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Adverse childhood experiences, sleep problems, low self-control, and adolescent delinquency: A longitudinal serial mediation analysis

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Abstract

Several studies link adverse childhood experiences (ACEs) to delinquency. Yet, developmental sequalae accounting for this association remain unclear, with previous research limited by cross-sectional research designs and investigations of singular mediating processes. To redress these shortcomings, this study examines the longitudinal association between ACEs and delinquency as mediated by both sleep problems and low self-control, two factors which past research implicates as potentially important for understanding how ACEs contribute to antisocial behavior. Data collected from 480 adolescents (71.3% boys; 86.3% White) and their parents participating in the Michigan Longitudinal Study was used to conduct a serial mediation analysis. The association between ACEs (prior to age 11) and delinquency in late adolescence was found to operate indirectly via sleep problems in early adolescence and low self-control in middle adolescence. Nonetheless, a direct association between ACEs and later delinquency remained. Pathways through which ACEs contribute to later delinquency are complex and multiply determined. Findings indicate that early behavioral interventions, including improving sleep and self-control, could reduce later delinquency. Still, more research is needed to identify additional avenues through which the ACEs–delinquency association unfolds across development.

Keywords: adverse childhood experiences; delinquency; low self-control; sleep

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Adverse childhood experiences (ACEs) are negative, potentially traumatic events (e.g., abuse and neglect, community violence) linked to mental and physical health problems (e.g., Brown & Shillington, 2017; Cicchetti, 2013; Felitti et al., 1998). Unfortunately, ACEs are common (Felitti et al., 1998; Merrick et al., 2018), with 48% of youth experiencing at least one (Bethell et al., 2014). Further, ACEs tend to co-occur (Anda et al., 1999; Dong et al., 2004; McLaughlin & Sheridan, 2016) and have a dose–response association with negative outcomes (e.g., Felitti et al., 1998; Lewis et al., 2019), making it critical to understand their cumulative impact. Previous research links ACEs to poorer physical and mental health outcomes generally (Belbasis et al., 2018; Green et al., 2010; Hughes et al., 2017; McLaughlin et al., 2019), and more specifically to delinquency (Brown & Shillington, 2017; Leban & Gibson, 2020), sleep problems (Turner et al., 2020), and self-control deficits (Meldrum et al., 2019). Additionally, both sleep problems (Connolly et al., 2021; Hambrick et al., 2018) and low self-control (Vazsonyi et al., 2017) are correlates of delinquency.

Developmental research supports cascade models of delinquency wherein risk factors (e.g., ACEs) in early development have a cascading effect on later developmental outcomes (Dodge et al., 2009). For example, ACEs may set off a psychological and biological reaction to stress, leading to the release of stress hormones (Lupien et al., 2009), which leads to psychological and physiological arousal (McEwen, 1998), which may contribute to sleep problems (Buckley & Schatzberg, 2005). Sleep problems may then contribute to executive function deficits, such as low self-control (Guarana et al., 2021), which has been associated with delinquency (Meldrum et al., 2015). Understanding the mediational pathways connecting these risk factors and outcomes is critical to determining how these constructs are related, which can then highlight possible intervention targets (Cicchetti, 2016) and inform "high impact and enduring interventions" (McMakin & Alfano, 2015). Accordingly, recent research suggests that the association between ACEs and delinquency partially operates through sleep problems (Hambrick et al., 2018), and additional studies point to the mediating role of low self-control between sleep problems and delinquency (Meldrum et al., 2015; Vazsonyi et al., 2018). Whether both sleep problems *and* low self-control operate sequentially to link ACEs and delinquency remains unexamined. Guided by the ACE framework (Felitti et al., 1998) and developmental cascade models (Dodge et al., 2009), the present study addresses this gap

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in research by examining sleep problems in childhood and low self-control in early adolescence as mediators of the association between ACEs and delinquency in late adolescence using longitudinal serial mediation.

ACEs and delinquency

Research supports an association between cumulative ACEs and negative outcomes, including delinquency (Leban & Gibson, 2020). For example, adolescents experiencing more ACEs engaged in more delinquent behaviors (Brown & Shillington, 2017), tended to be younger at their first arrest, and had more total arrests in adolescence (Baglivio et al., 2015). Additionally, adolescents who experienced maltreatment demonstrated high aggression (Fitton et al., 2018), truancy, and other rule-breaking behaviors (Stouthamer-Loeber et al., 2001). Adolescence is a sensitive period of development, wherein youth experience many social, physical, emotional, and cognitive changes (Dahl & Gunnar, 2009), including biological changes that may leave their stress systems and brains vulnerable to adverse experiences (Heim & Binder, 2012; Yoon, 2020). Indeed, when studying the timing of ACEs and their relative impact on externalizing behaviors, Yoon (2020) found that participants experienced the most adversity at the age of 6 years and that the effect of this adversity was most prominent when participants were 11.5 years old. Yet, few longitudinal studies investigating mechanisms underlying the association between ACEs and delinquency exist, thus hampering efforts to establish causal effects.

Sleep problems represent one potential link in the association between ACEs and delinquency (Hambrick et al., 2018). For example, El-Sheikh and colleagues (2006) found that children living in homes characterized by significant marital conflict had poorer sleep quality using actigraphy. Additionally, researchers have also found a significant association between sleep problems and both delinquency and risk-taking behavior (Backman et al., 2015; Clinkinbeard et al., 2011; Lin & Yi, 2015; Partin & Lehmann, 2021), as well as externalizing behaviors among youth aged 8–13 years old (Kelly & El-Sheikh, 2014; Vazsonyi et al., 2021). Furthermore, severe deficits in sleep duration and excessive sleep were associated with greater delinquency in a cross-sectional analysis of a nationally representative sample of youth (Mears et al., 2020), though other recent longitudinal research suggests that sleep quality, rather than sleep quantity, might be more consequential for delinquent and externalizing behavior (Connolly et al., 2021; Vazsonyi et al., 2021).

Low self-control is another potential mechanism linking ACEs and delinquency. For example, ACEs were negatively associated with self-control in a cross-sectional analysis across two separate samples of youth (Meldrum et al., 2019), as well as a more recent longitudinal analysis (Jones et al., 2021). In addition, a recent meta-analysis reported that both sleep quality and, to a lesser extent, sleep quantity are positively associated with self-control across a wide variety of methodological specifications (Guarana et al., 2021). Further, other studies have reported that low self-control partially mediates the association between sleep quality and delinquency (Meldrum et al., 2015; Vazsonyi et al., 2018).

Researchers have also posited important underlying links between sleep and self-control, such as executive function deficits due to poor or inadequate sleep (Beebe & Gozal, 2002; Guarana et al., 2021; Langner & Eickhoff, 2013; Lim & Dinges, 2010). Indeed, negative effects to the prefrontal cortex have been noted in people with low sleep duration and quality (Chuah et al., 2010; Nilsson et al., 2005). While more research is still needed to determine causal pathways between sleep and self-control, it seems reasonable that adolescents with more sleep problems and less self-control may engage in more delinquent activities.

ACEs and sleep problems

Sleep is important to health and well-being, and late childhood – early adolescence appears to be a sensitive period in development for sleep problems and resulting mental health issues (Kelly & El-Sheikh, 2014; McMakin & Alfano, 2015). Indeed, there is evidence of psychiatric problems, developmental disorders, and delinquency among adolescents with sleep problems (Meldrum & Restivo, 2014; Tesler et al., 2013). Furthermore, an association between ACEs and sleep problems has been documented (Lepore & Kliewer, 2013; Turner et al., 2020; Xiao et al., 2020). Of note, two longitudinal investigations support an association between ACEs and sleep problems. Noll et al. (2006) found childhood sexual abuse predicted sleep disturbances in adolescence/young adulthood, and Gregory et al. (2006) found an association between family conflict in childhood and adolescence was associated with insomnia at the age of 18 years. While there is not one single explanation for this association between ACEs and sleep problems, research suggests that ACEs may be a catalyst to psychological and biological reactions to stress, causing a release of stress hormones (Lupien et al., 2009), leading to increased psychological and physiological arousal (McEwen, 1998) which may contribute to sleep problems (Buckley & Schatzberg, 2005). Indeed, altered hypothalamic–pituitary–adrenal axis activity, including cortisol production, has been observed among trauma survivors (Kuhlman et al., 2015) and those with disturbed sleep (Abell et al., 2016; Minkel et al., 2014), highlighting this as a potential mechanism. Furthermore, certain ACEs, like community violence (Hall Brown et al., 2016), may lead youth to develop symptoms of anxiety and feelings of insecurity in their environment, and introduce frightening noises at night (e.g., gunshots, tire squeals) that trigger sleep disturbance.

Research documenting whether cumulative ACEs influence later delinquency via sleep problems, however, is not widely established. One exception exists wherein researchers found ACEs to be partially associated with delinquency through poor sleep (Hambrick et al., 2018). These findings provide precedent for the current study and leave areas for further development given the use of cross-sectional data. The current study builds upon this work using a longitudinal design and measures reflecting a broad range of ACEs, sleep problems, and delinquency to determine if sleep mediates the association between adversity in childhood and delinquency in adolescence.

ACEs and self-control

Self-control, often thought of as the antithesis of impulsivity, is associated with positive outcomes including self-regulatory skills (Shoda et al., 1990), health and well-being (Moffitt et al., 2011), and academic achievement (Duckworth & Seligman, 2005; Tangney et al., 2004). Self-control is also critical to one's ability to delay immediate gratification (Gillebaart, 2018), and multiple meta-analyses find that low self-control is associated with delinquency and other problem behaviors (de Ridder et al., 2011; Vazsonyi et al., 2017).

Like sleep and delinquency, self-control may also be impacted by ACEs. Indeed, many studies have found impulsivity (Cicchetti & Curtis, 2005; Narvaez et al., 2012; Pears & Fisher, 2005) and impaired emotion regulation skills (Kim & Cicchetti, 2010; Peh et al., 2017; Titelius et al., 2018) to be developmental sequelae of

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exposure to childhood adversity. Neurobiological studies also confirm exposure to ACEs alters stress–response systems (Sinha, 2008, 2009) and impairs neurocognitive functioning (Fava et al., 2019; Jaffee & Maikovich-Fong, 2011; Nemeroff, 2004). Yet, despite evidence of direct associations between ACEs and self-control, and self-control and delinquency, few studies consider whether self-control mediates that association. One exception is a longitudinal study combining both quantitative and neurological imaging data (Fava et al., 2019) that supports a pathway from ACEs to externalizing behavior via lower functioning in the anterior cingulate cortex. A second exception is a cross-sectional study, which found low self-control partially mediated the association between childhood trauma and delinquency (Pechorro et al., 2021).

Current study

Current knowledge about how ACEs impact delinquency is largely driven by cross-sectional research. Further, no previous studies have tested associations between ACEs, sleep problems in childhood, low self-control in early adolescence, and delinquency in late adolescence in one longitudinal model. Based on the reviewed literature, these development stages may represent sensitive periods for the different phenomenon in question; that is, middle to late childhood is an especially important time to assess and address sleep problems, early adolescence presents a time of malleability in self-control capacity, and late adolescence precedes adulthood wherein consequences for delinquent activities have a considerably higher cost. Testing multiple mediators at the same time helps reduce the risk of excluding important factors comprising the mechanistic process of an association (Preacher & Hayes, 2008). Further, such an analysis could elucidate avenues for intervention, thereby providing multiple opportunities to intervene during childhood and early adolescence to prevent youth from starting on trajectories of serious delinquency and later adult offending. To this end, the current study builds upon previous research by testing a longitudinal, serial mediation model. Specifically, we examined associations between cumulative ACEs (≤age 11 years), sleep problems (ages 9–11 years), low self-control (ages 12–14 years), and adolescent delinquency (ages 15–17 years). Exposure to more ACEs was expected to predict more sleep problems in childhood, which in turn would predict less self-control in early adolescence, which would then predict greater involvement in delinquency in late adolescence.

Method

Participants

Participants were 480 adolescents (71.3% boys; 86.3% White) from the Michigan Longitudinal Study (MLS; Zucker et al., 1996; Zucker et al., 2000) with available delinquency data during late adolescence. The MLS is an ongoing prospective, multi-wave study utilizing population-based methods for recruitment. The highest risk portion of the sample was ascertained by identifying all fathers in a circumscribed geographic area with drunk driving charges who met criteria for an alcohol use disorder (AUD). High-risk families (32.4%) were composed of the convicted fathers, their son, and the son's biological mother. Additional families were recruited from the same neighborhoods as these families. Families with a parent who met criteria for an AUD diagnosis but had no substance use related conviction were considered moderate-risk families (34.2%). Families that did not include a parent who met criteria for an AUD diagnosis were considered low risk (33.4%). For a full explanation of the sample and study procedures, see Zucker et al. (1996, 2000). Participants included in the current analyses did not differ significantly from the full sample ($N = 1252$) on biological sex, race, income, sleep problems, low self-control, or delinquency. Given that female siblings and non-White families were included in later waves of the MLS, only a subsample of data included complete information for the constructs of interest in the current study. Participants in the current sample had a slightly greater number of reported ACEs ($M = 4.62$; $F\ (1,\ 500) = 24.17$, $p < .001$) compared to the those with available ACE data in the full sample.

Procedure

Parents and children completed assessments following initial recruitment (i.e., Wave 1, aged 3–5 years) with subsequent assessments occurring at 3-year intervals (e.g., Wave 2, aged 6–8 years). Adolescents completed self-report measures concerning their delinquent behavior, while parents reported on childhood sleep problems, low self-control, and ACEs. This multi-informant approach helps limit concerns regarding shared method variance.

Ethical considerations

Informed consent and assent were obtained from parents and adolescents, respectively. The Institutional Review Board where this study was conducted approved the procedures.

Measures

ACEs

Consistent with prior work (Fava et al., 2019), a measure of ACEs during childhood (≤11; i.e., data across Waves 1–3) was used based on a combination of items across several questionnaires. Sample items include: not being able to pay bills, lacking clean clothes, applying for welfare or unemployment, domestic violence, sexual abuse, physical abuse, death of a sibling, parent incarceration, bullying, and parental AUD. In total, 21 items were aggregated to derive a measure of ACEs (skewness = 0.14, kurtosis = −0.51). Although the internal consistency was modest (Cronbach's $\alpha = 0.61$), the cumulative approach to measuring ACEs has received psychometric support (Bethell et al., 2017) and the reliability aligns with prior work (e.g., Whitaker et al., 2014). All items were dichotomized to reflect whether the event occurred (1 = *yes*, 0 = *no*). If an item was endorsed at multiple time points, the event was still coded as 1 (i.e., possible max value = 21), similar to prior research (e.g., Finkelhor et al., 2015; Hussong et al., 2008).

Sleep problems

Problematic sleep was assessed at Wave 3 (ages 9–11)[1] using the mean of six items based on caregiver reports from the Child Behavior Checklist (CBCL; Achenbach & Edelbrock, 1991): has nightmares, overtired without good reason, sleeps less than other kids, sleeps more than most kids, talks/walks in sleep, and trouble sleeping. This measure is consistent with prior work (Becker et al., 2015) except that the bedwetting item was omitted given a low correlation with the other six items. Items on the CBCL are rated on a 3-point Likert scale (0 = *not true* to 2 = *very true or often true*). Problematic sleep was normally distributed (skewness = 1.88, kurtosis = 4.21). Internal consistency was modest (Cronbach's $\alpha = 0.54$), yet consistent with recent research (Hambrick et al., 2018).

[1]To ensure correct temporal ordering between ACEs and sleep problems, we excluded cases from analyses where there was overlap in the reporting of these two constructs among individual participants. This is described in greater detail in the data analytic plan section.

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Low self-control

Low self-control was assessed at Wave 4 (ages 12–14 years) using the mean of 16 CBCL caregiver-reported items consistent with prior work (Hay & Forrest, 2006). Such items include: "My child throws temper tantrums or has a hot temper," "My child cannot concentrate or pay attention for long," and "My child is impulsive or acts without thinking." Items are rated on a 3-point Likert scale (0 = *not true* to 2 = *very true or often true*). The scale was normally distributed (skewness = 1.37, kurtosis = 2.68) and internal consistency was good (Cronbach's α = 0.87). Similar indexes of self-control have been used in previous research (e.g., Hay & Forrest, 2006; Meldrum et al., 2015; Raffaelli et al., 2005; Willems et al., 2018; Zucker et al., 1996) and when compared to measures of self-control/impulsivity drawn from the Weinberger Adjustment Inventory, substantively identical results were found (Meldrum et al., 2015).

Delinquency

Delinquency was assessed at Wave 5 (ages 15–17) using a sum of 24 items from the Antisocial Behavior Checklist-Adolescent version (ASB-R, Adol; Zucker & Noll, 1980; Zucker, 2005). Adolescents self-reported how often they engaged in 24 behaviors (e.g., shoplifting, fighting with others, and weapon carrying) in the last 3 years using a 4-point Likert scale (0 = *never*; *0 times in the last 3 years* to 3 = *often*; *10 or more times during the last 3 years*). Skew was not excessive (skew = 1.81, kurtosis = 3.67)[2] and internal consistency was good (Cronbach's α = 0.85).

Demographic characteristics

All models controlled for biological sex (0 = *boys*, 1 = *girls*), race (0 = *non-White*, 1 = *White*), and household income. Average household income was determined across biological parent reports (1 = *under $4,000* to 11 = *over $100,000*).

Data analytic plan

A serial mediation model was tested using the PROCESS macro for SAS v9.4. Of primary interest for the analysis was the indirect effect of sleep problems and low self-control on the association between ACEs and delinquency.[3] The model was analyzed with ACEs prior to the age of 11 years predicting sleep problems (aged 9–11 years), low self-control (aged 12–14 years), and delinquency (aged 15–17 years), controlling for biological sex, race, and household income. Sleep problems were included as a predictor of low self-control and delinquency. Lastly, low self-control was included as a predictor of delinquency. An advantage of using a longitudinal design is temporal precedence across the mediators and outcome (Kraemer et al., 2008). Accordingly, we took methodological precautions to ensure temporal precedence within our sample. Out of a potential 502 participants, we identified 22 for whom an ACE was reported at approximately the same time or slightly after sleep problems were assessed (i.e., between the ages of 9 and 11 years where there was overlap between Waves 1 and 3), presenting a potential issue for causal ordering. Therefore, we excluded these 22 participants from the current analyses. Thus, on an individual level, each participant's report of sleep problems occurred after the measured ACEs. However, for the sample as a whole, the reporting period for ACEs and sleep problems retains some overlap: ≤11 years old and 9–11 years old, respectively. The PROCESS macro provides a rigorous assessment of indirect effects. That is, indirect effects with bootstrapped confidence intervals (CIs) are estimated for simple mediation (ACEs sleep problems delinquency; ACEs low self-control delinquency) and serial mediation (ACEs sleep problems low self-control delinquency). Futhermore, statistical tests comparing each of the simple mediation effects to each other and the full serial mediation effects are provided for a total of three contrasts.

Results

Table 1 provides the descriptive statistics and correlations for all study variables. ACEs were positively correlated with sleep problems ($r = .10$, $p < .05$), low self-control ($r = .35$, $p < .001$), and delinquency ($r = .22$, $p < .001$). In addition, sleep problems were positively correlated with low self-control ($r = .34$, $p < .001$), but not with delinquency ($r = .00$, $p > .05$). Lastly, low self-control was positively correlated with delinquency ($r = .25$, $p < .001$).

The serial mediation model accounted for approximately 11% of the variance in adolescent delinquency (Table 2 and Figure 1). Pertinent to our hypotheses, there was evidence for a significant positive association between ACEs and sleep problems ($b = 0.0093$, $p < .05$). There was also evidence for a significant positive direct effect of ACEs on low self-control ($b = 0.0334$, $p < .001$) and delinquency ($b = 0.0104$, $p < .01$). In turn, there was evidence for significant positive associations between sleep problems and low self-control ($b = 0.4167$, $p < .001$) and low self-control and delinquency ($b = 0.1460$, $p < .001$). Greater family income was also negatively associated with both low self-control ($b = -0.0134$, $p < .05$) and delinquency ($b = -0.0093$, $p < .05$). Thus, consistent with study hypotheses, more ACEs predicted more sleep problems in childhood, which in turned predicted less self-control in early adolescence, which then predicted greater involvement in delinquency in late adolescence.

Also consistent with our hypotheses, there was support for serial mediation whereby the association between ACEs and delinquency in late adolescence was mediated by sleep problems and low self-control (indirect effect = 0.0006, 95% CI 0.0001–0.0013). There was also support for simple mediation, whereby a significant indirect effect of ACEs on delinquency via *only* low self-control (indirect effect = 0.0049, 95% CI 0.0023–0.0080) was observed. The indirect effect for the simple mediation of ACEs on delinquency via *only* sleep problems, however, was not statistically significant (indirect effect = −0.0007, 95% CI −0.0021–0.0001). Contrasts between the indirect effects across the simple mediation models versus the serial mediation model indicated that the indirect effect of the serial mediation significantly differed from the indirect effect of the simple mediation via sleep problems (indirect effect = −0.0013, 95% CI −0.0031 to −0.0001), as well as the indirect effect of the simple mediation via low self-control (indirect effect = 0.0043, 95% CI 0.0019–0.0073). That is, the specific indirect effect inclusive of *both* mediators (sleep problems and low self-control) was statistically different and more robust than the other specific indirect effects inclusive of only *one* of the two mediators. Thus, consistent with study hypotheses, findings indicate that childhood ACEs predict greater delinquency in late adolescence, and greater childhood sleep problems and early adolescent low self-control represent potential mechanisms across development linking these constructs.

[2]The model was also estimated with a square root transformation for delinquency. Importantly, the serial mediation effects were still significant.

[3]Given that siblings were included in the sample, a model was also estimated that included only the original target child. Results were substantively the same, including support for serial mediation. Thus, estimates using the entire sample are provided.

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Table 1. Means, standard deviations, and correlations of study variables

	Mean	SD	Range	1	2	3	4	5	6	7
1. Biological sex[a]	0.29	0.46	0–1	–	− 0.03	− 0.02	**− 0.18*****	− 0.07	**− 0.14****	**− 0.09***
2. Race[b]	0.86	0.34	0–1		–	**0.34*****	**0.16*****	0.04	0.01	− 0.03
3. Income	7.97	2.01	1–11			–	**− 0.14****	0.07	**− 0.12****	**− 0.16*****
4. ACEs	4.63	2.50	0–12				–	**0.10***	**0.35*****	**0.22*****
5. Sleep problems	0.14	0.21	0–1.33					–	**0.34*****	0.00
6. Low self-control	0.31	0.28	0–1.69						–	**0.25*****
7. Delinquency	0.17	0.19	0–1.13							–

Note. $N = 480$; [a]0 = boys, 1 = girls; [b]0 = non-White, 1 = White; ACEs = adverse childhood experiences; bold = statistically significant values. *$p < .05$; **$p < 0.01$; ***$p < 0.001$.

Table 2. Regression coefficients, standard errors, and summary information of serial mediation model predicting delinquency

	Sleep Problems (M_1)			Low Self-Control (M_2)			Delinquency (Y)		
	Coefficient	*SE*	*p*	Coefficient	*SE*	*p*	Coefficient	*SE*	*p*
Constant	0.0384	0.0473	0.4169	**0.2290**	**0.0563**	**0.0001**	**0.1731**	**0.0417**	**0.0000**
Biological sex	−0.0211	0.0215	0.3257	−0.0393	0.0256	0.1248	−0.0206	0.0187	0.2704
Race	−0.0073	0.0303	0.8092	−0.0161	0.0360	0.6549	−0.0113	0.0263	0.6673
Income	0.0091	0.0052	0.0782	**−0.0134**	**0.0062**	**0.0303**	**−0.0093**	**0.0045**	**0.0412**
ACEs	**0.0093**	**0.0040**	**0.0219**	**0.0334**	**0.0048**	**0.0000**	**0.0104**	**0.0037**	**0.0051**
Sleep problems	–	–	–	**0.4167**	**0.0546**	**0.0000**	−0.0797	0.0422	0.0591
Low self-control	–	–	–	–	–	–	**0.1460**	**0.0335**	**0.0000**
	$R^2 = 0.0201$			$R^2 = 0.2295$			$R^2 = 0.1061$		
	F (4, 475) = 2.4364, $p = 0.0464$			F (5, 474) = 28.2443, $p = 0.0000$			F (6, 473) = 9.3483, $p = 0.0000$		

Note. $N = 480$; ACEs = adverse childhood experiences; bold = statistically significant values.

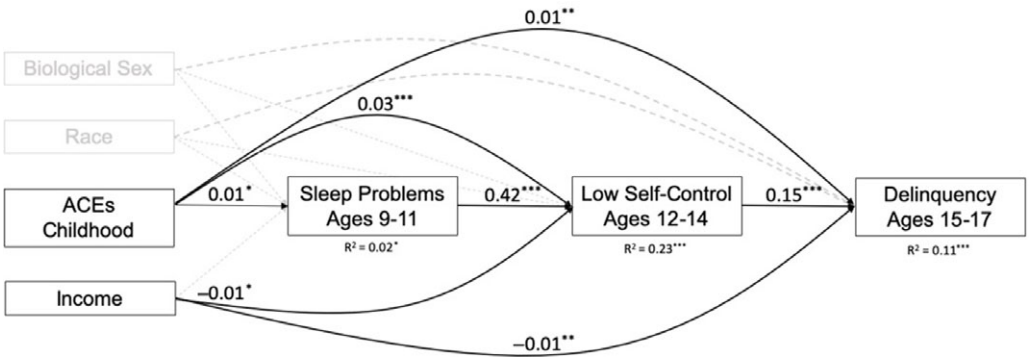

Figure 1. We remind readers that even though for the sample as a whole there is overlap in the window of reporting on ACEs and sleep problems, at the individual case level we ensured reports of ACEs always preceded the measure of sleep problems. Black lines represent statistically significant effects, whereas gray dashed lines represent nonsignificant effects. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. *Note.* ACEs = adverse childhood experiences.

Discussion

The aim of this study was to bridge multiple lines of research to provide a more complete understanding of the processes through which ACEs relate to later delinquency by focusing on the intervening roles of sleep problems in childhood and low self-control in early adolescence. While prior research (e.g., Hambrick et al., 2018; Meldrum et al., 2019) provides relevant preliminary evidence supporting the mediating role of these factors, that evidence is based on cross-sectional data. Findings from the current longitudinal serial mediation analysis indicate that ACEs affect later delinquency indirectly through both sleep problems and low self-control. It is important to note that mediated effects were significant even when controlling for income and race, representing important correlates of sleep problems, executive functioning, and delinquency (Vazsonyi et al., 2018). Vazsonyi et al. (2018) posit that invariance across socioeconomic strata are indicative of similar neurobiological processes underlying pathways linking sleep, executive functioning, and later adjustment across individuals regardless of SES and race/ethnicity. Moreover, consistent with prior research, our findings support direct associations between (1) ACEs and sleep problems (Hambrick et al., 2018; Turner

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et al., 2020) and low self-control (Jones et al., 2021; Meldrum et al., 2019), (2) sleep problems and low self-control (Vazsonyi et al., 2018), (3) low self-control and delinquency (Vazsonyi et al., 2017), and (4) ACEs and delinquency (Hambrick et al., 2018; Perez et al., 2018).

These findings align with developmental models of psychopathology and delinquency, which emphasize cascading effects of childhood adversity (Dodge et al., 2009; Felitti et al., 1998). Namely, there are multiple intervening pathways through which ACEs are likely to increase involvement in delinquent behavior. While our model offers support for the central relevance of low self-control as a mediator (and sleep problems to a lesser extent), the residual association between ACEs and delinquency suggests that additional social, cognitive, and emotional processes are at work. Existing research provides some direction as to these other potential mediating factors that could be investigated in future research. For example, ACEs are associated with increased depressive symptoms (e.g., Lee et al., 2020) and a large body of research links negative emotions to involvement in delinquency (e.g., Manasse & Ganem, 2009; Ozkan et al., 2018). Given established links between sleep problems and depressive symptoms (Lovato & Gradisar, 2014), depressive symptomatology may explain some of the residual effect of ACEs on delinquency our models were unable to explain.

Additionally, the results of our analyses highlight multiple potential points for intervention regarding developmental precursors of delinquency. Programming aimed at reducing exposure to adversity and trauma is critical given the cascading effects observed herein. While some ACEs would be difficult to target (e.g., sexual abuse by a neighbor, exposure to extreme weather), many pertain to the home environment (e.g., physical neglect, emotional abuse) and are amenable to programming. For example, home visitation interventions like the Nurse-Family Partnership program have proven effective at reducing childhood exposure to abuse and neglect (Eckenrode et al., 2016; Olds, 2006, 2007). Additional interventions such as economic support to families, access to education and training in positive parenting practices, and quality childcare options may also prevent ACEs (Fortson et al., 2016).

Poor sleep in childhood also emerged as an important target for intervention. Given the observed association between sleep problems and low self-control, programming directed at increasing healthy sleep habits is relevant (Hatch et al., 2019). Broader level interventions, such as changes to school start times are another potential target to improve sleep among adolescents (Bowers & Moyer, 2017; Minges & Redeker, 2016), and some research suggests that this type of policy change may also improve self-control (Semenza et al., 2019). Furthermore, a wealth of evidence exists supporting programmatic efforts to improve self-control as a way to reduce involvement in delinquent behavior (Piquero et al., 2016). Neurofeedback (Rogel et al., 2020; Schauss et al., 2019; van der Kolk et al., 2016) may be one way to help adolescents increase their self-control. Rogel et al. (2020), for example, implemented neurofeedback with children, 6–13 years old, who had experienced chronic developmental trauma. These researchers observed significant decreases in posttraumatic stress disorder symptoms, internalizing problems, externalizing problems, and behavioral and emotional problems (Rogel et al., 2020).

Despite the many strengths of our analyses, certain limitations of the current study warrant discussion. First, measurement issues are relevant. Specifically, our measure of sleep included a 2-year time span. Developmentally, this important time from 10 to 12 years may mask some important nuances that are worth considering in future research by examining more discrete time periods between measurements. In addition, while used in prior research (Hambrick et al., 2018), the measurement quality of the indicator for sleep problems was less than desirable. This might explain, in part, why the association between ACEs and sleep problems was modest, considering that measurement error tends to attenuate the magnitude of associations (Cole & Preacher, 2014). Moreover, prior work has largely focused on cross-sectional associations between ACEs and sleep problems (e.g., Hambrick et al., 2018), which often result in larger effect sizes. It is possible that the use of more objective measures (e.g., actigraphy) or surveys specific to sleep problems (e.g., the Pediatric Sleep Questionnaire; Chervin et al., 2000) could result in larger effect sizes. Second, our measure of ACEs was cumulative, therefore we were not able to assess the differential impact of certain ACEs, specific mechanistic pathways, or commonalities between similar ACEs (McLaughlin & Sheridan, 2016). For example, it may be important to determine the unique influence of one adverse event (e.g., child maltreatment vs. witnessing domestic abuse) over another or if ACEs comprising a similar dimension of adversity (i.e., threat vs. deprivation) differentially influence the trajectory of development. Indeed, the Dimensional Model of Adversity and Psychopathology (DMAP; McLaughlin et al., 2014; Sheridan & McLaughlin, 2014) approach has shown utility in understanding developmental and neurological effects of ACEs, such that experiences of threat (e.g., sexual and physical abuse, medical trauma, violence) tend to affect emotion reactivity and regulation whereas experiences of deprivation (e.g., neglect, caregiver SU and mental illness) tend to affect cognition (Henry et al., 2021; McLaughlin et al., 2014; Sheridan et al., 2020). Nonetheless, a cumulative measure of ACEs is still a robust predictor of developmental outcomes (Bethell et al., 2017; Evans et al., 2013) and ultimately, the measurement approach taken to the experience of ACEs is likely goal dependent, in that differences in approaches will serve different research aims (Henry et al., 2021). Third, we were unable to account for genetic confounds. While Connolly et al. (2021) recently found that the association between sleep quality and later delinquency is robust to familial confounds, other research suggests that the association between ACEs and delinquency is partly accounted for by genetically driven factors (Connolly, 2019). Given this, replication of our findigs using genetically sensitive designs is warranted. Fourth, given the primary aims of the Michigan Longitudinal Study, the sampling strategy involved recruiting a portion of youth at increased risk of initiating substance use as reflected in fathers meeting criteria for an AUD. Given that parental AUD is considered an ACE, and AUD is strongly associated with greater risk for negative social (e.g., domestic violence) and legal (e.g., incarceration) consequences, findings may not generalize to a community sample. Finally, claims of causality cannot be made given the limited set of controls and the nonexperimental nature of the analysis.

Conclusion

Our findings build on previous research (Hambrick et al., 2018) and underscore the negative impact that ACEs can have on diverse domains of development during adolescence. Through our longitudinal model, we bridged multiple domains of influence through a developmental lens. We found evidence of a significant association between ACEs and adolescent delinquency, both direct and indirect through sleep problems in childhood and low self-control in early adolescence. Our findings also provide a more accurate and complete explanation of the association between ACEs and

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adolescent delinquency by considering both mechanisms in the same model than if we only considered one of these mechanisms in isolation. By accounting for multiple interrelated factors as we did herein, we can better understand the complex association between ACEs and problematic outcomes, thus informing prevention and intervention programming for youth.

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Conflicts of interest. None.

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