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Adverse childhood experiences amplify the longitudinal associations of adult daily stress and health

Jooyoung Kong [a,*], Yin Liu [b], Jaime Goldberg [a], David M. Almeida [c]

[a] Sandra Rosenbaum School of Social Work, University of Wisconsin, 1350 University Avenue, Madison, WI 53706, United States of America
[b] Department of Human Development and Family Studies, Utah State University, 2905 Old Main Hill, Logan, UT 84322, United States of America
[c] Human Development and Family Studies, The Pennsylvania State University, University Park, PA 16802, United States of America

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ABSTRACT

Background and objective: The long-term negative impact of Adverse Childhood Experiences (ACEs) is now well-recognized; however, little research has explored the link between ACEs and daily stress processes in adulthood. The current study aimed to examine the effect of ACEs in the association between daily stressor exposure and daily negative affect, and whether such associations would predict long-term health and well-being.
Methods: Using data from the National Study of Daily Experiences 2 (NSDE 2) and the Midlife in the United States (MIDUS) studies, multilevel moderated mediation analyses were conducted to account for daily measurements nested within individuals. We tested whether the indirect effect of daily stressor exposure on prospective chronic health conditions and prospective depressive symptoms through daily negative affect would differ by adults' levels of ACEs.
Results: We found significant positive associations between daily stressor exposure and daily negative affect at both the within- and between-person levels. Between-person daily negative affect was, in turn, associated with more chronic health conditions and higher depressive symptoms ten years later. This indirect effect was stronger for adults with high ACEs compared to those with low ACEs.
Conclusions: The current study demonstrated that a history of ACEs may exacerbate the negative health effects of daily stress processes over time. Programs focusing on coping with daily stressors and resilience may benefit adults with ACEs and promote their health and well-being.

Adverse Childhood Experiences (ACEs) are potentially traumatic events that occur to children under the age of 18, including all types of abuse and neglect as well as exposure to household challenges (e.g., witnessing domestic violence, substance abuse in the family; Centers for Disease Control and Prevention [CDC], 2020; Felitti et al., 1998). Approximately 60% of adults in the US reported at least one form of ACE, and 15–25% reported three or more (Jones et al., 2020). Experiencing ACEs is associated with several harmful effects that can persist well into adulthood; for example, studies have found the dose-response relationships of ACEs with physical and mental health problems in adulthood, including the onset of chronic diseases (e.g., cancer), depression, and suicidality (Holman et al., 2016; Sheffler et al., 2020; Thompson et al., 2019). However, little research has focused on the daily stress process as a mechanism of these long-term detrimental outcomes of ACEs. Daily stressful events are seemingly minor but can occur frequently (e.g., traffic during

* Corresponding author at: Sandra Rosenbaum School of Social Work, University of Wisconsin-Madison, 1350 University Avenue, Madison, WI 53706, United States of America.
E-mail address: jkong7@wisc.edu (J. Kong).

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a commute or squabbles with a partner) and have immediate and long-term health effects (Almeida, Charles et al., 2020; Piazza et al., 2013). Adults who experienced ACEs may be more susceptible and vulnerable to daily stressors, potentially because of their overall increased stress sensitivity (Hammen et al., 2000; Harkness et al., 2015). Evidence exists that childhood adversity can disrupt the stress response system in the body, such as alterations in the hypothalamic-pituitary-adrenocortical (HPA) axis that involves dysregulated cortisol output and reactivity, increasing the subjective perception of stress and lowering the threshold of responding to stressful events (Agorastos et al., 2019; Karlamangla et al., 2018; Koss & Gunnar, 2018). An accumulation of such day-to-day strains is concerning as it can make individuals with ACEs more vulnerable to physical and mental health issues over time (Almeida, Piazza et al., 2020; Piazza et al., 2013; Mroczek et al., 2013). The current study aims to examine the role of ACEs in the effect of daily stressor exposure on daily negative affect in later adulthood and whether and how such associations predict long-term physical and mental health outcomes.

1. Daily stress processes and life course perspective

Research on daily stress processes addresses the ways individuals experience, respond to, and cope with daily stressors (Almeida, 2005; Almeida, Charles et al., 2020). Daily stressors refer to daily hassles or challenges that can irritate people and disrupt their routines; examples include arguments with children or unexpected work deadlines (Diehl et al., 2012). Although seemingly minor, these stressors happen during approximately 40% of all days, making them rather common occurrences in daily lives (Almeida, Piazza et al., 2020; Piazza et al., 2013). Studies have found significant between-person effects of daily stressors on daily emotional well-being, such that individuals who experience greater daily stressors report higher negative affect than those with less stressor exposure (Koffer et al., 2016; Liu et al., 2017; Zautra et al., 2005). Also, within-person associations between daily stressors and emotional well-being have been found such that, across the daily measurements, individuals tend to show higher negative affect on days when they experience stressors compared to days without stressor exposure (e.g., Hay & Diehl, 2010;Koffer et al., 2017 ; Kong et al., 2019).This emotional reactivity is considered trait-like and stable, demonstrating an individual's resilience or vulnerability to stressors or threats (Koffer et al., 2017; Kong et al., 2019). The harmful effects that daily stressors have on daily affect are known to accumulate, leading to individuals' compromised health and well-being over time (Charles et al., 2013; Chiang et al., 2018; Piazza et al., 2013; Maller et al., 2005).

The life course perspective attempts to understand the continuities and discontinuities in life trajectory by examining how chronological age, relationships, common life events/transitions, culture, social institutions, and sociohistorical events shape people's lives (Elder et al., 2003). A central premise of the life course perspective is that early life experiences and events exert a long-term influence on several aspects of adult lives, including individuals' health and well-being (Elder et al., 2003). Bringing the life course perspective into a daily stress context, we posit that risk factors in early life, such as ACEs, may serve to exacerbate individuals' daily stress processes in adulthood. Notably, exposure to early life adversity can give rise to long-term processes that result in various forms of vulnerability in later adulthood; therefore, considering risk factors from earlier in the life course can help understand the root causes of adult experiences and functioning (Elder et al., 2015; Pearlin, 2010).

2. ACEs and the daily stress processes

The Centers for Disease Control and Prevention (CDC) conducted the original ACEs study in 1995–1997 to examine the long-term relationships between childhood adversity and trauma and later-life health and well-being (Felitti et al., 1998). This ACEs study examined ten adverse experiences in three overall domains of abuse (physical, emotional, and sexual abuse), neglect (physical and emotional neglect), and household challenges (individual(s) with mental illness/substance use disorder in the household, divorce/separation, parental incarceration, and witnessing domestic violence; Felitti et al., 1998, Ports et al., 2020). Since the original research, studies have been replicated and adapted, some of which considered other types of adversities, such as economic hardship (Danielson & Sanders, 2018; Ports et al., 2020). These studies have consistently supported the lingering harmful effect of ACEs on several aspects of adult health (Metzler et al., 2017; Sheffler et al., 2020; Thompson et al., 2019).

One of the pathways to long-term negative health effects is related to how adults with ACEs experience and respond to stress and threats (Manyema et al., 2018; Nurius et al., 2015). Exposure to ACEs causes a toxic stress response, or prolonged activation of stress response systems in children this can lead to the development of stress systems that may increase the subjective perception of stress and lower the threshold of responding to stressful events (Bucci et al., 2016; Koss & Gunnar, 2018; Shonkoff et al., 2012). Studies have shown that such effects associated with childhood adversity can persist well into later adulthood (Hammen et al., 2000; McLaughlin, 2018).

The current study posits that an adult's experience of stress, particularly daily stress processes, may be influenced by their history of ACEs. Specifically, adults with high ACEs may be more emotionally vulnerable to daily stressor exposure by showing more pronounced negative emotions in the face of daily stressful events. Although the specific measure of ACEs has not been used, a small number of empirical studies have examined the idiosyncrasies of childhood adversity and daily stress experience and subsequent affect responses later in adulthood. For example, Mallers et al. (2010) found that more negative retrospective reports of mother-child and father-child relationship quality were associated with greater exposure to daily stressors. Similarly, Infurna et al. (2015) showed that adults who experienced childhood emotional, physical, and sexual abuse reported more frequent exposure to daily stressful events. Poon and Knight (2012) found that women with a history of frequent maternal emotional abuse showed higher emotional reactivity to network stressors (i.e., stressful events that happen to a close friend or relative) compared to women who experienced less frequent maternal emotional abuse. Kong et al. (2019) also found that more frequent exposure to maternal childhood abuse was associated with higher emotional reactivity to daily stressors.

3. Long-term health effects of daily stress processes

Exposure and response to daily stressors have considerable implications for long-term physical and mental health (Charles et al., 2013; Chiang et al., 2018; Piazza et al., 2013; Maller et al., 2005). Evidence exists that higher affective reactivity to daily stressors is associated with more chronic health problems (Piazza et al., 2013), affective distress and disorders (Charles et al., 2013), and greater depressive symptoms (Parrish et al., 2011) over time. Leger et al. (2018) also showed that persistently high levels of negative affect the day after a stressor is experienced were associated with more chronic conditions and lower functional status in a 10-year reassessment. Similarly, Chiang et al. (2018) found that greater negative affect in response to everyday stressors predicted mortality risk among individuals with at least one chronic illness, implying that there are serious harmful health effects of emotional reactivity especially for those who are already at heightened risk due to illness. The long-term health effect of overall stressor exposure itself, or frequency of daily stressors, has been less supported (Mroczek et al., 2013; Piazza et al., 2013; Sin et al., 2015); however, studies have shown that greater overall stressor exposure and higher daily negative affect can alter biological processes, such as cortisol regulation and inflammation, and this taxing of biological resources, in turn, can considerably hamper individuals' health outcomes over time (Chiang et al., 2012, 2018; Gouin et al., 2012; Maller et al., 2005; Stawski et al., 2013).

4. The current study

Based on theoretical frameworks and review of existing literature, the current study examined whether and how ACEs would manifest in adults' daily stress and emotional experiences and their long-term impact on health. The current study expands the existing literature in several ways. First, we used a more comprehensive and stringent measure for childhood adversity and trauma. Rather than focusing on any specific aspect or type of adversity, the ACEs measure in the current study assessed a tally of childhood traumatic events that have a potential long-term developmental impact (Danielson & Sanders, 2018; Felitti et al., 1998). This approach recognizes that such adversities often co-occur and are highly interrelated, making it difficult to differentiate the impact of a single event over time (Dong et al., 2004; Ports et al., 2020). Second, we analyzed large-scale daily diary data from a national sample of 2022 adults (i.e., National Study of Daily Experiences 2) to offer rigorous evidence about the association between ACEs and adults' daily stress experiences and outcomes. Lastly, we examined the daily stress process as a potential mechanism linking ACEs and long-term physical and mental health outcomes to uncover the pathway of how such childhood stressors can have a persistent influence over time. The current study specifically hypothesized that exposure to ACEs would moderate the association between daily stressor exposure and daily negative affect, which would in turn be associated with long-term physical and mental health outcomes (i.e., chronic health conditions and depressive symptoms).

5. Methods

5.1. Data source and study sample

This study utilized daily diary data from the second wave of the National Study of Daily Experiences (NSDE 2) combined with the longitudinal survey data from the Midlife in the United States (MIDUS) studies (http://www.midus.wisc.edu/; Almeida, 2005; Radler & Ryff, 2010). The first wave of MIDUS (MIDUS 1) was conducted in 1995–1996 using a national sample of 7108 American adults aged 25 to 74. Follow-up surveys were conducted in 2004–2006 (MIDUS 2) and 2013–2014 (MIDUS 3), which showed high retention rates (e.g., 77% for the MIDUS 3 telephone survey). NSDE 2 is one of the ancillary projects of MIDUS and aimed to examine the day-to-day lives of a subsample of MIDUS respondents, especially their experiences of daily stressful events. NSDE 2 respondents ($n = 2022$) were a representative sub-sample of MIDUS 2 who participated in daily telephone interviews across eight consecutive days in 2004–2009. NSDE 2 also incorporated participants from an African American subsample from Milwaukee ($n = 180$) to compensate for the limited minority representation. Data collection was spread throughout the year and consisted of separate "flights" of interviews, with each flight representing the eight-day sequence of interviews from approximately 20 respondents. The study sample completed an average of seven out of the eight daily interviews, resulting in a total of 14,912 valid daily interviews (92% completion rate).

In the current study, we analyzed the daily diary data (i.e., daily stressor exposures, daily negative affect) from the 2022 respondents in NSDE 2. In addition, respondents' childhood experiences (i.e., ACEs) and sociodemographic characteristics (e.g., educational attainment) were drawn from MIDUS 1 and 2. To assess the long-term health effects of daily stress processes, we obtained the respondents' health data from MIDUS 3 and used the corresponding health data from MIDUS 2 as controls. About 75% ($n = 1517$) of the 2022 respondents participated in MIDUS 3.

5.2. Measures

5.2.1. Adverse childhood experiences (ACEs)

The exposure to adverse childhood experiences was measured using seven ACE categories. MIDUS 1 and 2 contained the 24 items related to parental divorce, living with a household member with a substance use issue, sexual assault, emotional abuse, physical abuse, emotional neglect, and financial distress. Most of these items were rated on a Likert scale to assess the frequency of experiencing specific events. For example, to measure a history of emotional abuse, an item was asked for each parent: "*When you were growing up, how often did your mother/the woman who raised you (father/the man who raised you) insult you or swear at you; sulk or refuse to talk to you; stomp out of the room; do or say something to spite you; threaten to hit you; smash or kick something out of anger*?" Each item was rated by a 4-

point Likert scale: *never* (1), *rarely* (2), *sometimes* (3), and *often* (4). Based on the guidance of Danielson and Sanders (2018), the MIDUS variables were recoded to create seven dichotomous ACE categories (with a "1" indicating the presence of this ACE category for the individual). Each of the seven ACE categories was summed to produce a total count of ACEs with higher scores suggesting greater levels of ACEs exposure ($\alpha = 0.61$; expected range = 0–7). The summed score was considered a normal distribution with the skewness close to 1 ($M = 1.18$, $SD = 1.38$).

5.2.2. Chronic health conditions

In MIDUS 2 and 3, respondents were provided with a list of 30 different chronic health conditions and asked to indicate those they had experienced or had been treated for (1 = *yes* and 0 = *no*) during the previous year, which was adapted from the Medical Outcomes Study (Brazier et al., 1992; Wells et al., 1989). These conditions included asthma/bronchitis/emphysema, tuberculosis and other lung problems, joint/bone diseases, sciatica/lumbago/backache, persistent skin trouble, thyroid disease, hay fever, stomach trouble, urinary/bladder problem, constipation, gall bladder trouble, persistent foot trouble, varicose veins, AIDS/HIV, lupus/autoimmune disorder, persistent gum/mouth trouble, persistent teeth trouble, high blood pressure/hypertension, anxiety/depression, alcohol/drug problem, migraine headaches, chronic sleep problems, diabetes/high blood sugar, neurological disorder, stroke, ulcer, hernia, piles/hemorrhoids, and swallowing problems. A total score was constructed by taking the number of positive responses, with higher scores suggesting more chronic conditions (MIDUS 2: $\alpha = 0.67$; MIDUS 3: $\alpha = 0.71$; expected range = 0–30).

5.2.3. Depressive symptoms

In MIDUS 2 and 3, depressive symptoms were measured by six items as suggested by Mroczek and Kolarz (1998). Items include "*During the past 30 days, how much of the time did you feel (a) so sad nothing could cheer you up; (b) nervous; (c) restless or fidgety; (d) hopeless; (e) that everything was an effort; and (f) worthless*?" Participants rated the items on a 5-point scale (1 = *none of the time*, 2 = *a little of the time*, 3 = *some of the time*, 4 = *most of the time*, 5 = *all of the time*). The total score was calculated by averaging the six items, with higher scores suggesting higher levels of depressive symptoms (MIDUS 2: $\alpha = 0.86$; MIDUS 3: $\alpha = 0.85$; expected range = 1–5).

5.2.4. Daily stressor exposure

Daily stressors were assessed through the Daily Inventory of Stressful Events (DISE; Almeida et al., 2002). The instrument contains seven questions asking whether participants encountered seven types of daily stressors (1 = *yes* and 0 = *no*) that include 1) *having had an argument or disagreement with someone*, 2) *almost having had an argument or disagreement but having avoided it*, 3) *having had a stressful event happen at work or school*, 4) *having had a stressful event happen at home*, 5) *experiencing race, gender, or age discrimination*, 6) *having had something bad happens to a relative or close friend*, and 7) *having had anything else bad or stressful happen*. Consistent with prior studies (e.g., Almeida, 2005), we created a binary daily stressor variable summarizing across the seven categories that indicated *whether (= 1) or not (= 0) any daily stressor had occurred* on the day of the interview.

5.2.5. Daily negative affect

Daily negative affect was measured by combining 14 negative affect items derived from the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988). Each day, respondents reported how much they experienced 14 negative emotions in the past 24 h, including feeling lonely, afraid, irritable, worthless, hopeless, or that everything was an effort. Each item was rated on a five-point scale. The specific affect items were averaged to yield a total score, with higher scores suggesting higher levels of negative affect ($\alpha = 0.90$; expected range = 0–4).

5.2.6. Controls

Several sociodemographic characteristics measured at MIDUS 2 were included in the analyses as covariates, including gender (*male* = 1; *female* = 0), race (*White* = 1; *non-White* = 0), age, marital status (*currently married* = 1; *currently not married* = 0), and years of education. We also included respondents' self-rated health (five-point scale ranging from 1 = *poor* to 5 = *excellent)*, smoking status (*ever smoked* = 1; *never smoked* = 0), BMI, and the chronic health conditions/depressive symptoms also measured at MIDUS 2 as covariates.

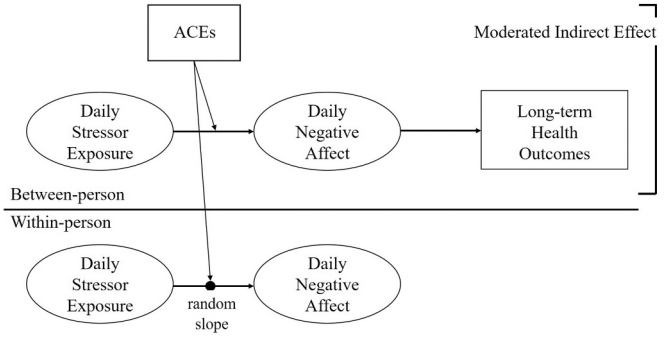

Fig. 1. Conceptual model for multilevel moderated mediation analysis.

5.3. Analytic strategy

We performed multilevel moderated mediation analyses using the multilevel structural equation modeling approach (MSEM; Preacher et al., 2010, 2011). The analysis was conducted using Mplus (version 8.6). A multilevel approach was used to account for the nested data structure where an individual is considered a cluster (level-2: between-persons), and repeated measures across the eight days are considered variations within an individual (level-1: within-person). MSEM partitions the variance of level-1 variables into latent within- and between-person components and estimates separate within- and between-person covariance matrices, overcoming possible conflation or bias of a multilevel indirect effect (Preacher et al., 2010).

As Fig. 1 illustrates, we tested the so-called 1–1-2 model that involved the level-1 independent variable (i.e., daily stressor exposure) and mediator (i.e., daily negative affect) and the level-2 dependent variables (i.e., prospective chronic health conditions and depressive symptoms). We also examined the moderating effect of ACEs (level-2) in the path between daily stressor exposure and daily negative affect at both within-and between-person levels (Preacher et al., 2010, 2011). We added the random slope for the within-person daily stressor effect (i.e., daily stress reactivity), allowing for individual differences.

We note that the estimated indirect effect and the moderated indirect effect were specific to the between-person level. There was no within-person indirect effect because only the independent variable and mediator were at level-1. The within-person association between daily stressor exposure and daily negative affect examined the effect that any daily stressor on a given day has on negative affect reported on that day. The between-person association examined the effect of overall stressor exposure on overall levels of negative affect across the study days, which would then be associated with individuals' prospective health outcomes. The moderated indirect effect was tested with the interaction of ACEs between overall stressor exposure and overall levels of negative affect to see if the aforementioned indirect effect would differ by adults' levels of ACEs.

Missing data were handled using the full information maximum likelihood (FIML) approach. Research suggested that FIML is comparable to multiple imputation, both of which are known to be superior to other missing data techniques (Acock, 2005; Lee & Shi, 2021). We conducted Little's missing completely at random test (Little, 1988) and found that the null hypothesis was rejected. Complete data were provided by 32.9% of participants; the smoking status variable reported the most missing data ($n = 844$; 41.7% of cases).

6. Results

Table 1 presents the descriptive characteristics of key variables in the study ($n = 2022$ individuals). About half of the sample was male (42.8%, $n = 865$), and the majority were White (82.7%, $n = 1672$) and married (68.6%, $n = 1387$). The average age was 56.3 years, with a range of 33–84. At MIDUS 3, respondents reported an average of three chronic conditions ($M = 2.87$, $SD = 2.70$) and experienced depressive symptoms *a little of the time* based on the five-point scale ($M = 1.49$, $SD = 0.60$). On average, respondents reported one ACE experience ($M = 1.18$, $SD = 1.38$). Respondents reported at least one stressor on 40% of the study days on average ($M = 0.40$, $SD = 0.27$). Preliminary multivariate analyses showed that ACEs were significantly associated with more chronic health conditions and greater depressive symptoms at MIDUS 3 (see Supplementary Table 1).

Table 2 presents the results of the multilevel moderated mediation model predicting M3 chronic health conditions. First, the effect

Table 1
Summary statistics of study sample and key variables ($N = 2022$)

	N or Mean (SD)	% or Observed Min./Max.
MIDUS 3 Chronic health conditions	2.87 (2.70)	0/16
MIDUS 3 Depressive symptoms	1.49 (0.60)	1/5
ACEs	1.18 (1.38)	0/7
Any daily stressors[a]	0.40 (0.27)	0/1
Daily negative affect[a]	0.21 (0.28)	0/2.54
Covariates		
Gender		
Male	865	42.78
Female	1157	57.22
Race		
White	1672	82.69
Others	291	14.39
Marital status		
Married	1387	68.60
Non-married	633	31.31
Age	56.25 (12.20)	33/84
Years of education	7.26 (2.53)	1/12
Self-rated health status	3.56 (1.02)	1/5
Smoking status	725	35.86
BMI	28.43 (6.32)	16.14/79.04
MIDUS 2 Chronic health conditions	2.54 (2.48)	0/17
MIDUS 2 Depressive symptoms	1.52 (0.61)	1/5

[a] Repeated measures were averaged across the eight study days.

of daily stressor exposure on daily negative affect was statistically significant at both within- and between-person levels ($b = 0.14$, $p < .001$; $b = 0.44$, $p < .001$, respectively), and ACEs significantly moderated the associations at both levels. The significant interaction of ACEs on the within-person daily stressor effect ($b = 0.02$, $p < .001$) indicated that individuals would show higher negative affect on days when they experienced any daily stressors compared to days with no stressors, and this reactivity to daily stressors was stronger for those with more ACEs. The significant interaction of ACEs on the between-person daily stressor effect ($b = 0.06$, $p < .01$) indicated that individuals with greater overall stressor exposure (i.e., those who experience more daily stressors) tend to report higher levels of negative affect overall than individuals with lower overall stressor exposures, and this association was stronger for those with more ACEs. Higher levels of overall negative affect were then associated with more chronic health conditions at MIDUS 3 ($b = 1.60$, $p < .001$), controlling for chronic health conditions and other covariates measured at MIDUS 2. We found a statistically significant indirect effect that individuals with greater overall stressor exposure tend to report higher levels of overall negative affect, which was, in turn, associated with more chronic health conditions ten years later ($b = 0.70$, $p < .001$). Overall exposure to daily stressors was not directly associated with prospective chronic health conditions ($b = -0.00$, $p = .994$). Further, the moderated indirect effect was statistically significant ($b = 0.09$, $p < .01$), indicating that the indirect effect of overall exposure to daily stressors on prospective chronic health conditions via overall daily negative affect was stronger for adults with high ACEs compared to those with low ACEs. The simple slopes of the moderated indirect effects are presented in Fig. 2. We plotted moderated indirect effects at the M ± 1 *SD* of ACEs. Since the M − 1 *SD* was outside of the range of data, we used the minimum value (0) instead.

We found similar patterns of results for the model predicting prospective depressive symptoms (Table 3). The indirect effect of overall stressor exposure on depressive symptoms through overall levels of negative affect was statistically significant ($b = 0.25$, $p < .001$). Further, this indirect effect was stronger for adults with high ACEs compared to those with low ACEs ($b = 0.03$, $p < .05$). The simple slopes of the moderated indirect effects for depressive symptoms are presented in Fig. 3.

7. Discussion

Extensive literature has examined the lingering impact of ACEs on numerous aspects of adult lives (Metzler et al., 2017; Sheffler et al., 2020; Thompson et al., 2019). Building upon these prior studies, the current study examined the role of ACEs in the daily stress process later in adulthood and its long-term health implications. Taking a daily stress framework through a life-course lens led us to recognize that ACEs would exacerbate the effects of daily stressors on daily emotional well-being in adulthood. Furthermore, we

Table 2
Multilevel moderated mediation predicting M3 chronic health conditions: unstandardized path estimates for direct and indirect effects.

	b (s.e.)	*p* value
Within-person level (WP)		
Daily negative affect		
Daily stressors	0.14 (0.01)	<0.001
Between-person level (BP)		
Daily negative affect		
Daily stressors	0.44 (0.03)	<0.001
ACEs	0.01 (0.00)	0.081
Daily stressors (BP) * ACEs	**0.06 (0.02)**	**0.003**
Daily stressors (WP)* ACEs	**0.02 (0.00)**	**<0.001**
Male	0.02 (0.01)	0.031
White	−0.06 (0.02)	0.002
Married	−0.04 (0.01)	<0.001
Age	−0.00 (0.00)	<0.001
Years of education	−0.01 (0.00)	0.013
Self-rated health status	−0.03 (0.01)	<0.001
Smoking status	−0.01 (0.02)	0.687
BMI	−0.00 (0.00)	0.001
M2 chronic health conditions	0.02 (0.00)	<0.001
M3 Chronic health conditions		
Daily negative affect	1.60 (0.32)	<0.001
Daily stressors	−0.00 (0.25)	0.994
Male	−0.26 (0.11)	0.019
White	−0.35 (0.18)	0.048
Married	−0.03 (0.12)	0.809
Age	0.01 (0.01)	0.014
Years of education	−0.03 (0.02)	0.209
Self-rated health status	−0.32 (0.07)	<0.001
Smoking status	0.15 (0.12)	0.231
BMI	0.05 (0.01)	<0.001
M2 chronic health conditions	0.55 (0.03)	<0.001
BP indirect effects		
Daily stressors ➔ Daily negative affect ➔ M3 chronic health conditions	0.70 (0.15)	<0.001
BP moderated indirect effects		
Daily stressors * ACEs ➔ Daily negative affect ➔ M3 chronic health conditions	**0.09 (0.03)**	**0.006**

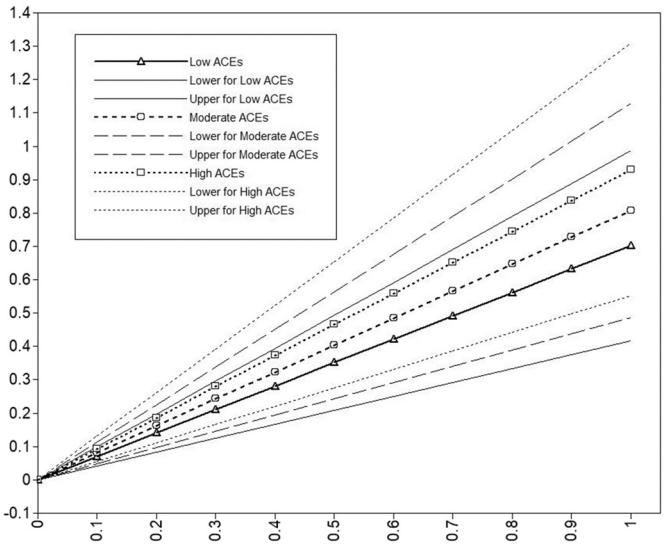

Fig. 2. Model predicting M3 chronic health conditions: simple slopes of the moderated indirect effects. *Note*. Lines represent the low (straight line, triangle), moderate (dashed line, circle), and high (dotted line, square) levels of ACEs, with lower and upper confidence intervals.

Table 3
Multilevel moderated mediation predicting M3 depressive symptoms: unstandardized path estimates for direct and indirect effects

	b (s.e.)	*p* value
Within-person level (WP)		
Daily negative affect		
Daily stressors	0.14 (0.01)	<0.001
Between-person level (BP)		
Daily negative affect		
Daily stressors	0.40 (0.03)	<0.001
ACEs	0.01 (0.00)	0.141
Daily stressors (BP) * ACEs	**0.05 (0.02)**	**0.009**
Daily stressors (WP)* ACEs	**0.02 (0.00)**	**<0.001**
Male	0.02 (0.01)	0.093
White	−0.05 (0.02)	0.005
Married	−0.03 (0.01)	0.003
Age	0.00 (0.00)	0.873
Years of education	−0.00 (0.00)	0.154
Self-rated health status	−0.02 (0.01)	0.013
Smoking status	−0.00 (0.02)	0.907
BMI	−0.00 (0.00)	0.031
M2 depressive symptoms	0.14 (0.01)	<0.001
M3 Depressive symptoms		
Daily negative affect	0.62 (0.09)	<0.001
Daily stressors	0.03 (0.06)	0.682
Male	0.04 (0.03)	0.098
White	0.07 (0.04)	0.069
Married	−0.08 (0.03)	0.006
Age	−0.00 (0.00)	0.560
Years of education	−0.01 (0.01)	0.140
Self-rated health status	−0.07 (0.02)	<0.001
Smoking status	0.03 (0.03)	0.307
BMI	−0.00 (0.00)	0.171
M2 depressive symptoms	0.42 (0.04)	<0.001
BP indirect effects		
Daily stressors ➔ Daily negative affect ➔ M3 depressive symptoms	0.25 (0.04)	<0.001
BP moderated indirect effects		
Daily stressors * ACEs ➔ Daily negative affect ➔ M3 depressive symptoms	**0.03 (0.01)**	**0.013**

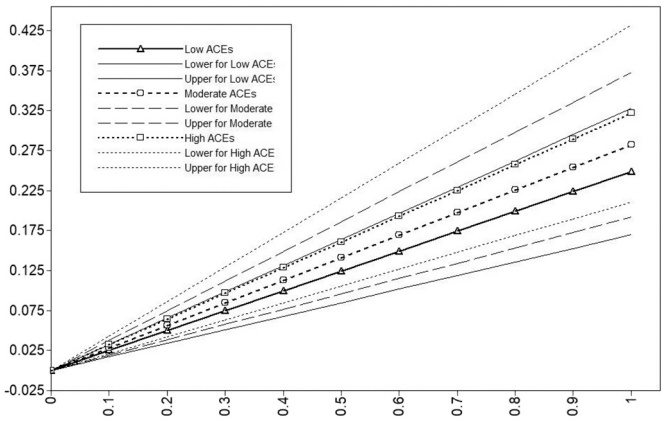

Fig. 3. Model predicting M3 depressive symptoms: simple slopes of the moderated indirect effects. *Note*. Lines represent the low (straight line, triangle), moderate (dashed line, circle), and high (dotted line, square) levels of ACEs, with lower and upper confidence intervals.

investigated whether such daily stress and emotional experiences may serve as a mechanism explaining the persistent negative effect of ACEs on health and well-being in later adulthood.

7.1. Effects of ACEs on the associations between daily stressor exposure and daily negative affect

One of our key findings was that the effects of daily stressor exposure on daily negative affect both at within- and between-person levels differed by the level of ACEs. First, ACEs moderated the within-person daily stressor effect; that is, adults with more ACEs exhibited higher emotional reactivity to daily stressors by showing a wider difference in the levels of negative affect on stressor-days compared to non-stressor days. Further, more frequent exposure to daily stressors was associated with higher overall negative affect, and this between-person effect was also stronger for adults who experienced more ACEs.

Such findings are consistent with the prior studies that have shown more pronounced associations between daily stressor exposure and daily emotional well-being for adults with histories of childhood adversity (Infurna et al., 2015; Kong et al., 2019; Poon & Knight, 2012). The ACEs literature indicates that exposure to chronic, severe stressors during childhood can cause repeated and prolonged activation of a stress response system in children (Bandoli et al., 2017; McLaughlin et al., 2010; Shonkoff et al., 2009, 2012). Our results may demonstrate such toxic stress response may extend into later adulthood, and ACEs can complicate adults' stress response dynamics in the context of their daily lives. The current study also supports the stress sensitization hypothesis that early life adversity is associated with increased emotional sensitivity to stressors later in adulthood (Hammen et al., 2000; Harkness et al., 2015). Future research may explore potential pathways, such as alteration in stress-responsive physiological systems (e.g., disruptions in the hypothalamic-pituitary-adrenal axis regulation; Cicchetti & Rogosch, 2012) or cognitive vulnerabilities (e.g., schema, cognitive styles, dysfunctional beliefs; Gibb, 2002), that explain the long-term negative impact of ACEs on daily stress processes later in adulthood. Such knowledge will help inform strategies to relieve the complications in daily stress experience for adults with a history of ACEs.

7.2. Long-term health effects of daily stress processes for adults with ACEs

We examined the longitudinal associations of the daily stress processes, moderated by ACEs, with chronic health conditions and depressive symptoms ten years later by employing a multilevel moderated mediational model. Our findings showed that the between-person daily stressor effect was associated with more prospective chronic health conditions and more frequent prospective depressive symptoms. The significant moderated indirect effect indicated that this indirect effect was stronger for adults with a high ACEs score than those with a low ACEs score.

This result adds to the existing literature, first, by showing that stressor exposure itself, or frequency of experiencing daily stressors, can lead to negative health effects over time. To date, predominant evidence exists regarding the long-term health impacts of within-person reactivity to daily stressors (Chiang et al., 2018; Mroczek et al., 2013; Piazza et al., 2013; Sin et al., 2015). For example, Charles et al. (2013) revealed that greater emotional reactivity to daily stressors is associated with a greater likelihood of reporting affective disorders and chronic health conditions ten years later, but these authors did not find long-term health effects of overall stressor exposure as was found in the current study.

Second, the current study highlights that the long-term adverse health effect of daily stressor exposure was more pronounced for adults who experienced more ACEs. As Figs. 2 and 3 illustrate, the indirect effect involving overall stressor exposure, overall daily negative affect, and long-term health outcomes was stronger for adults with high ACEs than those with low ACEs. This result supports the daily stress process as a promising mechanism explaining the life-long health risks associated with ACEs. One caveat is that although the coefficients were statistically significant, the effect sizes were small (e.g., moderated indirect effects = 0.03, 0.09).

The well-established ACEs literature suggests that exposure to toxic stress during childhood can have potentially permanent biological disruptions, such as physiological stress response systems, which can lead to an array of physical and mental health

problems later in adult life (Juster et al., 2010; McEwen & Gianaros, 2010). These prior studies assert that many adult health complications should be viewed as developmental disorders inflicted by childhood circumstances, such as ACEs (Shonkoff et al., 2012). The current study adds to such evidence by showing that the harmful impact of ACEs may be prolonged over time through the cumulative, daily stress-induced emotional tolls on the individuals. More research is needed to provide further evidence about the role of daily stress processes as a mechanism linking childhood trauma and adversity with long-term health consequences. Such research efforts can support the importance of improving daily emotional experiences through facilitating adaptive coping with daily stressors, which can ultimately help mitigate the persistent, negative health effects of ACEs. Relatedly, future research should explore the risk and resilience factors in the daily stress context that are specific to adults with ACEs.

7.3. Limitations and implications

We acknowledge the limitations of the current study. First, the ACEs items were based on retrospective self-reports that could involve recall errors. Due to data availability, we were only using seven ACEs indicators, which may limit the interpretation of our findings in relation to the ACEs literature. Second, the study sample may not reflect the characteristics of the general population. According to Radler and Ryff (2010), the MIDUS 2 respondents tended to be White, female, and married, as well as those with better self-reported health and higher levels of education. The longitudinal MIDUS sample and the NSDE subsample had similar distributions for age and marital and parenting status. However, the NSDE subsample included better-educated participants, on average, and more females and fewer minority participants. In terms of the daily stressors measure, we focused on examining the exposure to any daily stressors rather than differentiating specific types of daily stressors. Much of the previous daily stress studies (e.g., Surachman et al., 2019) relied on this approach to increase statistical power by offering a comprehensive examination of various types of stress exposures. However, future research may incorporate examining the interactive health effects of ACEs and specific daily stressor types (e.g., interpersonal stressors vs. non-interpersonal stressors).

Despite these noted limitations, the current study offers several contributions to the existing literature. First, taking a life-course approach in daily stress processes can lead to generating potential future research that investigates the ways in which life course factors mitigate or exacerbate daily stress effects. More research may explore how ACEs affect other aspects of daily lives and their concomitant and long-term health impacts. Second, our finding adds to the ACEs literature by showing the long-term effect of ACEs on increased reactivity to daily stressors, further supporting stress sensitization for adults who experienced childhood adversity and trauma. Third, in addition to the known pathways, the findings of this study suggest the daily stress process of adults with ACEs as a potential mechanism leading to long-term negative health outcomes. To further support such an association, future research may explore the neurobiological effects of daily stress and its relation to ACEs and health over time.

The findings of this study provide important implications for practice. First, it is noteworthy for practitioners that, however minor, daily hassles and stressors can have long-term health implications, which could be more pronounced for adults with ACEs exposure. Thus, interventions for adults with histories of ACEs may aim to ease their experience of daily stressful events and help manage emotional responses to daily stressors. For example, one approach is to help these adults to have a heightened awareness of how they interpret, process, and respond to daily stressful events and guide them to incorporate stress relief modalities and self-care practices, such as mindfulness, into their daily routines (An et al., 2019). Considering the impact of ACEs on day-to-day lives in adulthood, it will be important to increase public awareness about the potential impact of ACEs not only in medical settings, where dissemination has been focused, but also in other social settings such as families, work, or communities, and incorporate trauma-sensitive practices into these various life domains (e.g., trauma-informed community building; Weinstein et al., 2014).

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