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Sleep Quality as a Critical Pathway Between Adverse Childhood Experiences and Multimorbidity and the Impact of Lifestyle

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Abstract

Objectives: This study aims to establish the effects of ACEs on multimorbidity through sleep quality and investigate whether lifestyle factors (e.g., eating habits and exercise) may influence this relationship among middle-aged and older adults.

Methods: Participants were drawn from a cross-sectional sample of community dwelling older adults (N = 276, 55+) and three waves of data from the Midlife in the United States study (MIDUS, N = 843). We examined the direct and indirect effects of ACEs, sleep quality, and health conditions, as well as the conditional effects of physical activity and eating habits.

Results: Across both samples, sleep quality mediated the relationship between ACEs and chronic health conditions. Moderating effects of unhealthy eating and physical activity differed between samples.

Discussion: Sleep quality is an important pathway connecting ACEs and adult multimorbidity, and health behaviors may provide targets for intervention particularly in older adults.

Keywords

adverse childhood experiences, sleep, multimorbidity, health behaviors, lifestyle, nutrition, physical activity, older adults

Introduction

Adverse childhood experiences (ACEs) are traumatic and stressful experiences occurring in childhood that can influence health and well-being throughout the life course (Sachs-Ericsson, Rushing, Stanley, & Sheffler, 2016a, 2016b). ACEs typically include measures of childhood abuse (sexual, emotional, and physical), family dysfunction, parental psychopathology, substance misuse, incarceration, and parental loss (Felitti et al., 1998). A large body of literature has established ACEs as a predictor of mid- and late-life multimorbidity (Draper et al., 2008; Fitzgerald & Notice, 2022). In addition to reducing an individual's life span, multimorbidity affects an individual's well-being and quality of life (Navickas et al., 2016). Several models describe potential mechanisms linking ACEs to chronic health problems in later life (Sachs-Ericsson et al., 2016; Sachs-Ericsson et al., 2016a, 2016b). Given the complexity of these lifespan trajectories linking ACEs with later health outcomes, it is important to identify transdiagnostic modifiable factors that may provide the greatest risk reduction. We examine poor sleep quality as one such pathway.

ACEs and Health

Previous literature has established that ACEs are associated with multimorbidity across the lifespan (Draper et al., 2008; Fitzgerald & Notice, 2022; Sachs-Ericsson et al., 2016; Sachs-Ericsson et al., 2016a, 2016b). This relationship occurs in a dose-response manner, such that the number of ACEs experienced is associated with a greater number of health conditions (Atkinson et al., 2023; Vásquez et al., 2019). Research suggests that ACEs contribute to multimorbidity

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through complex biological and psychosocial pathways. For example, ACEs are associated with increased use of maladaptive coping strategies (Sheffler et al., 2023), greater psychosocial stress in midlife (Sheffler et al., 2023), inflammation (Lacey et al., 2020), and increased allostatic load (Atkinson et al., 2023). Indeed, several studies have shown that those who experienced ACEs have significantly greater rates of inflammatory diseases (Lacey et al., 2020). Each of these factors may contribute to increased risk for chronic health conditions with age (Guidi et al., 2020; Sachs-Ericsson et al., 2009; Sachs-Ericsson et al., 2016; Sachs-Ericsson et al., 2016a, 2016b; Sachs-Ericsson et al., 2017). Sleep is a common factor implicated in multiple diseases and has strong associations with ACEs (Semsar et al., 2021). For example, Semsar and colleagues (2021) found both childhood neglect and abuse were associated with clinical sleep disturbance. Yet few studies have examined sleep impairment as a possible mediator between ACEs and later health problems.

ACEs, Sleep, and Health

Sleep disturbances may be more prevalent in individuals with a history of ACEs. This relationship may be due in part to the lack of emotional security developed during childhood between parents and the child, which can hinder the development of emotion regulation skills (Poon & Knight, 2011). In homes where abuse occurs, it may be the case that the parent models maladaptive emotion regulation skills. Indeed, one study found emotion regulation difficulties mediated the relationship between childhood abuse and reported pre-sleep arousal (Tinajero et al., 2020). Additionally, ACEs occur during a critical period in life that may cause neurodevelopmental setbacks and long-term structural changes to the brain (Ibrahim et al., 2021), influencing vital biological functions such as sleep (Semsar et al., 2021). For example, ACEs are associated with dysregulation in the hypothalamic-pituitary-adrenal axis (HPA; Bezerra, Rodrigues, & Souza, 2022), a system that has also been tied to sleep disturbance.

The HPA axis plays a central role in response to threat (Heim et al., 2001). If the HPA axis is activated chronically, as is common for individuals with multiple ACEs, the brain becomes more responsive to subsequent threats throughout life (Heim et al., 2001; Loman & Gunnar, 2010). Indeed, higher stress levels are associated with sleep impairment (Nollet et al., 2020), and stress and poor sleep often predict elevations in systemic inflammation contributing to health problems (Dolsen et al., 2019). Moreover, stress is associated with more rapid aging of the brain (Kandlur et al., 2020). In their review, Yiallouris and colleagues (2019) state that glucocorticoid excess may have serious consequences to both the structural and functional integrity of several key areas in the brain, with consequent impairment to health. Despite the clear link between ACEs, poor sleep, and health problems, there has been limited research examining sleep impairment as a potential pathway between ACEs and multimorbidity in middle and older age.

Importantly, ACEs are an established predictor of poor sleep quality and greater sleep disturbance across the lifespan (Sullivan et al., 2019). Other research reports that individuals with ACEs are over two times more likely to have sleep disturbances compared to their counterparts with no history of ACEs (Chapman et al., 2011). Research has shown that sleep disturbances associated with ACEs persist across the lifespan. Baiden et al (2015) demonstrated that higher ACEs are associated with a 10% increase in midlife sleep disturbances, such as trouble initiating and maintaining sleep, insomnia, and parasomnias. Similarly, another study showed that sleep disturbances were present in individuals (median age 47) who were sexually abused before the age of 18, suggesting that abnormal sleep behaviors persist decades after ACEs occurred (Chapman et al., 2013).

Studies have also found that ACEs are significantly associated with worse sleep quality in older adults (Sheffler et al., 2023). Indeed, ACEs may affect sleep disturbance for up to 50 years after ACEs had occurred (Sullivan et al., 2019). Brown and colleagues (2022) concluded that sleep disturbances may be a key behavioral health risk factor implicated in the relationship between maltreatment and poor health across the lifespan. In their systematic review across 73 studies, there was a robust association between childhood maltreatment and behavioral sleep disturbances throughout adulthood. They concluded that given that behavioral sleep disturbances are modifiable, more research is needed to identify specific points of intervention to mitigate the potential long-term impacts of childhood maltreatment on health across socio-demographically diverse populations. Such interventions may be helpful for middle-aged and older adults with sleep disturbances who report ACEs.

Potential Moderating Effects of Lifestyle

ACEs are associated with unhealthy lifestyle behaviors including unhealthy eating and poor exercise habits, which may partially be due to physiological stress responses that exacerbate impulsivity and promote unhealthy mechanisms for emotion regulation (Pop et al., 2020; Nurius et al., 2016). There is a strong association between ACEs and increased risky behaviors like disordered eating, such that one-fifth of an adult sample seeking surgical treatment for obesity were sexually and physically abused during childhood and more than one-third were exposed to violence (Pop et al., 2020). According to Nurius et al., buffering factors for childhood adversity may include lifestyle behaviors such as physical activity, which can reduce stress levels and improve physiological functioning, resulting in better physical health outcomes (2016). Higher levels of chronic stress due to ACEs can lead to impairment in insulin signaling that can increase risk for a range of cardiometabolic conditions (Alberry & Silveira, 2023; De Felice et al., 2022). Further, lifespan models of early adversity (e.g., neuro-immune network hypothesis) demonstrate complex crosstalk between stress, inflammatory, and reward systems in the brain (Hostinar et al., 2018). Specifically, poor health behaviors may be bidirectionally associated with systemic inflammation and reduced reward sensitivity, such that low physical activity levels and eating high fat/simple carbohydrate diets can exacerbate inflammatory processes (Hostinar et al., 2018). Finally, eating behaviors and physical activity play an important role in buffering or exacerbating the negative effects of stress on insulin signaling and associated chronic health conditions (Frøsig & Richter, 2009). Combined, research suggests that lifestyle factors such as physical activity and healthy eating habits may buffer or worsen the effects of ACEs on health through multiple biological pathways.

Lifestyle risk behaviors are responsible for a large proportion of disease burden worldwide (Ding et al., 2015). Independent of ACEs, lifestyle factors such as unhealthy eating and lack of exercise may exacerbate both sleep difficulties and chronic health conditions. Several studies have found poor eating habits are associated with sleep deficits (Vernia et al., 2021; Pattnaik et al., 2022). For example, in one large study (N = 3129) of middle-aged females in Japan, researchers found that low intake of vegetables and fish and high intake of confections and noodles were independently associated with poor sleep quality (Katagiri, 2014). In a large-scale review study (Godos et al., 2021), consumption of healthy foods was associated with better sleep quality, while higher intake of processed and sugar-rich foods was associated with worse sleep. In another study, the relationships between sleep quality and physical and mental health were partially mediated by diet quality as well as physical activity (King et al., 2016).

Additionally, regular exercise is one factor that increases health functioning during aging (Radak et al., 2019). As suggested by Radak et al. (2019), regular physical activity has the powerful effect of decreasing the incidence of a wide range of diseases, and the effect appears to be systematic. Further, regular physical activity enhances sleep quality (Wang & Bíró, 2021). Thus, poor eating habits and lack of exercise among older adults with ACEs may further exacerbate sleep difficulties (Katagiri et al., 2014; Yang, Ho, Chen, & Chien, 2012; Yang et al., 2012), as well as contribute to chronic health conditions (Cecchini et al., 2010). Researchers stress the importance of conducting longitudinal studies of mediators and moderators of ACE-sleep disorder associations (Kajeepeta, Gelaye, Jackson, & Williams, 2015).

Current Study

Based on prior literature, we first established the relationship between ACEs and number of health conditions. Next, we built on prior work by examining sleep quality as a mediator between ACEs and health conditions. Finally, we examine the conditional effects of physical activity levels and unhealthy eating habits on the proposed direct and indirect effects of ACEs on health conditions. The current study used two separate samples of community dwelling adults and older adults in order to determine whether our findings are reproducible in multiple populations. Replicability of results across distinct populations is important for providing greater confidence in the strength of the effects and reliability of results (Frias-Navarro et al., 2020), and replication of findings may be especially important in secondary data analyses where risk for Type 1 error may be greater.

Methods

Participants

MIDUS Longitudinal data sets. Data from three waves of the Midlife in the United States Longitudinal survey (MIDUS) were included in analyses (i.e., MIDUS I, MIDUS II Biomarker study, and MIDUS III). MIDUS I (N = 7108) was collected in 1995–1996, the MIDUS II Biomarker study (N = 1255) was collected from 2004–2009, and MIDUS III (N = 3683) was collected in 2013–2014. Subjects who participated in MIDUS I, the longitudinal survey subsample in MIDUS II Biomarker sub-study, and MIDUS III was selected for the current analyses (N = 945). Their ages ranged from 25 years to 74 years at MIDUS I. Those who did not report health conditions in MIDUS III were further excluded, resulting in a total sample of N = 885 participants. The full protocol for MIDUS data collection is reported elsewhere (Brim et al., 2020; Ryff et al., 2019a, 2019b).

Community Dwelling older adults. Data was collected from a community sample of older adults aged 55 years and older who participated in two online surveys. These surveys were designed to be complementary. Participants were recruited primarily through an existing participant registry from Florida State University's Institute for Successful Longevity, as well as flyers and recruitment at community events. All participant activities were approved by the Florida State University Internal Review Board. The initial survey was created to build a participant pool for future clinical trials and collect demographic information, as well as basic psychosocial and health information. The second survey was sent within a year of the first to collect additional information about health and related psychosocial variables. A total of N = 505 older adults participated in the survey. With those who did not report health conditions excluded, N = 325 participants remained in the analyses.

Measures

Participants' adverse childhood experiences (ACEs), sleep quality, physical activity, unhealthy eating, health conditions, as well as a few covariates were collected. These measures were recoded to become more comparable across the two samples.

Covariates. Based on established epidemiological literature (Kessler et al., 2005), age (numeric value), sex assigned at birth (1 = male, 2 = female), race (1 = white, 2 = people of color), participant level of education (1 = no bachelor's, 2 = bachelor's, 3 = master's and more), and average household income (past 12 months) were included in all models as covariates. Income was categorized into three groups based on tertiles. It was coded 1 = Less than US$49,000, 2 = US$50,000-US$99,999, 3 = US$100,000 or greater in the community older adult sample, and was coded 1 = Less than US$42,500, 2 = US$42,500-US$85,000, 3 = US$85,000 or greater in the MIDUS sample. For longitudinal analyses in the MIDUS data, MIDUS 1 chronic health conditions were included as a covariate in a separate model.

Adverse Childhood Experiences (ACEs). In the community *older adult sample*, ACEs were evaluated using a 10-item ACE questionnaire based on the original measure used by Felitti et al. (1998). Participants were asked to report on their experience of emotional (1), physical (2), and sexual abuse (3), neglect (4), parental psychopathology (5) and parental drug/alcohol abuse (6), parental divorce (7), violence in the home (8), and financial strain (9), all occurring before the age of 18. "Yes" responses were coded at 1 and summed to create a continuous total ACE score ranging from 0 to 9. A 90% winsorization was used when taking ACEs into the path analyses.

In the *MIDUS sample*, ACEs were assessed using the Self-Administered Questionnaire (SAQ) collected in MIDUS 1. A count variable was created using reported ACEs in the categories of (1) emotional, (2) physical, and (3) severe physical abuse, (4) financial strain during childhood, (5) divorce or separation of parents, (6) death of a parent, (7) parental substance abuse, (8) sexual assault, and (9) parental neglect. Participants who reported an ACE category as often, sometimes, or rarely were coded as yes (1) for experiencing an event, and never as no (0) for not experiencing that event in one of the categories described above. A 90% winsorization was used when taking ACEs into the path analyses.

Sleep Quality. In the community *older adult sample*, sleep quality was assessed using the Pittsburgh Sleep Quality Inventory (PSQI) item, "During the past month, how would you rate your sleep quality overall?" This item is rated on a scale of 1 (very good) to 4 (very bad).

In the *MIDUS sample*, sleep quality was assessed at MIDUS 2 (2004–2006) using four items evaluating sleep quality during the "past 30 days": (1) trouble falling asleep frequency, (2) waking up during the night frequency, (3) waking up too early frequency, and (4) feeling unrested during the day frequency. Items were rated on a Likert scale from 1 (never) to 5 (almost always) and summed to create a measure of sleep quality. The four items were averaged to represent the sleep quality after transforming the 5-point scale to a 4-point scale.

Physical Activity. For the community *older adult sample*, physical activity was evaluated using the two questions: "How often do you take part in sports or activities that are moderately or vigorously energetic such as gardening, walking at a moderate pace, dancing, floor or stretching exercises, swimming, aerobics, gym workout, or tennis?" and "On days that you engage in moderate to strenuous exercise, how many minutes, on average, do you exercise at this level?" A dichotomous variable was created to represent participants' physical activity levels. Considering the overall age of this sample, those who took part in moderate or vigorous activities for 20 minutes or more at least once per week were coded yes (1); otherwise no (2).

For the *MIDUS sample*, physical activity was evaluated based on participant self-reported typical weekly exercise frequency using the item, "Do you engage in regular exercise, or activity, of any type for 20 minutes or more at least 3 times/week?" Respondents answered yes (1) or no (2) from the MIDUS 2 Biomarker Project (2004–2009).

Unhealthy Eating. Community older adult sample. Unhealthy eating habits were assessed using a single item, "Over the past 7 days, how many times did you eat fast-food, unhealthy snacks, or pizza?" Participants wrote a numeric value, where higher values indicate greater consumption of "fast-food" or unhealthy snacks. Responses were recoded to five values ranging from 1 (never) to 5 (7 or more times/week) to be in accordance with MIDUS sample.

MIDUS sample. Participants were asked, "In an average week, how often do you eat at a fast-food restaurant or order food for takeout or delivery?" during the MIDUS 2 Biomarker Project (2004–2009). Responses were coded ranging from 1 (never) to 5 (7 or more times/week).

Health Conditions (Dependent Variables). Community older adult sample. A health conditions count variable was created using 29 condition categories, excluding the chronic sleep problems item. Participants were asked about a range of physical conditions mirroring the chronic conditions assessed at MIDUS 1. Items included asthma, thyroid disease, stomach troubles, AIDs/HIV, hypertension, diabetes, stroke, etc. This variable was used as a dependent measure for health outcomes in the older adult sample. See MIDUS 3 protocol (Ryff et al., 2019a). A 90% winsorization was used when taking health conditions into the path analyses.

MIDUS sample. 39 conditions were assessed at MIDUS 3 (Brim et al., 2020; Ryff et al., 2019a). Of the 39 categories, 29 conditions that were assessed at MIDUS 1, excluding the chronic sleep problems item, were used to create the health conditions count variable. A 90% winsorization was used when taking into the path analyses. MIDUS 1 chronic health conditions were included as a covariate in longitudinal models. This health variable was created by summing the number of health conditions assessed at MIDUS 1, excluding reported sleep dysfunction.

Analytic Plan

All analyses were completed using R version 4.3.0 and SPSS version 25 IBM Corp Released 2017 IBM SPSS Statistics for Windows, version 25.0. Armonk, NY: IBM Corp. First, descriptive statistics were used to assess the distribution of the variables. Association between main measures and continuous demographics were assessed using linear and logistic regression; differences between participants with regard to demographics were described using the *t* test, ANOVA test, and chi-squared test. Second, path analyses (PROCESS macro, Model 4 in SPSS) were used to evaluate the mediation of sleep quality on the relationship between ACEs and health conditions. The bootstrapping method was used to develop the 95% confidence intervals (CIs) for indirect effects with 5000 repetitions. All path models were adjusted for age, sex, race, education, and income. In the longitudinal analyses, MIDUS health conditions were included as a covariate in separate model. Finally, PROCESS Model 15 was used to analyze the conditional direct and conditional indirect effects models incorporating physical activity and eating habits as moderators; 16th, 50th, and 84th percentiles were used to break down the conditioning values for unhealthy eating habits. Listwise deletion was used to handle missing data, resulting in a final sample of $N = 843$ for the MIDUS sample and $N = 276$ for the older adult sample. Limitations of this approach are explored in the Discussion section.

Results

Sample Characteristics

The characteristics of participants and measures in each sample are summarized in Tables 1 and 2. In the community older adult sample, the average age was 70.08 (SD = 5.64) years. Among the participants in this sample, 40.6% of them were male; 93.8% of them were white; 23.2%, 29.7%, 47.1% of them had no bachelor's degree, bachelor's degree, and master's degree and more correspondingly; 30.4%, 42.4%, 27.2% of them had relatively low, moderate, and high incomes correspondingly. Age was significantly associated with ACEs and physical activity. Different education levels were associated with differences in ACEs, sleep quality, and physical activity levels; different income levels were associated with differences in physical activity levels and chronic health conditions. Sex and race were not associated with the other measures.

In the MIDUS sample, the average age at MIDUS I was 45.6 (SD = 11.02) years. Among the participants, 40.0% were male; 94.2% were white. 54.7%, 28.6%, 16.7% of the sample had no bachelor's degree, bachelor's degree, and master's degree and more, respectively. 33.6%, 33.1%, 33.3% of them had relatively low, moderate, and high incomes, respectively. In this sample, age was significantly associated with ACEs, sleep quality, unhealthy eating habits, and health outcomes. Differences in sleep quality, unhealthy eating habits, and health outcomes were found in different sex groups. Education was associated with ACEs, unhealthy eating habits, and health outcomes; income was significantly associated with sleep quality, physical activity, and health conditions. In addition, the health conditions score increased by .53 on average over 18 years. Health conditions were significantly associated with ACEs, sleep quality, and physical activity.

Direct Effects

Direct effects in all models are summarized in Table 3.

Community Older Adult Sample. Consistent with prior work, higher ACEs were significantly associated with a greater number of health conditions ($B = .182$, $SE = .070$, $p = .010$). Higher ACEs were associated with significantly worse sleep quality ($B = .067$, $SE = .023$, $p = .004$), and poorer sleep quality was significantly associated with a greater number of health conditions ($B = .880$, $SE = .176$, $p < .001$).

MIDUS Sample. ACEs were significantly associated with a greater number of health conditions at MIDUS 3 ($B = .200$, $SE = .046$, $p < .001$). Higher ACEs were also significantly associated with poorer sleep quality ($B = .070$, $SE = .014$, $p < .001$), and poorer sleep quality assessed at MIDUS 2 was associated with a greater number of health conditions approximately 10 years later at MIDUS 3 ($B = .868$, $SE = .109$, $p < .001$). When adjusting for MIDUS 1 health conditions, ACEs were not associated with health conditions at MIDUS 3 ($B = .066$, $SE = .042$, $p = .113$); however, higher ACEs were still significantly associated with poorer sleep quality ($B = .052$, $SE = .014$, $p < .001$), and poorer sleep quality was significantly associated with a greater number of health conditions at MIDUS 3 ($B = .530$, $SE = .101$, $p = .001$).

Indirect Effects

Indirect effects in all models are also summarized in Table 3.

Community Older Adult Sample. Sleep quality significantly mediated the relationship between ACEs and health conditions ($B = .055$, Boot $SE = .024$, Boot $CI = .014–.110$), such that higher ACEs were associated with worse sleep quality, and worse sleep quality was associated with a greater number of health conditions. When sleep was entered into the model, the direct effect of ACEs on health conditions became non-significant, further indicating that the association between ACEs and health conditions was mediated by sleep quality.

MIDUS Sample. In the model that did not control for MIDUS 1 health conditions, sleep quality (measured at Wave (2) mediated the relationship between ACEs and MIDUS 3 health conditions ($B = .057$, Boot $SE = .014$, Boot $CI = .032–.086$) by about 28.3%. Controlling for MIDUS 1 health

Table 1. Community Older Adult Sample Characteristics.

	ACEs	SQ	PA, active	UE	HCs
Overall	1.72 (1.96)	1.98 (.70)	185 (67.0%)	2.92 (1.31)	2.59 (2.43)
Age, 70.08 (5.64)	**		**		
Sex					
Male, *N* = 112	1.53 (1.76)	1.96 (.63)	78 (69.6%)	2.88 (1.32)	2.35 (2.40)
Female, *N* = 164	1.86 (2.07)	1.99 (.74)	107 (65.2%)	2.94 (1.30)	2.76 (2.45)
Race					
White, *N* = 259	1.73 (1.94)	1.98 (.68)	174 (67.2%)	2.95 (1.31)	2.54 (2.4)
People of color, *N* = 17	1.71 (2.26)	2.00 (.94)	11 (64.7%)	2.35 (1.22)	3.29 (2.87)
Education	*	*	**		
No bachelor's, *N* = 64	2.25 (2.36)	2.17 (.83)	37 (57.8%)	3.14 (1.25)	3.09 (2.73)
Bachelor's, *N* = 82	1.71 (1.88)	1.90 (.70)	54 (65.9%)	3.01 (1.34)	2.63 (2.63)
Master's and more, *N* = 130	1.48 (1.74)	1.93 (.61)	94 (72.3%)	2.75 (1.31)	2.32 (2.11)
Income			**		*
Less than US$49,000, *N* = 84	2.12 (2.25)	2.02 (.79)	51 (60.7%)	3.00 (1.34)	3.02 (2.77)
US$50,000–US$99,999, *N* = 117	1.53 (1.76)	1.93 (.64)	76 (65.0%)	2.95 (1.23)	2.63 (2.40)
US$100,000 or greater, *N* = 75	1.59 (1.85)	2.00 (.68)	58 (77.3%)	2.77 (1.39)	2.04 (1.97)

Note. Values reported are *M* (SD) or Count (%); $^{**}p < .01$, $^{*}p < .05$ for difference or association; *N* = 276. ACEs, adverse childhood experiences; SQ, sleep quality; PA, physical activity; UE, unhealthy eating; HCs, health conditions.

Table 2. MIDUS Sample Characteristics.

	ACEs	SQ	PA, active	UE	HCs
Overall	2.23 (1.61)	2.10 (.62)	675 (80.1%)	2.43 (.90)	2.58 (2.42)
Age[a], 45.60 (11.02)	**	*		**	**
Sex		**		**	**
Male, *N* = 377	2.27 (1.41)	1.98 (.57)	302 (80.1%)	2.55 (.92)	2.24 (2.38)
Female, *N* = 446	2.20 (1.75)	2.21 (.64)	373 (80.0%)	2.34 (.89)	2.85 (2.41)
Race					
White, *N* = 794	2.21 (1.61)	2.11 (.62)	639 (80.5%)	2.42 (.90)	2.56 (2.42)
People of color, *N* = 49	2.55 (1.60)	2.08 (.70)	36 (73.5%)	2.55 (.96)	2.86 (2.29)
Education	**			*	**
No bachelor's, *N* = 461	2.46 (1.71)	2.14 (.68)	352 (76.4%)	2.47 (.90)	2.80 (2.73)
Bachelor's, *N* = 241	2.02 (1.44)	2.03 (.51)	201 (83.4%)	2.48 (.91)	2.36 (1.87)
Master's and more, *N* = 141	1.83 (1.42)	2.13 (.55)	122 (86.5%)	2.24 (.89)	2.21 (2.07)
Income		**	**		**
Less than US$42,500, *N* = 283	2.34 (1.66)	2.20 (.68)	213 (75.3%)	2.40 (.09)	3.05 (2.51)
US$42,500–US$85,000, *N* = 279	2.30 (1.64)	2.10 (.61)	224 (80.3%)	2.44 (.89)	2.39 (2.54)
US$85,000 or greater, *N* = 281	2.05 (1.51)	2.02 (.55)	238 (84.7%)	2.46 (.92)	2.29 (2.11)
HCs at MIDUS 1, 2.05 (2.05)	**	**	*		**

Note. Values reported are *M* (SD) or Count (%); $^{**}p < .01$, $^{*}p < .05$ for difference or association; *N* = 843.
[a]age at MIDUS 1; age at MIDUS 3 has 63.78 (11.02). ACEs, adverse childhood experiences; SQ, sleep quality; PA, physical activity; UE, unhealthy eating; HCs, health conditions.

conditions, the indirect effect of ACEs on health conditions at MIDUS 3 through sleep quality remained significant (*B* = .027, Boot *SE* = .009, Boot *CI* = .011–.045), suggesting that the effect of ACEs on health conditions developed over time was mediated by poor sleep quality.

Conditional Effects and Index of Moderated Mediation

Community Older Adult Sample (Unhealthy Eating). Although the relationship between ACEs and health conditions was not dependent on unhealthy eating habits (*B* = −.052, *SE* = .050,

Table 3. Direct and Indirect Effects.

	Community older adult sample		MIDUS sample		MIDUS sample adjusted for baseline health conditions	
	B	SE	*B*	SE	*B*	SE
Total effect						
ACEs → health	.182*	.070	.200*	.046	.066	.042
Standardized effect	.157*		.150*		.050	
ACEs → sleep	.067*	.023	.070*	.014	.052*	.014
Standardized effect	.177*		.173*			
Sleep → health	.880*	.176	.868*	.109	.530*	.101
Standardized effect	.288*		.264*		.161*	
Direct effect						
ACEs → health	.127	.069	.144*	.045	.040	.042
Standardized effect	.109		.108*		.030	
ACEs → sleep	.067*	.023	.070*	.014	.052*	.014
Standardized effect	.177*		.173*			
Sleep → health	.823*	.178	.808*	.110	.517*	.102
Standardized effect	.269*		.246*		.158*	
Indirect effect[a]						
ACEs → health	.055*	.024	.057*	.014	.027*	.009
95% bootstrapped CI	(.014, .110)		(.032, .086)		(.011, .045)	
Standardized effect	.048*		.043*		.020*	
Standardized effect CI	(.012, .094)		(.024, .064)		(.008, .033)	
Mediated %	Fully		28.3%		-	

Note. *$p < .05$ (2-tailed)
[a]the values for SE are the bootstrapped SEs.

p = .303), unhealthy eating significantly *moderated* the relationship between sleep quality and health conditions (B = .311, SE = .132, p = .020), such that worse sleep quality was only associated with greater health conditions for individuals who reported more frequent unhealthy eating habits (see Figure 1). Further, unhealthy eating moderated the indirect effect of ACEs on health through sleep quality (Index = .021, Boot SE = .012, CI = .001–.049), such that the mediation effect remained significant only at moderate and higher levels of unhealthy eating. Thus, the pathway from ACEs to health through sleep quality dissipates for people with healthier eating and worsens for people with less healthy eating. More detailed results can be found in Appendix Table A1.

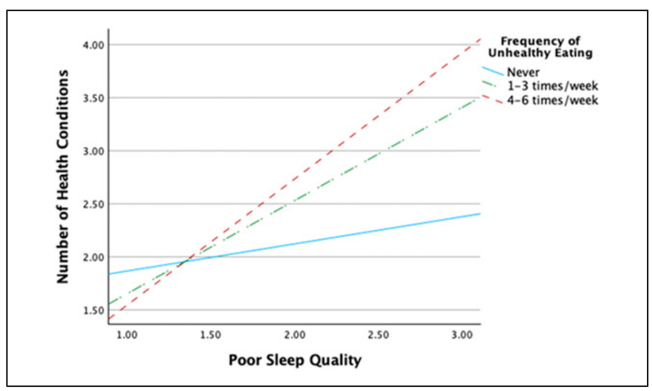

Figure 1. Community older adult sample: Sleep quality's association with health conditions based on frequency of unhealthy eating habits.

Community Older Adult Sample (Physical Activity). The direct relationship between ACEs and health was significantly *moderated* by physical activity (B = .363, SE = .145, p = .013), such that ACEs had no impact on health conditions for individuals who reported more frequent physical activity levels (see Figure 2). The effects of ACEs on health conditions through sleep quality moderated by physical activity were both significant, indicating the presence of an indirect effect of ACEs on health. However, this indirect effect was not dependent on physical activity levels (Index = .006, Boot SE = .028, Boot CI = −.054-.064). The association between sleep quality and the number of health conditions was not dependent on physical activity either (B = .093, SE = .381, p = .807). More detailed results can be found in Appendix Table A2. Of note, both of these non-significant associations become statistically significant when examining physical activity as continuous rather than dichotomous in the model.

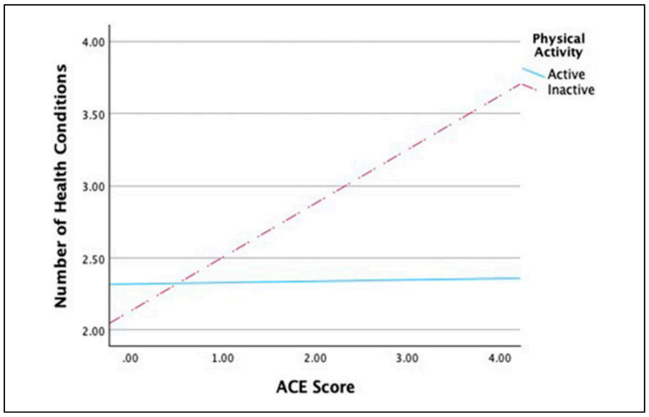

Figure 2. Community older adult sample: The relationship between ACEs and health moderated by physical activity levels.

MIDUS Sample (Unhealthy Eating). Regardless of whether baseline health conditions were included in the model, reported unhealthy eating habits did not significantly moderate the effects of sleep ($B = .025$, $SE = .123$, $p = .842$; $B = -.002$, $SE = .112$, $p = .989$ adjusted for baseline health conditions) or ACEs ($B = -.006$, $SE = .050$, $p = .907$; $B = .015$, $SE = .045$, $p = .737$ adjusted for baseline health conditions) on health conditions. Further, the index of moderated mediation was non-significant in this sample (Index = .002, Boot $SE = .010$, Boot $CI = -.018$-.023; Index = $-.000$, Boot $SE = .007$, Boot $CI = -.013$-.014 adjusted for baseline health conditions).

MIDUS Sample (Physical Activity). Regardless of whether baseline health conditions were included in the model, reported physical activity levels did not significantly moderate the effects of sleep ($B = .011$, $SE = .254$, $p = .965$; $B = -.119$, $SE = .230$, $p = .604$ adjusted for baseline health conditions) or ACEs ($B = -.048$, $SE = .105$, $p = .650$; $B = -.045$, $SE = .095$, $p = .640$ adjusted for baseline health conditions) on health conditions. Further, the index of moderated mediation was non-significant in this sample (Index = .001, Boot $SE = .019$, Boot $CI = -.039$-.038; Index = $-.006$, Boot $SE = .013$, Boot $CI = -.035$-.018 adjusted for baseline health conditions).

Discussion

Previous research has established that ACEs are associated with multimorbidity across the lifespan, and there is evidence to suggest that sleep impairment may be a critical pathway between ACEs and multimorbidity. In the current study, we demonstrated the mediating role of sleep quality on the relationship between ACEs and health conditions in two separate samples, a sample of community dwelling older (55+) adults and a longitudinal sample of community dwelling midlife to older aged adults from the MIDUS data sets. Further, we evaluated whether physical activity and unhealthy eating behaviors affect these pathways. Our findings demonstrate that ACEs influence multimorbidity by negatively impacting sleep quality across mid- and late-life. The moderating effects of physical activity and unhealthy eating differed between samples. Implications of these findings are discussed below.

ACE-Sleep-Health

Consistent with prior literature, we found that (1) ACEs were associated with worse sleep quality across two distinct samples (Semsar et al., 2021) and (2) poor sleep quality was consistently associated with a greater number of health conditions (Anothaisintawee et al., 2016; Dube et al., 2003; Li et al., 2014; Meng et al., 2013; Nicholson et al., 2020). Building on prior literature, our study demonstrated that ACEs influence multimorbidity in middle-aged and older adults indirectly through its impact on sleep quality. These findings held consistent when examining the model cross-sectionally in older adults and longitudinally in a sample of middle-aged and older adults, even after accounting for earlier health in the model. Our study demonstrates that sleep impairment is an important pathway linking negative early life experiences (i.e., ACEs) with health across the adult lifespan.

This finding is especially important, given that sleep impairment is a transdiagnostic risk factor for a range of physical and mental health conditions (Irwin, 2019; Jackson et al., 2020), and the negative effects of ACEs are sustained into older age. Importantly, sleep quality is modifiable through pharmacological and non-pharmacological interventions (Bacaro et al., 2020; Qaseem et al., 2016). Poor sleep can be successfully addressed through existing behavioral approaches and may be ameliorated through lifestyle modification (Bacaro et al., 2020). For example, cognitive behavioral therapy for insomnia (CBT-I) is the gold standard treatment for sleep disruption, with meta-analysis showing its efficacy for insomnia symptoms, sleep latency, onset, and sleep efficiency (Trauer et al., 2015). Additionally, pharmacological interventions may be helpful (Fang et al., 2019), providing multiple options for addressing health outcomes through improving sleep quality.

Eating Habits and Physical Activity

Growing-up in homes where there is considerable instability has impacts across multiple domains of psychological and biological functioning (Sachs-Ericsson et al., 2016a, 2016b). For one, it is the case that ACEs are associated with unhealthy lifestyle habits, such as poorer quality diet (Fuemmeler et al., 2009; McDonnell & Garbers, 2018; Risso et al., 2023) and lower levels of physical activity (Risso et al., 2023), and these lifestyle choices may in turn influence sleep and health (Cecchini et al., 2010; Katagiri et al., 2014; Yang et al., 2012). We found that the moderating effects of lifestyle factors differently influenced the relationships between ACEs, sleep quality, and health conditions across the two samples.

In the community older adult sample, we found that the association between poor sleep quality and a greater number of health conditions depended on more frequent unhealthy eating habits. Further, in the older adult sample, unhealthy eating moderated the indirect effect of ACEs on health conditions through sleep quality, such that the indirect effect of ACEs on health through sleep remained significant only at moderate and high levels of unhealthy eating. In the longitudinal sample, the negative effects of ACEs on sleep and health problems were independent of eating habits.

Consistent with our findings, there is growing scientific evidence suggesting that diet and poor sleep may be related (Godos et al., 2021). In their meta-analysis and review, Godos et al. (2021) found that consumption of healthy foods was associated with better sleep quality, while higher intake of processed and sugar-rich foods was associated with worse sleep quality. Further, there is substantial evidence of bidirectional relationships between sleep and metabolic functions that can be influenced by diet, such as glucose metabolism (Kothari et al., 2021), which has substantial implications for long-term health. Our findings add to this growing literature, showing that unhealthy eating habits can exacerbate the negative effects of sleep impairments on health across the life span, while healthier eating may be protective against the negative effects of sleep impairments on older adult's health problems. However, the differing findings across the two samples may suggest that these effects may not be as pronounced when examined longitudinally or across mid- to late-life.

In regard to physical activity, in the community sample of older adults we found that the relationship between ACEs and health was moderated by physical activity levels such that ACEs had no impact on health conditions for individuals who reported more frequent physical activity levels. Physical activity did not significantly impact the other relationships in the model when measured dichotomously. However, post-hoc analyses demonstrated that using the full scale rather than dichotomized version resulted in physical activity significantly buffering the relationship between sleep and health and the overall indirect effect. This subtle change may be important to consider for future studies measuring and evaluating the impacts of physical activity on health. Notably, in the MIDUS sample, physical activity again had no impact on the relationships between ACEs, sleep, and health conditions.

Our discrepant findings across the two samples for the moderating effects of eating and physical activity may be due to multiple factors that require some consideration. In the MIDUS sample, neither lifestyle factor influenced the relationships between ACEs, sleep, and health conditions, regardless of whether the models adjusted for baseline health conditions. It is possible that the timing of when lifestyle factors are measured in relation to health outcomes is especially important. In MIDUS, lifestyle factors were assessed approximately 10 years prior to the health outcomes, whereas in the community older adult sample, lifestyle factors were assessed at the same time point as the health outcome. This result may have important implications for examining the effects of health behaviors using longitudinal models. It may be that more proximal lifestyle habits are most impactful on current health, and that if a person's behaviors change, then later outcomes will change as well. Another interpretation is that maintaining positive health behaviors through older age provides greater protection against the negative effects of ACEs and poor sleep quality. Given that the negative biological effects of ACEs are thought to accumulate across the lifespan (Draper et al., 2008; Sheffler et al., 2023), it may be that the benefits of healthy eating and physical activity are strongest (e.g., easiest to measure) as risk for multimorbidity increases. However, it may also be the case that the effects of physical activity and unhealthy eating on these relationships may be relatively small and inconsistent across different samples. These discrepant findings highlight the need to examine relationships using multiple samples to better evaluate the potential clinical and scientific importance of findings. Our findings demonstrate that further research in this area is needed to establish the potential benefits of healthy eating and physical activity for older adults with ACEs.

In support of our findings for older adults, however, researchers have found positive changes in healthy eating, as well as in physical exercise result in notable improvements in older adults (Bardach et al., 2016). Unfortunately, motivation is a significant barrier for increasing physical activity (Dishman, 1994), as well as healthy eating among older adults (Bardach et al., 2016). Researchers (Bardach et al., 2016) suggest the importance of creating more positive images of old age and tailoring health promotion efforts to older adults' motivations and confidence in their ability to make such behavioral changes. Others have found disease prevention to be the strongest motivator for healthier eating in older adults (Dijkstra et al., 2014). In a recent study (Moon et al., 2021) that included a multi-pronged approach to improve cognitive functioning through exercise and dietary improvement—they focused on motivation. Their treatment included an initial motivational intervention to act as a psychological resource that helps maintain and strengthen motivation (Binns & Low, 2017). In their intervention they found good adherence was associated with improvements in measures of cognitive functioning (Moon et al., 2021). Other researchers (Resnick & Spellbring Ann, 2000) have proposed that interventions focusing on teaching older adults about the benefits of exercise, establishing appropriate goals, and decreasing unpleasant and increasing pleasant sensations associated with exercise may be useful to improve adherence to a regular exercise program. Additionally, the use of a socially framed phone app, customized to the preferences and needs of midlife and older adults, showed early improvement of physical activity and a decrease in sedentary behavior patterns (King et al., 2016).

Finally, for older adults who have experienced ACEs, it may be appropriate to address past trauma, which can also influence sleep and lifestyle behaviors. Older adults have generally not been included in randomized clinical trials of psychotherapy for post-traumatic stress disorder. However, in one meta-analysis (Dinnen et al., 2015), they found evidence-based interventions validated in younger and middle-aged populations appear acceptable and efficacious with older adults including CBT, cognitive processing therapies, and prolong exposure (Foa et al., 2007; Resick & Schnicke, 1992). These CBT based treatments that focus on trauma-focused meaning and involve the processing of traumatic material have been found to be efficacious in older adult populations (Asmundson et al., 2019). Given the associations found among ACEs, sleep, health, and lifestyle, it is necessary to develop a multi-pronged approach to address each of these domains to improve sleep and health outcomes. Indeed, researchers have found changes in physical activity and sleep quality predicted physical, mental and social well-being and global quality of life across a 6-month exercise trial in a sample of healthy older adults (Gothe et al., 2020).

Limitations and Future Directions

In regard to limitations, it is important to first note that our measure of ACEs was retrospective**.** As we have reported earlier (Sachs-Ericsson et al., 2007), it is possible that our retrospective reports underestimated rates of ACEs, in part because of the lack of specificity of the abuse-related items. Moreover, childhood abuse experiences may be more salient to those who were most affected by the abuse (e.g., those experiencing health and sleep problems). In contrast, given the lack of specificity of the abuse items, those least affected by the abuse may be more likely to underreport abuse experiences. This may have overestimated the associations examined in the current study.

Another consideration is how missing data were handled. We tended to handle missing data in the same way for the two samples; thus, listwise deletion was adopted considering less than 5% cases were missing in the MIDUS sample. However, it is hard to support the assumption that the data are missing completely at random in the community sample. There is a risk that the loss of information may produce biased estimates. In addition, the missing data may limit our ability to detect effects in the longitudinal MIDUS sample. Given that individuals with high ACEs may be most likely to develop chronic disease and experience earlier mortality (e.g., selective mortality; Friedman et al., 2015), loss of these highest risk individuals may weaken our ability to detect significant relationships.

It is also the case that both samples were limited in racial diversity; moreover, participants generally had higher than average education and income levels. The extent to which our results would generalize to a more diverse or lower resource population is not known. Prior research suggests that individuals from minoritized populations and individuals with lower socioeconomic backgrounds have greater risk for developing health conditions with age (Wagner et al., 2022) and may also have experienced higher rates of ACEs (Giano et al., 2020). Thus, it is possible that the direct effect of ACEs may have been strengthened in a more diverse population; however, it remains unclear whether sleep quality and lifestyle factors would play a similar role in a more representative sample.

Finally, although we attempted to match measures across the two studies, the wording and measurement slightly differed between the two samples. These differences in measurement may have impacted the accuracy of participant reporting and may have contributed to differences in the results between the two samples. One such example is the assessment of physical activity may have led to differences in results between samples. Moreover, for the MIDUS sample there was a long period between measurement of physical activity and health outcomes. The MIDUS physical activity measurement may not have been representative of physical activity over the long intervals between waves, thus weakening results.

Conclusions

In conclusion, in analyses of two distinct samples, our findings establish sleep quality as a key pathway between ACEs and multimorbidity in middle- and older aged individuals. Our findings also demonstrate the potential importance of modifiable health behaviors on risk for health conditions among older adults exposed to ACEs. A multi-pronged treatment approach targeting sleep health, physical activity, and diet appears necessary to address the emergence of multiple chronic diseases in middle-age and older adulthood for individuals with ACEs. Such an intervention may benefit from use of a trauma-informed approach to holistically address lifestyle risks for multimorbidity.

Appendix

Table A1. Conditional Effects and Moderated Mediation by Unhealthy Eating in the Community Older Adult Sample.

	Effect	SE	*p*-value	95% CI
Direct effects moderated by unhealthy eating				
ACEs → health	−.052	.050	.303	(-.150, .047)
Sleep quality → health	.311[a]	.132	.020	(.050, .571)
Indirect effect moderated by unhealthy eating[b]				
ACEs → health	.021[a]	.012	-	(.001, .049)
Conditional direct effects of sleep on health				
Unhealthy eating: never	.256	.298	.392	(-.331, .843)
Unhealthy eating: 1–3 times/week	.878[a]	.177	<.001	(.530, 1.226)
Unhealthy eating: 4–6 times/week	1.188[a]	.234	<.001	(.727, 1.649)
Conditional direct effects of ACEs on health				
Unhealthy eating: never	.232	.125	.065	(-.014, .479)
Unhealthy eating: 1–3 times/week	.129	.068	.058	(-.004, .262)
Unhealthy eating: 4–6 times/week	.078	.081	.339	(-.082, .237)
Conditional indirect effects of sleep quality on health[b]				
Unhealthy eating: never	.017	.025	-	(-.026, .074)
Unhealthy eating: 1–3 times/week	.059[a]	.025	-	(.016, .112)
Unhealthy eating: 4–6 times/week	.080[a]	.033	-	(.022, .150)

[a]significant effect.
[b]the values for SE and 95% CI are the bootstrapped SEs and 95% CIs.

Table A2. Conditional Effects and Moderated Mediation by Physical Activity in the Community Older Adult Sample.

	Effect	SE	*p*-value	95% CI
Direct effects moderated by physical activity				
ACEs → health	.363[a]	.145	.013	(.077, .650)
Sleep quality → health	.093	.381	.807	(-.657, .843)
Indirect effect moderated by physical activity[b]				
ACEs → health	.006	.028	-	(-.054, .064)
Conditional direct effects of ACEs on health moderated by physical activity				
Physical activity: active	.010	.081	.907	(-.150, .169)
Physical activity: inactive	.373[a]	.122	.003	(.132, .614)
Conditional indirect effects of ACEs on health moderated by physical activity[b]				
Physical activity: active	.049[a]	.024	-	(.010, .105)
Physical activity: inactive	.055[a]	.031	-	(.006, .123)

[a]significant effect
[b]the values for SE and 95% CI are the bootstrapped SEs and 95% CIs.

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