respondent's residence between April 2012 and June 2013. The NESARC-III employed multistage probability sampling to select respondents randomly. Counties or groups of contiguous counties were used as primary sampling units, groups of Census-defined blocks as secondary sampling units, and households within secondary sampling units as tertiary sampling units. Within each household, eligible adults were randomly selected. However, Hispanic, Black,

and Asian household members were oversampled (i.e., two respondents from households with more than four eligible minority members), relative to White household members. NESARC-III response rates were reported to be 72.0% for the screener and 84.0% for the person level assessment. The overall NESARC-III response rate was 60.1% which is similar to other current U.S. national surveys (Grant et al., 2015). This study focused on NHW, NHB, or Hispanic respondents who are 55 years and older (*N* = 10,794). Respondents were excluded if they were missing data on ACEs, resulting in a final sample size of 10,727.

## Multimorbidity (somatic)

We defined somatic multimorbidity as the presence of two or more physical chronic conditions, consistent with the list of prevalent and persistent conditions identified by the U.S. Department of Health and Human Services framework (USHHS) for multimorbidity measurement, and previous work (Goodman, Posner, Huang, Parekh, & Koh, 2013; Quiñones et al., 2018; Salive, 2013; U.S. Department of Health and Human Services, 2010). For this study, we focused on self-reported diagnoses in the past year for the following conditions: cardiovascular disease assessed by self-reported myocardial infarction, angina pectoris, tachycardia, and other forms combined, hypertension (i.e., high blood pressure), stroke, diabetes, arthritis, lung problems (chronic bronchitis, emphysema, pneumonia, or influenza), and cancer (liver, breast, mouth/tongue/throat/esophageal, and other types of cancer combined). Note: obesity is increasingly being considered an important somatic chronic condition. Although obesity is not currently included in the USHHS framework of recommended conditions, we added it as a covariate (Diederichs, Berger, & Bartels, 2011). We measured obesity by body mass index (self-reported weight [lb]/self-reported height [in]$^2$ × 703) ≥ 30.

## Multimorbidity (psychiatric disorder)

A structured diagnostic interview, the NIAAA Alcohol Use Disorder and Associated Disabilities Interview Schedule-5 (AUDADIS-5; Grant et al., 2011), was used to assess a range of *DM-5*-defined psychiatric disorders and their criteria, both over the lifetime and the past 12 months. AUDADIS-5-generated psychiatric disorders as coded by NESARC-III were used in this study. This included mood disorders (major depressive episodes, persistent depression, and bipolar I), anxiety disorders (specific phobia, social phobia, panic disorders, agoraphobia, and generalized anxiety disorder), post-traumatic stress disorder, substance use disorders (alcohol use disorder, drug use disorder, nicotine use disorder), personality disorder (antisocial, borderline, and schizotypal), and conduct disorder. Good test–retest reliability and fair-to-moderate concordance rates for the AUDADIS-5 with a semistructured diagnostic interview

administered by independent research-clinicians have been reported for substance use and psychiatric disorders (Grant et al., 2015; Hasin et al., 2015). Similar to somatic multimorbidity, we defined psychiatric multimorbidity as presence of two or more *DSM-5* 12 months psychiatric diagnoses. The test–retest and internal consistency results for these measures were predominantly good (kappa > 0.63; ICC > 0.69; alpha > 0.75) and reliability for risk factor measures fell within the good to excellent range (intraclass correlations = 0.50–0.94; alpha = 0.64–0.90; Ruan et al., 2008).

## Childhood Adverse Experiences (ACEs)

Respondents self-reported five types of childhood maltreatment (physical neglect [five items], emotional neglect [five items], physical abuse [two items], emotional abuse [three items], and sexual abuse [four items]) by parents or caregiver. For all childhood maltreatment questions, response options were: 0 = Never, 1 = Almost never, 2 = Sometimes, 3 = Somewhat often, and 4 = Very often, and we followed the previous studies to score this scale.

There were 13 other self-reported adverse events that occurred before 18 years old, including four items on witnessing domestic violence (0 = Never, 1 = Almost never, 2 = Sometimes, 3 = Somewhat often, and 4 = Very often; response of at least "sometimes" = a positive response), four items on traumatic events related with parents/other adults living in home (1 = Yes, 0 = No), and five items on traumatic events related with home environment (1 = Yes, 0 = No). We coded each question consistent with previous studies (Fenton et al., 2013; Udo & Grilo, 2016), and defined a positive history of ACEs as reporting any childhood maltreatment or other adverse events (1 = Yes, 0 = No). Supplementary Table 1 describes questions and operationalization of childhood adversity.

## Covariates

The following sociodemographic information was included as covariates including: age, sex, and income (<\$25,000, \$20,000–\$34,999, \$35,000–\$69,999, ≥\$70,000). Stressful life events (SLEs) included questions about 16 stressful events (e.g., financial problems, legal problems, deaths in family or friends, changes in job or job responsibilities) occurring during the past 12 months (1 = Yes, 0 = No). A total number of SLEs were calculated (range 0–16; Supplementary Table 1 describes questions and operationalization of SLEs). The NESARC-III interviews included questions regarding lifetime smoking status (never, former, and current) and patterns of alcohol consumption defined by both frequency and quantity of use in the 12 months prior to the interviews (Rehm, Greenfield, & Rogers, 2001; Sobell & Sobell, 1995; Udo, Vasquez, & Shaw, 2015). Respondents also reported whether they were diagnosed by a doctor with problems

with falling asleep or staying asleep in the past 12 months (1 = Yes, 0 = No). We also determined whether respondents on average met the physical activity level recommended by the CDC 2008 Physical Activity Guidelines for Americans ("Physical Activity Guidelines Advisory Committee report, 2008. To the Secretary of Health and Human Services. Part A: executive summary," 2009) in the past year (1 = Yes for meeting ≥150 min/week, 0 = No) consistent with prior studies (Vásquez et al., 2018).

### Analysis

Statistical Analysis System (SAS; release 9.4, 2002–2012, SAS Institute, Cary, NC) was used to complete all analyses. All analyses accounted for complex NESARC survey design by using Proc Survey procedures with Taylor series variance estimation method. Rao-Scott chi-square test was used to compare the proportion of lifetime cigarette use, meeting recommended physical activity level by ACEs history and by race/ethnicity.

For the main analyses, analysis of covariance (ANCOVA) was performed to examine whether the presence of somatic and psychiatric multimorbidity differed by a history of ACEs and by race/ethnicity while adjusting for lifetime cigarette use, alcohol use, whether respondents met recommended physical activity, and the number of SLEs in the past 12 months. All analyses were stratified by age groups (55–64 years old and ≥65 years old). Tukey–Kramer post hoc test (for ANCOVA) was used to probe significant omnibus tests.

## Results

### Sample Characteristics by Adverse Childhood Experience

Table 1 displays the weighted means or percentages of selected variables by history of adverse childhood experiences. The total sample consisted of 81.1% NHW, 10.02% NHB, and 8.87% Hispanics. When evaluating ACE history males reported the lowest proportion (45.3%). Middle-aged adults reported the lowest proportion (48.7%) of ACE when compared to older adults (52%).

Supplementary Table 2 displays the weighted means and percentages of the sample by ACEs, age and race/ethnicity. In general, NHW reported higher income and education when compared to NHB and Hispanics. NHW were also likely to be past smokers while NHB were likely to be current smokers.

### Prevalence of Somatic and Psychiatric Multimorbidity by Childhood Aadversity and Age

Figure 1a and b shows the prevalence of somatic and psychiatric disorder multimorbidity by age and race/ethnicity.

A history of ACEs was associated with more somatic and psychiatric multimorbidity independent of age, race/ethnicity.

### ACE and Multimorbidity-Adjusted Models for Middle-Aged Adults (55–64 years)

Adjusting for sociodemographic and other health risk factors respondents between 55 and 64 years old with a history of ACEs had more somatic and psychiatric disorder multimorbidity, compared with those without a history of ACEs (1.37 ± 0.04 vs 1.13 ± 0.04). We also found there was a significant ACEs history by race/ethnicity interaction ($p \leq .05$) in this age group. Hispanics reported significantly less somatic multimorbidity (1.04 ± 0.05) relative to NHW (1.31 ± 0.04) and NHB (1.40 ± 0.06). In addition, a history of ACEs was associated with a significantly greater number of somatic multimorbidity in NHW and Hispanics, but not in NHB when compared to no ACEs.

Among respondents between 55 and 64 years old, regardless of racial and ethnic classification, respondents with a history of ACEs reported more psychiatric disorder multimorbidity, compared with those without a history of ACEs (0.54 ± 0.03 vs 0.27 ± 0.03). There was a significant association between race and ethnicity where middle-aged NHW reported more psychiatric multimorbidity when compared to NHB (0.47 ± 0.03 vs 0.36 ± 0.04, respectively).

### ACE and Multimorbidity-Adjusted Models for Older Adults (≥65 years)

Hispanics aged 65 years and older reported significantly fewer numbers of chronic medical conditions (1.63 ± 0.07) relative to NHW (1.88 ± 0.03) and NHB (1.86 ± 0.06). There was no significant ACEs history by race/ethnicity interaction in this group. In this group, a history of ACEs was associated with more psychiatric multimorbidity when compared with those without a history of ACEs.

## Discussion and Implications

Using a large epidemiological data (NESARC-III), we investigated the relationship between a history of ACEs and middle-aged and later-life physical and psychiatric disorder multimorbidity accounting for sample differences by race/ethnicity. Overall we found that even after adjusting for selected covariates the middle-aged respondents with a history of ACEs had more somatic multimorbidity, compared with those without a history of ACEs. When evaluating psychiatric disorder multimorbidity our middle-aged group (55–64 years old) with a history of ACEs reported a greater number of *DSM-5* 12 months psychiatric disorders, compared with those without a history of ACEs. Both of these findings were independent of race/ethnic classification.

**Table 1.** Sample Description: Weighted Percentages by Adverse Childhood Events

| | Total sample | ACE[a] | Non-ACE | Difference between ACE and non-ACE[b] |
|---|---|---|---|---|
| Variable | Mean ± (*SE*) or proportion | | | |
| Age | 66.83 (0.11) | 66.48 (0.15) | 67.26 (0.14) | * |
| Sex (%) | | | | ** |
| Male | 46.03 | 45.43 | 46.76 | |
| Female | 53.97 | 54.57 | 53.24 | |
| Age group (%) | | | | *** |
| Between 55 and 64 | 48.05 | 48.74 | 47.2 | |
| Older than 65 | 51.95 | 51.26 | 52.8 | |
| Race (%) | | | | *** |
| Non-Hispanic White | 81.1 | 78.5 | 84.27 | |
| Non-Hispanic Black | 10.02 | 11.7 | 7.99 | |
| Hispanic | 8.87 | 9.8 | 7.74 | |
| Smoking (%) | | | | *** |
| Current | 19.06 | 20.84 | 16.89 | |
| Former | 35.04 | 37.75 | 31.74 | |
| Never | 45.91 | 41.42 | 51.37 | |
| Income (%) | | | | *** |
| <$20,000 | 23.18 | 25.64 | 20.2 | |
| $20,000–$34,999 | 19.98 | 20.73 | 19.06 | |
| $35,000–$69,999 | 27.64 | 27.07 | 28.33 | |
| ≥$70,000 | 29.2 | 26.56 | 32.41 | |
| Education (%) | | | | *** |
| Less than high school | 14.46 | 17.48 | 10.8 | |
| High school/GED | 27.51 | 27.25 | 27.82 | |
| Some college or more | 58.03 | 55.27 | 61.38 | |
| Quantity of drinks per occasion | 1.32 (0.04) | 1.35 (0.05) | 1.29 (0.06) | |
| Number of days drinking alcohol past year[c] | 64.32 (1.95) | 64.23 (2.34) | 64.41 (2.33) | |
| Number of past year stressful life events (log) | 0.54 (0.01) | 0.61 (0.01) | 0.46 (0.01) | *** |
| Meets physical activity guidelines (%)[d] | | | | *** |
| No | 40.49 | 40.22 | 40.82 | |
| Yes | 59.51 | 59.78 | 59.18 | |
| *N* | 10,727 | 6,130 | 4,597 | |

*Note*: GED = general education diploma; [a]Adverse childhood events (this includes both maltreatment and other adverse experiences). [b]Difference between ACE and non-ACE groups were tested by t-test (continuous variables) or chi-square test (categorical). [c]Number of days drinking alcohol past year (log-transformed). [d]Met the physical activity level recommended by the CDC 2008 Physical Activity Guidelines for Americans.
Significance level *$p$ < .1; **$p$ < .05; ***$p$ < .001.

Moreover, middle-aged respondents reported a greater number of multimorbidity associated with a history of ACEs when compared to the older group (≥65 years). In the middle-aged group, a history of ACEs had the strongest impact among NHW. In particular, psychiatric disorder multimorbidity where we found a higher prevalence in NHW and Hispanic relative to NHBs (see Table 2). However, for NHB the prevalence of somatic and psychiatric multimorbidity was high regardless of ACEs history. These findings suggest perhaps there is a need to further evaluate the association between ACEs and multimorbidity among race/ethnic groups. It also suggests the necessity to evaluate the more nuanced individual ACE items and/or dose–response relationship; in particular, whether the individual ACEs items and/or dose–response varies by race/ethnicity.

We conducted sensitivity analysis and found a positive dose response, whereas three or more ACEs were significantly correlated with increasing numbers of morbidities (≥3; results not shown). We found several studies describe the dose–response relationship between the number of ACEs reported and increase prevalence of comorbidity in adulthood (Gruenewald et al., 2012; Vannorsdall & Munro, 2017). Yet, our findings highlight the role of ACEs in the development of somatic and psychiatric disorder multimorbidity that may serve to increase vulnerability of racial/ethnic middle-aged and older adult samples. Interestingly, much of the work concerning potential dose–response of increasing ACE risks has focused on outcomes as they present in young or middle adulthood, which may not generalize to later life, as there may be cohort effects in the prevalence of ACEs (Crowell

**Table 2.** Adjusted Means of Reporting Multimorbidity by a History of ACEs, Age, and Race/Ethnicity

| | ACE | | | Non-ACE | | |
|---|---|---|---|---|---|---|
| | Non-Hispanic white | Non-Hispanic black | Hispanic | Non-Hispanic white | Non-Hispanic black | Hispanic |
| **Age 55–64** | | | | | | |
| Somatic multimorbidity $M \pm SE$ | 1.49 (0.05) | 1.45 (0.06) | 1.24[a] (0.07) | 1.14[b] (0.04) | 1.38[a] (0.08) | 0.83[a,b] (0.06) |
| Psychiatric disorder multimorbidity $M \pm SE$ | 0.65[b] (0.04) | 0.48[a] (0.05297 | 0.57[a,b] (0.05) | 0.30 (0.03) | 0.24 (0.06) | 0.16[a] (0.03) |
| **Age ≥65** | | | | | | |
| Somatic Multimorbidity $M \pm SE$ | 1.93[b] (0.04) | 2.06[a] (0.06) | 1.63[a,b] (0.10) | 1.80 (0.04) | 1.71 (0.09) | 1.60[b] (0.13) |
| Psychiatric disorder multimorbidity $M \pm SE$ | 0.32 (0.02) | 0.30 (0.04) | 0.22 (0.04) | 0.12 (0.01) | 0.06[b] (0.02) | 0.10 (0.04) |

*Note*: ACE = Adverse childhood events.
Reference group: [a]Significantly different from non-Hispanic White at $p < .05$. [b]Significantly different from non-Hispanic Black at $p < .05$.
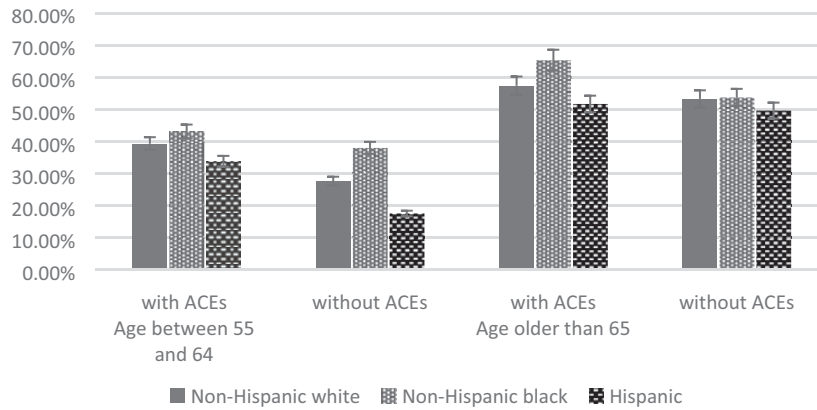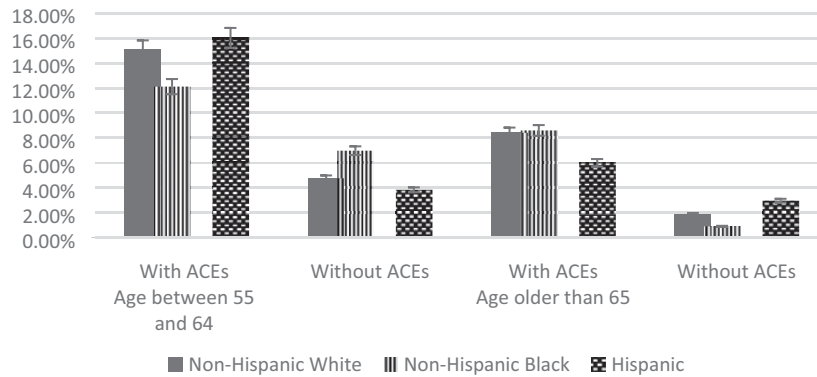


**Figure 1.** (a and b) Prevalence of somatic and psychiatric disorder multimorbidity by a history of adverse childhood events by race and ethnicity and by age group. ACE = Adverse childhood events.

et al., 2016). Our study adds to the literature by including older adults when evaluating the association between ACEs and somatic and psychiatric disorder multimorbidity.

Although beyond the aim of our paper and the specific mechanism is unknown, psychosocial stress such as exposure to ACEs may impart an enduring biological imprint on

middle age an older adult health. Some of the hypothesized direct mechanisms can be associated with the life course approach and fetal origins hypothesis, which proposes that in general prenatal environments have lasting consequences for cardiovascular and metabolic systems (Barker, 1990). Several studies suggest that exposures during the childhood age range can have a prolonged biological imprint on health. For example, a study evaluating an index of early-life adversity similar to the one used in our study found ACEs to be associated with inflammatory markers among middle-aged NHB adults even after adjusting for adult behaviors and exposures (Slopen et al., 2010). A recent meta-analysis posed that multiple domains of childhood maltreatment were associated with an elevated prevalence of obesity over the life course and that the association persisted independent of childhood and adulthood socioeconomic conditions and health behaviors (Danese & Tan, 2014).

With regard to psychiatric disorder multimorbidity, respondents with a history of ACEs reported a higher prevalence of psychiatric disorder independent of race and ethnicity or age group. A study by Mersky, Topitzes, & Reynolds, 2013 used a racial diverse sample in Chicago and found a robust association between ACEs and poor outcomes in early adulthood. They also found a dose–response where higher levels of adversity were associated with poorer self-rated health and life satisfaction, as well as more frequent depressive symptoms (Mersky et al., 2013). Similar to the Mersky et al. 2013, our results suggest that perhaps the consequences of a history of ACEs may lead to differential morbidity and mortality among middle-aged and older adults.

### Strengths and Limitations

When evaluating our findings, it is important to remember that our study is cross-sectional and thus, we were unable to test a causal relationship between ACEs and somatic and psychiatric disorder multimorbidity. Bias in retrospective reporting of childhood adversities may represent another limitation. However, several important studies support the validity of evaluating ACEs retrospectively and finding minor differences between prospective and retrospective reports (Scott, McLaughlin, Smith, & Ellis, 2012). Furthermore the evaluations of ACEs used by NESARC-III employed a comprehensive method of assessing ACEs previously used by our team. Although the current study focused on ACE as a categorical variable, certain forms of ACEs may have stronger relationship with adulthood multimorbidity. The disentangling of ACEs by number and severity are important questions to be investigated by future studies. Our study has several strengths and adds to the literature as an interdisciplinary endeavor suggesting that a history of ACEs should be considered as a potential risk factor for middle-aged and older adult multimorbidity.

Finally, with the expected growth of the older adult population and the new cohort of middle-aged and older adults reporting greater numbers of ACEs than their more senior counterparts investment in programs and policies that prevent ACEs and ameliorate their impacts is warranted. Our findings have explicit public health implication suggesting that middle-aged adults with a history of ACEs are more likely to suffer from somatic and psychiatric multimorbidity, highlighting the importance of screening for ACEs in promoting healthy aging.

## Conflict of Interest

None reported.

## References

Atun, R. (2015). Transitioning health systems for multimorbidity. *Lancet,* **386**(9995), 721–722. doi:10.1016/S0140-6736(14)62254–6

Barker, D. J. (1990). The fetal and infant origins of adult disease. *BMJ (Clinical Research Ed.),* **301**, 1111. doi:10.1136/bmj.301.6761.1111

Crowell, J. A., Davis, C. R., Joung, K. E., Usher, N., McCormick, S. P., Dearing, E., & Mantzoros, C. S. (2016). Metabolic pathways link childhood adversity to elevated blood pressure in midlife adults. *Obesity Research & Clinical Practice,* **10**, 580–588. doi:10.1016/j.orcp.2015.10.009

Danese, A., & Tan, M. (2014). Childhood maltreatment and obesity: Systematic review and meta-analysis. *Molecular Psychiatry,* **19**, 544–554. doi:10.1038/mp.2013.54

Diederichs, C., Berger, K., & Bartels, D. B. (2011). The measurement of multiple chronic diseases–a systematic review on existing multimorbidity indices. *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences,* **66**, 301–311. doi:10.1093/gerona/glq208

Ehrlich, K. B., Ross, K. M., Chen, E., & Miller, G. E. (2016). Testing the biological embedding hypothesis: Is early life adversity associated with a later proinflammatory phenotype? *Development and Psychopathology,* **28**, 1273–1283. doi:10.1017/S0954579416000845

Felitti, V. J., Anda, R. F., Nordenberg, D., Williamson, D. F., Spitz, A. M., Edwards, V.,…Marks, J. S. (1998). 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,* **14**, 245–258.

Fenton, M. C., Geier, T., Keyes, K., Skodol, A. E., Grant, B. F., & Hasin, D. S. (2013). Combined role of childhood maltreatment, family history, and gender in the risk for

alcohol dependence. *Psychological Medicine,* **43**, 1045–1057. doi:10.1017/S0033291712001729

Friedman, E. M., Karlamangla, A. S., Gruenewald, T. L., Koretz, B., & Seeman, T. E. (2015). Early life adversity and adult biological risk profiles. *Psychosomatic Medicine,* **77**, 176–185. doi:10.1097/PSY.0000000000000147

Frodl, T., Janowitz, D., Schmaal, L., Tozzi, L., Dobrowolny, H., Stein, D. J.,…Grabe, H. J. (2017). Childhood adversity impacts on brain subcortical structures relevant to depression. *Journal of Psychiatric Research,* **86**, 58–65. doi:10.1016/j.jpsychires.2016.11.010

Gijsen, R., Hoeymans, N., Schellevis, F. G., Ruwaard, D., Satariano, W. A., & van den Bos, G. A. (2001). Causes and consequences of comorbidity: A review. *Journal of Clinical Epidemiology,* **54**, 661–674. doi:10.1016/S0895-4356(00)00363-2

Goodman, R. A., Posner, S. F., Huang, E. S., Parekh, A. K., & Koh, H. K. (2013). Defining and measuring chronic conditions: Imperatives for research, policy, program, and practice. *Preventing Chronic Disease,* **10**, E66. doi:10.5888/pcd10.120239

Grant, B. F., Chu, A., Sigman, R., Amsbary, M., Kali, J., Sugawara, Y., ... Goldstein, R. (2014). *Sources and Accuracy Statement: National Epidemiologic Survey on Alcohol and Related Conditions-III (NESARC-III).* Rockville, MD: National Institute on Alcohol Abuse and Alcoholism. Retrieved from http://www.niaaa.nih.gov/sites/default/files/NESARC_Final_Report_FINAL_1_8_15.pdf.

Grant, B. F., Goldstein, R. B., Chou, S. P., Saha, T. D., Ruan, W. J., Huang, B., ... Hasin, D. S. (2011). *The alcohol use disorder and associated disabilities interview schedule-Diagnostic and statistical manual of mental disorders, Fifth Edition Version (AUDADIS-5).* Rockville, MD.

Grant, B. F., Goldstein, R. B., Smith, S. M., Jung, J., Zhang, H., Chou, S. P.,…Hasin, D. S. (2015). The alcohol use disorder and associated disabilities interview schedule-5 (AUDADIS-5): Reliability of substance use and psychiatric disorder modules in a general population sample. *Drug and Alcohol Dependence,* **148**, 27–33. doi:10.1016/j.drugalcdep.2014.11.026

Grant, B. F., Saha, T. D., Ruan, W. J., Goldstein, R. B., Chou, S. P., Jung, J.,…Hasin, D. S. (2016). Epidemiology of DSM-5 drug use disorder: Results from the national epidemiologic survey on alcohol and related conditions-III. *JAMA Psychiatry,* **73**, 39–47. doi:10.1001/jamapsychiatry.2015.2132

Gruenewald, T. L., Karlamangla, A. S., Hu, P., Stein-Merkin, S., Crandall, C., Koretz, B., & Seeman, T. E. (2012). History of socioeconomic disadvantage and allostatic load in later life. *Social Science & Medicine (1982),* **74**, 75–83. doi:10.1016/j.socscimed.2011.09.037

Hasin, D. S., Greenstein, E., Aivadyan, C., Stohl, M., Aharonovich, E., Saha, T.,…Grant, B. F. (2015). The alcohol use disorder and associated disabilities interview schedule-5 (AUDADIS-5): Procedural validity of substance use disorders modules through clinical re-appraisal in a general population sample. *Drug and Alcohol Dependence,* **148**, 40–46. doi:10.1016/j.drugalcdep.2014.12.011

Hussey, J. M., Chang, J. J., & Kotch, J. B. (2006). Child maltreatment in the United States: Prevalence, risk factors, and adolescent health consequences. *Pediatrics,* **118**, 933–942. doi:10.1542/peds.2005-2452

Kessler, R. C., Davis, C. G., & Kendler, K. S. (1997). Childhood adversity and adult psychiatric disorder in the US national comorbidity survey. *Psychological Medicine,* **27**, 1101–1119. doi:10.1017/S0033291797005588

Koroukian, S. M., Schiltz, N. K., Warner, D. F., Sun, J., Stange, K. C., Given, C. W., & Dor, A. (2017). Multimorbidity: Constellations of conditions across subgroups of midlife and older individuals, and related medicare expenditures. *Journal of Comorbidity,* **7**, 33–43. doi:10.15256/joc.2017.7.91

Levine, M. E., Cole, S. W., Weir, D. R., & Crimmins, E. M. (2015). Childhood and later life stressors and increased inflammatory gene expression at older ages. *Social Science & Medicine (1982),* **130**, 16–22. doi:10.1016/j.socscimed.2015.01.030

Lochner, K. A., & Cox, C. S. (2013). Prevalence of multiple chronic conditions among medicare beneficiaries, United States, 2010. *Preventing Chronic Disease,* **10**, E61. doi:10.5888/pcd10.120137

Merrick, M. T., Ford, D. C., Ports, K. A., & Guinn, A. S. (2018). Prevalence of adverse childhood experiences from the 2011-2014 behavioral risk factor surveillance system in 23 states. *JAMA Pediatrics,* **172**, 1038–1044. doi:10.1001/jamapediatrics.2018.2537

Mersky, J. P., Topitzes, J., & Reynolds, A. J. (2013). Impacts of adverse childhood experiences on health, mental health, and substance use in early adulthood: A cohort study of an urban, minority sample in the U.S. *Child Abuse & Neglect,* **37**, 917–925. doi:10.1016/j.chiabu.2013.07.011

Nagel, G., Peter, R., Braig, S., Hermann, S., Rohrmann, S., & Linseisen, J. (2008). The impact of education on risk factors and the occurrence of multimorbidity in the EPIC-Heidelberg cohort. *BMC Public Health,* **8**, 384. doi:10.1186/1471-2458-8-384

Norman, R. E., Byambaa, M., De, R., Butchart, A., Scott, J., & Vos, T. (2012). The long-term health consequences of child physical abuse, emotional abuse, and neglect: A systematic review and meta-analysis. *Plos Medicine,* **9**, e1001349. doi:10.1371/journal.pmed.1001349

van Oostrom, S. H., Gijsen, R., Stirbu, I., Korevaar, J. C., Schellevis, F. G., Picavet, H. S., & Hoeymans, N. (2016). Time trends in prevalence of chronic diseases and multimorbidity not only due to aging: Data from general practices and health surveys. *Plos One,* **11**, e0160264. doi:10.1371/journal.pone.0160264

Physical Activity Guidelines Advisory Committee report. (2008). To the Secretary of Health and Human Services. Part A: Executive summary. (2009). *Nutrition Reviews,* **67**, 114–120. doi:10.1111/j.1753-4887.2008.00136.x

Quiñones, A. R., Liang, J., Bennett, J. M., Xu, X., & Ye, W. (2011). How does the trajectory of multimorbidity vary across black, white, and Mexican Americans in middle and old age? *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences,* **66**, 739–749. doi:10.1093/geronb/gbr106

Quiñones, A. R., Markwardt, S., Thielke, S., Rostant, O., Vásquez, E., & Botoseneanu, A. (2018). Prospective disability in different combinations of somatic and mental multimorbidity. *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences,* **73**, 204–210. doi:10.1093/gerona/glx100

Rehm, J., Greenfield, T. K., & Rogers, J. D. (2001). Average volume of alcohol consumption, patterns of drinking, and all-cause

mortality: Results from the US National Alcohol Survey. *American Journal of Epidemiology,* **153**, 64–71. doi:10.1093/aje/153.1.64

Rocca, W. A., Boyd, C. M., Grossardt, B. R., Bobo, W. V., Finney Rutten, L. J., Roger, V. L., ... St Sauver, J. L. (2014). Prevalence of multimorbidity in a geographically defined American population: Patterns by age, sex, and race/ethnicity. *Mayo Clinic proceedings,* **89**, 1336–1349. doi:10.1016/j.mayocp.2014.07.010

Ruan, W. J., Goldstein, R. B., Chou, S. P., Smith, S. M., Saha, T. D., Pickering, R. P.,…Grant, B. F. (2008). The alcohol use disorder and associated disabilities interview schedule-IV (AUDADIS-IV): Reliability of new psychiatric diagnostic modules and risk factors in a general population sample. *Drug and Alcohol Dependence,* **92**, 27–36. doi:10.1016/j.drugalcdep.2007.06.001

Salive, M. E. (2013). Multimorbidity in older adults. *Epidemiologic Reviews,* **35**, 75–83. doi:10.1093/epirev/mxs009

Schilling, E. A., Aseltine, R. H. Jr, & Gore, S. (2007). Adverse childhood experiences and mental health in young adults: A longitudinal survey. *BMC Public Health,* **7**, 30. doi:10.1186/1471-2458-7-30

Scott, K. M., McLaughlin, K. A., Smith, D. A., & Ellis, P. M. (2012). Childhood maltreatment and DSM-IV adult mental disorders: Comparison of prospective and retrospective findings. *The British Journal of Psychiatry,* **200**, 469–475. doi:10.1192/bjp.bp.111.103267

Slopen, N., Lewis, T. T., Gruenewald, T. L., Mujahid, M. S., Ryff, C. D., Albert, M. A., & Williams, D. R. (2010). Early life adversity and inflammation in african americans and whites in the midlife in the united states survey. *Psychosomatic Medicine,* **72**, 694–701. doi:10.1097/PSY.0b013e3181e9c16f

Sobell, L. C., & Sobell, M. B. (1995). Alcohol consumption measures. *Assessing Alcohol Problems: A Guide for Clinicians and Researchers,* **2**, 75–99.

Tomasdottir, M. O., Sigurdsson, J. A., Petursson, H., Kirkengen, A. L., Krokstad, S., McEwen, B.,…Getz, L. (2015). Self reported childhood difficulties, adult multimorbidity and allostatic load. A cross-sectional analysis of the Norwegian HUNT study. *Plos One,* **10**, e0130591. doi:10.1371/journal.pone.0130591

Tucker-Seeley, R. D., Li, Y., Sorensen, G., & Subramanian, S. V. (2011). Lifecourse socioeconomic circumstances and multimorbidity among older adults. *BMC Public Health,* **11**, 313. doi:10.1186/1471-2458-11-313

Udo, T., & Grilo, C. M. (2016). Perceived weight discrimination, childhood maltreatment, and weight gain in U.S. Adults with overweight/obesity. *Obesity (Silver Spring, Md.),* **24**, 1366–1372. doi:10.1002/oby.21474

Udo, T., Vásquez, E., & Shaw, B. A. (2015). A lifetime history of alcohol use disorder increases risk for chronic medical conditions after stable remission. *Drug and Alcohol Dependence,* **157**, 68–74. doi:10.1016/j.drugalcdep.2015.10.008

U.S. Department of Health and Human Services. (2010). *Multiple chronic conditions—A strategic framework: Optimum health and quality of life for individuals with multiple chronic conditions.* Washington, DC: U.S. Department of Health and Human Services.

Vannorsdall, T. D., & Munro, C. A. (2017). The link between childhood adversity and late-life mental health: Evidence for the influence of early-life experiences or illusory correlations? *International Psychogeriatrics,* **29**, 357–358. doi:10.1017/S1041610216002416

Vásquez, E., Sahakyan, K., Batsis, J. A., Germain, C., Somers, V. K., & Shaw, B. A. (2018). Ethnic differences in all-cause and cardiovascular mortality by physical activity levels among older adults in the US. *Ethnicity & Health,* **23**, 72–80. doi:10.1080/13557858.2016.1253830