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Prospective association of screen time with binge-eating disorder among adolescents in the United States: The mediating role of depression

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Abstract

Objective: Screen time has been reported to be associated with binge-eating disorder (BED) among adolescents in the US; however, potential mediators remain unclear. This study aimed to evaluate depression symptoms as a mediator of the prospective association between screen time and BED.

Method: We utilized data from 9465 children (aged 9–11 years at baseline) from the Adolescent Brain Cognitive Development (ABCD) study (2016–2021). A generalized structural equation model was used to examine the prospective association between average daily screen time at baseline and BED at year 2, adjusting for baseline BED diagnosis, and other potential covariates (e.g., age, sex, and income). Mediation was examined using bias-corrected (BC) 95% confidence intervals for the indirect effect of baseline screen time on year 2 BED through depression symptoms (change from baseline to year 1).

Results: One hundred and one participants (42.7% male, 49.4% racial/ethnic minority) met the criteria for BED in year 2. Participants were 9.9 years of age on average at baseline, 51.3% identified as male, and 43.1% identified as a racial/ethnic minority. Adjusting for covariates, screen time was prospectively associated with BED

(OR = 1.09, 95% CI [1.03, 1.14], $p = .005$). Depression symptoms ($B = .19$, BC 95% CI [0.10, 0.28]) partially mediated (9.2%) the prospective association between screen time and BED.

Discussion: Among US adolescents, higher baseline screen time was prospectively associated with BED diagnosis at year 2, and this relationship was partially mediated by increased depression symptoms. Preventive approaches targeting high screen use may have utility for reducing BED risk among adolescents.

Public significance: Among U.S. adolescents, higher screen time was prospectively associated with the incidence of BED. This association was partially mediated by the change in depressive symptoms. Preventive approaches targeting high screen use may have utility for reducing BED risk among adolescents.

KEYWORDS
binge eating, depression, feeding and eating disorders, screen use, social media

1 | INTRODUCTION

In the last decade, rapid technological advances have led to an increase in digital screen use among adolescents. According to the 2023 US Surgeon General's Advisory, 95% of adolescents aged 13–17 years reported using social media platforms, with over 33% indicating they use social media "almost constantly" (Office of the Surgeon General, 2023). It was also reported that about 40% of children aged 8–12 years use social media (Office of the Surgeon General, 2023) in the U.S. This pattern of increasing screen time has raised concerns about its potential effects on mental and physical health among adolescents (Domingues-Montanari, 2017; Lissak, 2018).

Emerging work on adolescent mental health outcomes in relation to screen time has focused on numerous forms of psychopathology, including eating disorders (Fiechtner et al., 2018; Padín et al., 2021; Santos et al., 2023). Concurrent and prospective associations between excessive screen time and binge-eating disorder (BED) in particular have been reported previously in studies of U.S. adolescents, including by our group (Nagata et al., 2021) and others (Fiechtner et al., 2018; Kim & Mackert, 2022; Saul et al., 2022; Vizcaino et al., 2020). In contrast, research on potential psychological mediators of this association has been comparatively limited. For example, one longitudinal study of adolescents found that self-esteem was a significant mediating variable between screen time and eating-related symptoms (Livet et al., 2022), but this was not specific to BED. However, other theoretically salient clinical factors have yet to be explored in relation to BED. Depression symptoms represent one factor that may underlie the association between screen time and binge eating. Specifically, evidence suggests that higher screen time is associated with depression symptoms (Boers et al., 2019), likely due to a combination of social, psychological, and behavioral factors such as reduced social interactions, sleep disturbances, and physical inactivity (Boers et al., 2019; Li et al., 2022). Moreover, depression is one of the common co-occurring mental health concerns in individuals with BED (Araujo et al., 2010), and findings from prior research indicate that depression is a risk factor for BED onset (Wade, 2017). Among adolescents specifically, those with (versus without) depression symptoms are more likely to develop BED symptoms 12 months later (Kenny et al., 2022). Depression and negative affect, more broadly, also are implicated as precipitating factors in several conceptual models of binge eating and related behaviors, such as affect regulation theories and the dual pathway model (Weinbach et al., 2018). However, to our knowledge, no prospective studies have examined depression symptoms as a mediator of the association between screen time and BED onset in adolescents.

Our prior analyses using data from the Adolescent Brain Cognitive Development (ABCD) Study, a large, diverse national (U.S.) cohort of 9–10-year-olds followed prospectively, provide the foundation for the present study (Nagata, Smith-Russack, et al., 2023). At baseline, participants reported nearly 4 h of daily screen time (Nagata et al., 2022), and the prevalence of BED was 1.1% at the 1-year follow-up (Murray et al., 2022). Baseline screen time also was prospectively associated with BED at 1-year follow-up (Nagata et al., 2021). Furthermore, our findings indicated significant positive associations between food insecurity and adverse childhood experiences (ACEs) with BED (Chu et al., 2022; Nagata, Smith-Russack, et al., 2023). These two factors are also known to be linked to negative emotional, cognitive, and behavioral outcomes, including depression symptoms (Schilling et al., 2007; Zheng et al., 2021). Therefore, we considered these factors in the current study.

The ABCD study recruited participants aged 9–10 at baseline because it is the age of the transition from childhood to adolescence. This transition period includes significant changes in cognitive abilities, emotional regulation, and social skills. This age allows us to identify risk factors for mental and physical health outcomes. The diverse cohort provides insights into the interplay of genetic, environmental, and behavioral factors during early adolescence informing targeted interventions and preventive strategies. Therefore, the objectives of this investigation were to examine the prospective association of screen time with BED onset over 2 years in a diverse sample of U.S. adolescents and to determine if depression symptoms at the 1-year follow-up mediated that association. We selected these

intervals to assess the stability and consistency of cross-sectional findings over a longitudinal framework. This longitudinal approach allows us to not only confirm the initial cross-sectional results but also to observe the progression or variation over time, which is essential for drawing more reliable and insightful conclusions about the relationships among our study variables.

2 | METHOD

2.1 | Participants

The ABCD study, established in 2016–2018, is an ongoing longitudinal, epidemiological study of brain development and child health in the U.S. 11,875 children (aged 9–10 years) were recruited from 21 recruitment sites. Details about the ABCD Study participants, recruitment, protocol, and measures are reported elsewhere (Barch et al., 2018). The current study utilized data from baseline to year 2 of the ABCD study. We excluded those with missing data for screen time or covariates at baseline ($n = 1262$), depression symptoms at baseline and year 1 ($n = 534$), and BED diagnosis at year 2 ($n = 614$) (see Table A1 for a comparison of characteristics of included and excluded participants), with 9465 participants remaining for the current analyses.

Institutional review board approval was received from the University of California, San Diego, and the respective IRBs of each study site. Written assent and informed consent were obtained from participants and caregivers, respectively.

2.2 | Measures

2.2.1 | Screen time

Screen time was assessed using the ABCD Youth Screen Time Survey administered at baseline (2016–2018). The survey included 14 questions about the number of hours per weekday/weekend day they spent on six different screen modalities, including: viewing/streaming TV shows or movies, watching/streaming videos [e.g., YouTube], playing videogames, texting, video chatting [e.g., Skype, Facetime], and social media [e.g., Facebook, Instagram, Twitter]. Screen time for weekdays and weekends was calculated separately based on a previously validated measure (Bagot et al., 2018; Gray et al., 2020; Paulus et al., 2019). From these data, we calculated a weighted average to obtain participants' average daily screen time (Guerrero et al., 2019), using the following formula: [(weekday average × 5) + (weekend average × 2)]/7 (Guerrero et al., 2019). Weighted average screen time was reported as a continuous variable reflecting average daily screen time in hours. An examination of the concordance between self-reported screen time and screen time measured objectively using a passive-sensing smartphone app offers support for the validity of the self-report measure (i.e., a moderate correlation, $r = 0.49$; Wade et al., 2021).

2.2.2 | Binge-eating disorder

BED was assessed at baseline (2016–2018) and year 2 (2018–2021) using the Kiddie Schedule for Affective Disorders and Schizophrenia (KSADS-5) (Kaufman et al., 1997), which utilizes DSM-5 definitions to classify mental health concerns in children and adolescents (Sarmiento & Lau, 2020). Parents/caregivers completed a subset of KSADS-5 modules assessing the frequency, duration, and characteristics of their child's eating behaviors. Based on the KSADS-5 scoring system, responses to the relevant interview questions were used to diagnose BED consistent with DSM-5 criteria (Sarmiento & Lau, 2020). Overall, the KSADS has demonstrated good convergent validity with clinical rating scales of depressive and anxiety disorders (Townsend et al., 2020), and there is favorable concordance between parent and adolescent self-report for these mental health concerns (Townsend et al., 2020). However, validity data for BED specifically are lacking. While earlier studies with different measures have suggested low concordance between parent and child reports of binge eating (Tanofsky-Kraff et al., 2005; Townsend et al., 2020), it is important to note that parents play a crucial role as reporters for eating disorders in their children, given that youth may have limited insight into their eating behaviors.

2.2.3 | Change in depression symptoms

At baseline (2016–2018) and year 1 (2017–2019), parents/caregivers completed the Child-Behavior Checklist (CBCL) (Achenbach & Ruffle, 2000), responding to statements about their child's behavior using a scale from 0 (not true) to 2 (very true/often true). The questionnaire was based on the CBCL's DSM-Oriented Scales which consists of six scales developed to help practitioners in the differential diagnostic process, including depression symptoms (Achenbach & Ruffle, 2000). Change in depression symptom scores from baseline to year 1 were analyzed in the current study. The Child Behavior Checklist has high test–retest reliability (intraclass correlation coefficient [ICC] = .95), acceptable internal consistency (Taber, 2018) with alphas ranging from .63 to .79, and robust validity (all items showing significant discrimination at $p < .01$) (Achenbach & Rescorla, 2000). Confirmatory factor analysis results for the DSM-Oriented Scales indicate a good fit (comparative fit index [CFI] of .96 and root mean square error of approximation [RMSEA] of .045) (Hu & Bentler, 1999; Price et al., 2013).

2.2.4 | Covariates

Based on their theoretical relevance to the prospective relationship between screen time and BED (Chu et al., 2022; Nagata et al., 2021; Nagata, Chu, et al., 2023), the following baseline variables were included as covariates in the analyses: age (years), sex (female, male), race/ethnicity (White, Latino/Hispanic, Black, Asian, Native American, and other), household income (U.S. dollars, six categories: less than $25,000, $25,000 through $49,999, $50,000 through $74,999, $75,000 through $99,999, $100,000 through $199,999, and

$200,000 and greater), highest parental education (high school or less vs. college or more), food insecurity (food secure vs. food insecure), adverse childhood experiences (ACEs, number of ACEs), study site, BED diagnosis at baseline, and the date of BED diagnoses (pre-COVID (before March 13, 2020) and during COVID).

2.2.5 | Statistical analysis

Differences in baseline characteristics according to year 2 BED diagnosis were examined using Students' *t*-tests and chi-square tests. Generalized structural equation models with maximum likelihood estimation were used to assess prospective associations of average daily screen time at baseline and depression symptoms from baseline to year 1 with BED at year 2, adjusting for age, sex, race, household income, highest parental education, study site, BED diagnosis at baseline, date of BED diagnoses, food insecurity, and ACEs. The prospective association between baseline screen time and the change in depression symptoms from baseline to year 1 was also examined. The model was not adjusted for the covariates, as doing so may increase the variance of the natural direct effect (NDE) estimator and may either elevate or diminish the variance of the natural indirect effect (NIE) estimator (Diop et al., 2021). Furthermore, the change in depression symptoms was examined as a mediator of the association between baseline screen time and year 2 BED. A *p*-value of <.05 was considered to indicate statistical significance. We generated bias-corrected (BC) 95% CIs for the indirect effect using 5000 bootstrap samples and statistical significance was indicated if the CI values did not cross zero. Finally, we calculated the effect size for the association between screen time and the change in depression symptoms with BED using standardized values. Screen time and the change in depression symptoms were normalized by subtracting the means and dividing by the standard deviations before applying generalized structural equation models. Analyses were performed using Stata 18 (College Station, TX), and propensity weights based on the American Community Survey were applied (Heeringa et al., 2017).

3 | RESULTS

3.1 | Participant characteristics

A total of 9465 children aged 9–11 years at baseline were included in this study. Among them, 101 children met the criteria for BED in year 2 (see Table 1). Compared to adolescents without BED, those with BED had higher average daily screen time at baseline and higher change in depression symptoms from baseline to year 1 ($p < .001$; see Table 1).

3.2 | Prospective associations of screen time and depression symptoms with BED

Table 2 shows findings from unadjusted and adjusted models for the associations of average daily screen time at baseline and increased depression symptoms from baseline to year 1 with BED diagnosis at year 2. Adjusting for covariates, higher baseline screen time was significantly associated with a 9% increase in the odds of BED diagnosis at year 2 (OR = 1.09, 95% CI 1.03, 1.14, $p = .005$). Similarly, increased depression symptoms from baseline to year 1 were significantly associated with a 21% increase in the odds of BED diagnosis at year 2 (OR = 1.21, 95% CI 1.11, 1.32, $p < .001$) when adjusting for covariates.

3.3 | Prospective association of screen time with depression symptoms

Higher baseline screen time was significantly associated with increased depression symptoms from baseline to year 1 ($B = .04$, 95% CI .03, .05, $p < .001$).

3.4 | Mediation analysis

Adjusting for covariates, the results showed a significant indirect effect of screen time at baseline on BED at year 2 (OR = 1.01 (1.00, 1.01); $B(SE) = .008$ (.002); bias-corrected 95% CI .004, .014; $p < .001$). This suggests that increased depression symptoms partially mediated the relationship between baseline screen time and BED in year 2. However, there was also a significant direct effect between baseline screen time and BED at year 2 (OR = 1.09 (1.03, 1.14); $p = .005$), indicating that the association was not entirely explained by increasing screen time. This finding supports partial mediation, suggesting the presence of additional pathways in which screen time may influence BED.

The contribution of depression symptoms as a mediator of the association between screen time and BED was 9.2% (95% CI 1.9%, 16.5%, $p = .013$). Pathway estimates are shown in Figure 1.

4 | DISCUSSION

Consistent with our hypotheses, we found that a higher average daily screen time at baseline was prospectively associated with the incidence of BED 2 years later in a national sample of U.S. adolescents participating in the ABCD study. We also found that baseline screen time was associated with increased depression symptoms over 1 year and that increased depression symptoms from baseline to year 1 partially mediated the association between baseline screen time and year 2 BED incidence.

The current prospective findings on the incidence of BED at the two-year follow-up extend prior work showing a positive association between screen time and BED among adolescents (Fiechtner et al., 2018; Nagata et al., 2021). Moreover, replicating findings from prior studies, this investigation found that screen time was also prospectively associated with increased depression symptoms over 1 year (Boers et al., 2019; Li et al., 2022). However, different studies have

TABLE 1 Characteristics of participants with and without binge-eating disorder (BED) at year 2 follow-up in the Adolescent Brain Cognitive Development (ABCD) Study.

Sample size	Non-BED 9364	BED 101	Total 9465	*p*	Effect size
Age (baseline) (years), mean (*SD*)	9.9 (0.6)	9.9 (0.6)	9.9 (0.6)	.606	0.067
Sex (%)					
Female	48.6%	57.3%	48.7%	.095	0.019
Male	51.4%	42.7%	51.3%		
Parental education (baseline) (%)					
≥College	83.8%	78.8%	83.7%	.221	0.015
≤High school	16.2%	21.2%	16.3%		
Household income (baseline) (%)					
<25K	16.4%	28.4%	16.6%	.002	0.050
25 to <50K	19.5%	26.1%	19.5%		
50 to <75K	17.8%	19.0%	17.8%		
75 to <100K	14.5%	10.0%	14.5%		
100 to <200K	24.1%	14.5%	24.0%		
≥200K	7.7%	2.0%	7.6%		
Race/ethnicity (baseline) (%)					
White	56.9%	50.6%	56.9%	.291	0.036
Latino	17.7%	20.9%	17.7%		
Black	15.3%	21.2%	15.3%		
Asian	5.4%	-	5.4%		
Native American	3.0%	5.1%	3.0%		
Other	1.7%	2.2%	1.7%		
BED diagnosis (baseline) (%)					
Non-BED	99.6%	83.8%	99.4%	<.001	0.222
BED	0.4%	16.2%	0.6%		
Food insecurity (baseline) (%)					
Food secure	91.1%	83.2%	91.0%	.063	0.030
Food insecure	8.9%	16.8%	9.0%		
Date of BED diagnoses					
Pre-COVID	71.3%	58.5%	71.1	.048	0.031
During COVID	27.7%	41.5%	28.9		
ACEs (number of ACEs) (baseline), mean (*SD*)	1.9 (1.7)	2.7 (1.5)	1.9 (1.7)	<.001	0.586
Average daily screen time (baseline) (h), mean (*SD*)	3.9 (3.1)	5.4 (3.3)	3.9 (3.1)	<.001	0.482
Change in depression symptoms (baseline to year 1), mean (*SD*)	1.1 (1.5)	2.2 (2.0)	1.1 (1.5)	<.001	0.732

Note: Each continuous variable is reported as mean (standard deviation). Results based on Student's *t*-tests and Chi-square tests for continuous and categorical variables, respectively. Effect sizes were calculated as Cohen's *d* for continuous variables and Cramer's *V* for categorical variables.

yielded different results regarding the relationship between screen time and depression symptoms. While some have suggested a bidirectional relationship (Houghton et al., 2018), others have not found such a relationship (Fitzpatrick et al., 2023) or have reported that depression symptoms do not predict digital media use 4 years later (Engberg et al., 2022). The directionality of the association is crucial, with a stronger influence of screen time on depression symptoms than the reverse; notably, the use of newer forms of technology (such as smartphone use) exhibits a more robust association compared to older forms (such as watching television) (Tang et al., 2021). The current results contribute to the broader literature regarding negative mental and physical health outcomes associated with screen time in adolescents (Boers et al., 2019; Twenge et al., 2019).

Perhaps most notably, we found that increased depression symptoms partially mediated the prospective association between screen time and BED. This finding is consistent with a prior study that found

TABLE 2 Associations of baseline average daily screen time and change in depression symptom scores (baseline to year 1) with year 2 binge-eating disorder (BED) in the Adolescent Brain Cognitive Development (ABCD) study.

	Unadjusted			Adjusted[a]			
Variables	*B* (95% CI)	OR (95% CI)	*p*	*B* (95% CI)	OR (95% CI)	Effect size[b] (standardized coefficient)	*p*
Average daily screen time (baseline)	0.10 (0.05, 0.15)	1.31 (1.20, 1.42)	<.001	0.08 (0.031, 0.14)	1.09 (1.03, 1.14)	0.213	.005
Change in depression symptoms (baseline to year 1)	0.27 (0.18, 0.35)	1.30 (1.20, 1.42)	<.001	0.19 (0.10, 0.28)	1.21 (1.11, 1.32)	0.453	<.001

[a]Adjusted for baseline age, sex, race, household income, parent education, BED diagnosis, food insecurity, ACEs, and date of BED diagnosis.
[b]The standardized coefficient was computed by subtracting the mean from each variable and then dividing the result by the standard deviations (*SD*) before applying generalized structured equation models.

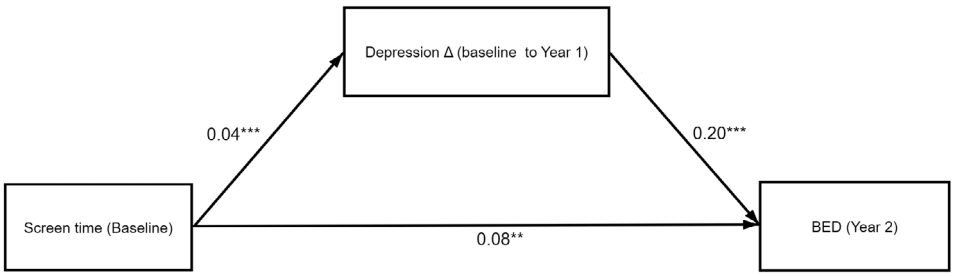

FIGURE 1 The indirect effect of baseline average daily screen time on year 2 binge-eating disorder (BED) through the change in depression symptoms from baseline to year 1. We provide estimated coefficients for the adjusted structural equation models. **p* < .05; ***p* < .01; ****p* < .001.

that depression was a significant mediating factor in the relationship between social media use and overall disordered eating symptoms (as reflected by the Eating Attitudes Test-26 total score) in adolescents (Ghergut et al., 2022). Higher screen time may contribute to increased depression symptoms through several interpersonal (e.g., less social interactions, lower social support) and behavioral (e.g., poor sleep quality, less physical activity) factors (Boers et al., 2019; Li et al., 2022). Furthermore, screen time on social media may contribute to lowering self-esteem and increased depression symptoms in adolescents via upward social comparisons (i.e., comparing themselves to others who have more favorable social positions) (Li et al., 2022). Although not examined here, the role of social media screen time may be particularly relevant to eating disorders like BED, given potential impacts on other known risk factors such as body dissatisfaction and dietary restraint.

The prospective link between the increased depression symptoms and BED found in this study is consistent with several theories of binge-eating risk/maintenance. For example, both affect regulation theory and escape theory (Heatherton & Baumeister, 1991) conceptualize binge eating as functioning to reduce the experience/awareness of aversive affective states (Gross, 2015; Spoor et al., 2006). Further, individuals with lower self-esteem and negative body image are at an increased risk of engaging in binge eating. Cognitive and emotional reactions following exposure to media or advertising featuring unrealistic body ideals could exacerbate the risk for binge-eating and eating disorders more broadly (Kenny et al., 2022). Moreover, findings from ecological momentary assessment studies evaluating real-time affect in relation to subsequent binge eating have also shown that increases in negative affect commonly precipitate binge-eating episodes (Haedt-Matt & Keel, 2011), and that negative affect mediates the relationship between stressful events and binge eating (Goldschmidt et al., 2014). However, increased depression symptoms were only found to be a partial mediator of the relationship between screen time and BED in the current investigation, indicating that screen time may have a direct effect on BED onset among adolescents, and/or other factors may mediate this association. A possible explanation for the direct effect of screen time on BED is that adolescents are more susceptible to various forms of disinhibited eating when distracted by screens, even in the absence of hunger (Fiechtner et al., 2018; Kim et al., 2020). Additionally, the habit of binge-watching content may contribute to overconsumption and a lack of control, similar to patterns observed in binge-eating behaviors (Flayelle et al., 2019; Vizcaino et al., 2020). There is a need for additional research to identify other potential mediators that contribute to this association.

The current study added to the existing literature by elucidating potential mechanisms involved in the onset of BED and highlighting modifiable risk factors like screen time. These findings may offer clinical and public health implications as adolescents could benefit from interventions aimed at reducing excessive screen time and thus mitigating associated mental health issues, such as depression symptoms. It also revealed a partial mediating effect; targeting screen use can improve other related symptoms (e.g., depressive symptoms) too.

4.1 | Strengths and limitations

This study had several strengths. First, the prospective data allowed us to test the temporal associations of the variables in the proposed mediation model. Second, by controlling for baseline BED diagnosis,

the focus of the analyses was on the incidence of BED, strengthening the ability to derive clinically meaningful implications. Third, data was collected from a large, diverse, population-based sample of U.S. adolescents, supporting the generalizability of the findings to U.S. adolescent populations. However, there were also limitations. First, screen time was self-reported by adolescents, and thus subject to potential self-report bias. Second, depression symptom and BED diagnosis variables were based on parent reports, and findings may be different from those based on adolescent-reported measures. Parents are important reporters of eating disorders in younger children given that youth may have less insight and more limited recollection regarding their eating behaviors (Barch et al., 2018; Braet et al., 2007). However, this may lead to lower concordance between parent and child reports of binge eating (Bartholdy et al., 2017; Tanofsky-Kraff et al., 2005). Third, the available data lacked details regarding the content of screen time, including content that may be particularly salient to BED risk (e.g., body image-related); therefore, future research examining specific content-based screen time in relation to BED risk is recommended. Fourth, the number of participants who met the criteria for BED in this study was relatively small ($n = 101$). Among them, only 49.4% were non-white, which resulted in inadequate sample sizes to compare across racial/ethnic groups. Future studies with a more diverse sample of youth with BED are needed, as other important factors (e.g., discrimination, acculturative stress) among racial/ethnic groups may be salient to BED risk and the associations examined here (Raney et al., 2023). Further, the content of screen time (e.g., social media, TV, etc.) may differentially relate to binge eating across groups.

5 | CONCLUSION

In this national longitudinal study of U.S. adolescents, we found that higher screen time was prospectively associated with increased depression symptoms and increased incidence of BED and that the association between screen time and BED incidence was partially mediated by increased depression symptoms. These findings suggest that approaches to reducing excessive screen time among adolescents may have benefits in terms of reducing depression and BED risk. Such interventions may focus on educating parents and adolescents about the negative mental and physical health impacts of excessive screen time. Healthcare providers may consider screening for screen time, depression symptoms, and binge eating among adolescents. Finally, given that increased depression symptoms not only partially mediated the association between screen time and BED, but also emerged as a strong predictor of BED, future research should explore other theoretically relevant psychosocial and behavioral variables that may also underlie the association between screen time and BED in adolescents.

AUTHOR CONTRIBUTIONS

Abubakr A. A. Al-shoaibi: Conceptualization; formal analysis; writing – original draft; writing – review and editing. **Iris Yuefan Shao:** Writing – review and editing. **Kyle T. Ganson:** Writing – review and editing. **Jason Matthew Lavender:** Writing – review and editing. **Alexander Testa:** Writing – review and editing. **Orsolya Kiss:** Writing – review and editing. **Jinbo He:** Writing – review and editing. **David Glidden:** Writing – review and editing. **Fiona C. Baker:** Conceptualization; data curation; methodology; writing – review and editing. **Jason Ming-Hung Nagata:** Conceptualization; formal analysis; supervision; writing – original draft; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts to disclose.

DATA AVAILABILITY STATEMENT

Data used in the preparation of this article were obtained from the ABCD Study (https://abcdstudy.org), held in the NIMH Data Archive (NDA). Investigators can apply for data access through the NDA (https://nda.nih.gov/).

ETHICS APPROVAL

The University of California, San Diego (UCSD) provided centralized institutional review board (IRB) approval and each participating site received local IRB approval.

CONSENT TO PARTICIPATE

Written informed consent was obtained from the parents/caregivers of adolescents, and written assent was obtained from adolescents.

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REFERENCES

Achenbach, T., & Rescorla, L. (2000). *Manual for the ASEBA preschool forms and profiles*. Research Center for Children, Youth, & Families.

Achenbach, T. M., & Ruffle, T. M. (2000). The child behavior checklist and related forms for assessing behavioral/emotional problems and competencies. *Pediatrics in Review*, *21*(8), 265–271. https://doi.org/10.1542/pir.21.8.265

Araujo, D. M. R., Santos, G. F. D. S., & Nardi, A. E. (2010). Binge eating disorder and depression: A systematic review. *The World Journal of*

Biological Psychiatry, *11*(2), 199–207. https://doi.org/10.3109/15622970802563171

Bagot, K. S., Matthews, S. A., Mason, M., Squeglia, L. M., Fowler, J., Gray, K., Herting, M., May, A., Colrain, I., Godino, J., Tapert, S., Brown, S., & Patrick, K. (2018). Current, future and potential use of mobile and wearable technologies and social media data in the ABCD study to increase understanding of contributors to child health. *Developmental Cognitive Neuroscience*, *32*, 121–129. https://doi.org/10.1016/j.dcn.2018.03.008

Barch, D. M., Albaugh, M. D., Avenevoli, S., Chang, L., Clark, D. B., Glantz, M. D., Hudziak, J. J., Jernigan, T. L., Tapert, S. F., Yurgelun-Todd, D., Alia-Klein, N., Potter, A. S., Paulus, M. P., Prouty, D., Zucker, R. A., & Sher, K. J. (2018). Demographic, physical and mental health assessments in the adolescent brain and cognitive development study: Rationale and description. *Developmental Cognitive Neuroscience*, *32*, 55–66. https://doi.org/10.1016/j.dcn.2017.10.010

Bartholdy, S., Allen, K., Hodsoll, J., O'Daly, O. G., Campbell, I. C., Banaschewski, T., Bokde, A. L. W., Bromberg, U., Büchel, C., Quinlan, E. B., Conrod, P. J., Desrivières, S., Flor, H., Frouin, V., Gallinat, J., Garavan, H., Heinz, A., Ittermann, B., Martinot, J. L., … Schmidt, U. (2017). Identifying disordered eating behaviours in adolescents: How do parentand adolescent reports differ by sex and age? *European Child and Adolescent Psychiatry*, *26*(6), 691–701. https://doi.org/10.1007/s00787-016-0935-1

Braet, C., Soetens, B., Moens, E., Mels, S., Goossens, L., & Van Vlierberghe, L. (2007). Are two informants better than one? Parent–child agreement on the eating styles of children who are overweight. *European Eating Disorders Review*, *15*(6), 410–417. https://doi.org/10.1002/erv.798

Boers, E., Afzali, M. H., Newton, N., & Conrod, P. (2019). Association of screen time and depression in adolescence. *JAMA Pediatrics*, *173*(9), 853–859. https://doi.org/10.1001/jamapediatrics.2019.1759

Chu, J., Raney, J. H., Ganson, K. T., Wu, K., Rupanagunta, A., Testa, A., Jackson, D. B., Murray, S. B., & Nagata, J. M. (2022). Adverse childhood experiences and binge-eating disorder in early adolescents. *Journal of Eating Disorders*, *10*(1), 168. https://doi.org/10.1186/s40337-022-00682-y

Diop, A., Lefebvre, G., Duchaine, C. S., Laurin, D., & Talbot, D. (2021). The impact of adjusting for pure predictors of exposure, mediator, and outcome on the variance of natural direct and indirect effect estimators. *Statistics in Medicine*, *40*(10), 2339–2354. https://doi.org/10.1002/sim.8906

Domingues-Montanari, S. (2017). Clinical and psychological effects of excessive screen time on children: Effects of screen time on children. *Journal of Paediatrics and Child Health*, *53*(4), 333–338. https://doi.org/10.1111/jpc.13462

Engberg, E., Hietajärvi, L., Maksniemi, E., Lahti, J., Lonka, K., Salmela-Aro, K., & Viljakainen, H. (2022). The longitudinal associations between mental health indicators and digital media use and physical activity during adolescence: A latent class approach. *Mental Health and Physical Activity*, *22*, 100448. https://doi.org/10.1016/j.mhpa.2022.100448

Fiechtner, L., Fonte, M. L., Castro, I., Gerber, M., Horan, C., Sharifi, M., Cena, H., & Taveras, E. M. (2018). Determinants of binge eating symptoms in children with overweight/obesity. *Childhood Obesity*, *14*(8), 510–517. https://doi.org/10.1089/chi.2017.0311

Fitzpatrick, C., Lemieux, A., Smith, J., West, G. L., Bohbot, V., & Asbridge, M. (2023). Is adolescent internet use a risk factor for the development of depression symptoms or vice-versa? *Psychological Medicine*, *53*(14), 6773–6779. https://doi.org/10.1017/S0033291723000284

Flayelle, M., Canale, N., Vögele, C., Karila, L., Maurage, P., & Billieux, J. (2019). Assessing binge-watching behaviors: Development and validation of the "watching TV series motives" and "binge-watching engagement and symptoms" questionnaires. *Computers in Human Behavior*, *90*, 26–36. https://doi.org/10.1016/j.chb.2018.08.022

Ghergut, A., Maftei, A., & Grigore, A. (2022). The light and the dark side of social media use: Depression, anxiety, and eating attitudes among adolescents. *Psihologija*, *55*(3), 269–296. https://doi.org/10.2298/PSI210516001G

Goldschmidt, A. B., Wonderlich, S. A., Crosby, R. D., Engel, S. G., Lavender, J. M., Peterson, C. B., Crow, S. J., Cao, L., & Mitchell, J. E. (2014). Ecological momentary assessment of stressful events and negative affect in bulimia nervosa. *Journal of Consulting and Clinical Psychology*, *82*(1), 30–39. https://doi.org/10.1037/a0034974

Gray, J. C., Schvey, N. A., & Tanofsky-Kraff, M. (2020). Demographic, psychological, behavioral, and cognitive correlates of BMI in youth: Findings from the Adolescent Brain Cognitive Development (ABCD) study. *Psychological Medicine*, *50*(9), 1539–1547. https://doi.org/10.1017/S0033291719001545

Gross, J. J. (Ed.). (2015). *Handbook of emotion regulation* (2nd ed.). The Guilford Press.

Guerrero, M. D., Barnes, J. D., Chaput, J.-P., & Tremblay, M. S. (2019). Screen time and problem behaviors in children: Exploring the mediating role of sleep duration. *International Journal of Behavioral Nutrition and Physical Activity*, *16*(1), 105. https://doi.org/10.1186/s12966-019-0862-x

Haedt-Matt, A. A., & Keel, P. K. (2011). Revisiting the affect regulation model of binge eating: A meta-analysis of studies using ecological momentary assessment. *Psychological Bulletin*, *137*(4), 660–681. https://doi.org/10.1037/a0023660

Heatherton, T. F., & Baumeister, R. F. (1991). Binge eating as escape from self-awareness. *Psychological Bulletin*, *110*(1), 86–108. https://doi.org/10.1037/0033-2909.110.1.86

Heeringa, S., West, B. T., & Berglund, P. A. (2017). *Applied survey data analysis* (2nd ed.). CRC Press, Taylor & Francis Group.

Houghton, S., Lawrence, D., Hunter, S. C., Rosenberg, M., Zadow, C., Wood, L., & Shilton, T. (2018). Reciprocal relationships between trajectories of depressive symptoms and screen media use during adolescence. *Journal of Youth and Adolescence*, *47*(11), 2453–2467. https://doi.org/10.1007/s10964-018-0901-y

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Kaufman, J., Birmaher, B., Brent, D., Rao, U., Flynn, C., Moreci, P., Williamson, D., & Ryan, N. (1997). Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL): Initial reliability and validity data. *Journal of the American Academy of Child & Adolescent Psychiatry*, *36*(7), 980–988. https://doi.org/10.1097/00004583-199707000-00021

Kenny, B., Fuller-Tyszkiewicz, M., Moodie, M., Brown, V., & Williams, J. (2022). Bi-directional associations between depressive symptoms and eating disorder symptoms in early adolescence. *Body Image*, *42*, 246–256. https://doi.org/10.1016/j.bodyim.2022.06.012

Kim, S., Favotto, L., Halladay, J., Wang, L., Boyle, M. H., & Georgiades, K. (2020). Differential associations between passive and active forms of screen time and adolescent mood and anxiety disorders. *Social Psychiatry and Psychiatric Epidemiology*, *55*(11), 1469–1478. https://doi.org/10.1007/s00127-020-01833-9

Kim, B. R., & Mackert, M. (2022). Social media use and binge eating: An integrative review. *Public Health Nursing*, *39*(5), 1134–1141. https://doi.org/10.1111/phn.13069

Li, L., Zhang, Q., Zhu, L., Zeng, G., Huang, H., Zhuge, J., Kuang, X., Yang, S., Yang, D., Chen, Z., Gan, Y., Lu, Z., & Wu, C. (2022). Screen time and depression risk: A meta-analysis of cohort studies. *Frontiers in Psychiatry*, *13*, 1058572. https://doi.org/10.3389/fpsyt.2022.1058572

Lissak, G. (2018). Adverse physiological and psychological effects of screen time on children and adolescents: Literature review and case study. *Environmental Research*, *164*, 149–157. https://doi.org/10.1016/j.envres.2018.01.015

Livet, A., Boers, E., Laroque, F., Afzali, M. H., McVey, G., & Conrod, P. J. (2022). Pathways from adolescent screen time to eating related symptoms: A multilevel longitudinal mediation analysis through self-esteem.

Psychology & Health, *1–16*, 1–16. https://doi.org/10.1080/08870446.2022.2141239

Murray, S. B., Ganson, K. T., Chu, J., Jann, K., & Nagata, J. M. (2022). The prevalence of preadolescent eating disorders in the United States. *Journal of Adolescent Health*, *70*(5), 825–828. https://doi.org/10.1016/j.jadohealth.2021.11.031

Nagata, J. M., Chu, J., Cervantez, L., Ganson, K. T., Testa, A., Jackson, D. B., Murray, S. B., & Weiser, S. D. (2023). Food insecurity and binge-eating disorder in early adolescence. *International Journal of Eating Disorders*, *56*(6), 1233–1239. https://doi.org/10.1002/eat.23944

Nagata, J. M., Ganson, K. T., Iyer, P., Chu, J., Baker, F. C., Gabriel, K. P., Garber, A. K., Murray, S. B., & Bibbins-Domingo, K. (2022). Sociodemographic correlates of contemporary screen time use among 9–10-year-old children. *The Journal of Pediatrics*, *240*, 213–220.e2. https://doi.org/10.1016/J.JPEDS.2021.08.077

Nagata, J. M., Iyer, P., Chu, J., Baker, F. C., Pettee Gabriel, K., Garber, A. K., Murray, S. B., Bibbins-Domingo, K., & Ganson, K. T. (2021). Contemporary screen time modalities among children 9–10 years old and binge-eating disorder at one-year follow-up: A prospective cohort study. *International Journal of Eating Disorders*, *54*(5), 887–892. https://doi.org/10.1002/eat.23489

Nagata, J. M., Smith-Russack, Z., Paul, A., Saldana, G. A., Shao, I. Y., Al-Shoaibi, A. A. A., Chaphekar, A. V., Downey, A. E., He, J., Murray, S. B., Baker, F. C., & Ganson, K. T. (2023). The social epidemiology of binge-eating disorder and behaviors in early adolescents. *Journal of Eating Disorders*, *11*(1), 182. https://doi.org/10.1186/s40337-023-00904-x

Office of the Surgeon General. (2023). *Office of the Surgeon General. Social Media and Youth Mental Health: The U.S. Surgeon General's Advisory*. *U. S*. Department of Health and Human Services (HHS). Retrieved July 21, 2023, from. https://www.hhs.gov/sites/default/files/sg-youth-mental-health-social-media-advisory.pdf

Padín, P. F., González-Rodríguez, R., Verde-Diego, C., & Vázquez-Pérez, R. (2021). Social media and eating disorder psychopathology: A systematic review. *Cyberpsychology: Journal of Psychosocial Research on Cyberspace*, *15*(3), 6. https://doi.org/10.5817/CP2021-3-6

Paulus, M. P., Squeglia, L. M., Bagot, K., Jacobus, J., Kuplicki, R., Breslin, F. J., Bodurka, J., Morris, A. S., Thompson, W. K., Bartsch, H., & Tapert, S. F. (2019). Screen media activity and brain structure in youth: Evidence for diverse structural correlation networks from the ABCD study. *NeuroImage*, *185*, 140–153. https://doi.org/10.1016/j.neuroimage.2018.10.040

Price, M., Higa-McMillan, C., Ebesutani, C., Okamura, K., Nakamura, B. J., Chorpita, B. F., & Weisz, J. (2013). Symptom differentiation of anxiety and depression across youth development and clinic-referred/nonreferred samples: An examination of competing factor structures of the child behavior checklist DSM-oriented scales. *Development and Psychopathology*, *25*(4pt1), 1005–1015. https://doi.org/10.1017/S0954579413000333

Raney, J. H., Al-Shoaibi, A. A., Shao, I. Y., Ganson, K. T., Testa, A., Jackson, D. B., He, J., Glidden, D. V., & Nagata, J. M. (2023). Racial discrimination is associated with binge-eating disorder in early adolescents: A cross-sectional analysis. *Journal of Eating Disorders*, *11*(1), 139. https://doi.org/10.1186/s40337-023-00866-0

Santos, R. M. S., Mendes, C. G., Sen Bressani, G. Y., De Alcantara Ventura, S., De Almeida Nogueira, Y. J., De Miranda, D. M., & Romano-Silva, M. A. (2023). The associations between screen time and mental health in adolescents: A systematic review. *BMC Psychology*, *11*(1), 127. https://doi.org/10.1186/s40359-023-01166-7

Sarmiento, C., & Lau, C. (2020). Diagnostic and statistical manual of mental disorders, 5th ed.: DSM-5. In B. J. Carducci, C. S. Nave, & C. S. Nave (Eds.), *The Wiley encyclopedia of personality and individual differences* (1st ed., pp. 125–129). Wiley. https://doi.org/10.1002/9781118970843.ch198

Saul, J., Rodgers, R. F., & Saul, M. (2022). Adolescent eating disorder risk and the social online world. *Child and Adolescent Psychiatric Clinics of North America*, *31*(1), 167–177. https://doi.org/10.1016/j.chc.2021.09.004

Schilling, E. A., Aseltine, R. H., & Gore, S. (2007). Adverse childhood experiences and mental health in young adults: A longitudinal survey. *BMC Public Health*, *7*(1), 30. https://doi.org/10.1186/1471-2458-7-30

Spoor, S. T. P., Stice, E., Bekker, M. H. J., Van Strien, T., Croon, M. A., & Van Heck, G. L. (2006). Relations between dietary restraint, depressive symptoms, and binge eating: A longitudinal study. *International Journal of Eating Disorders*, *39*(8), 700–707. https://doi.org/10.1002/eat.20283

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, *48*(6), 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Tang, S., Werner-Seidler, A., Torok, M., Mackinnon, A. J., & Christensen, H. (2021). The relationship between screen time and mental health in young people: A systematic review of longitudinal studies. *Clinical Psychology Review*, *86*, 102021. https://doi.org/10.1016/j.cpr.2021.102021

Tanofsky-Kraff, M., Yanovski, S. Z., & Yanovski, J. A. (2005). Comparison of child interview and parent reports of children's eating disordered behaviors. *Eating Behaviors*, *6*(1), 95–99. https://doi.org/10.1016/j.eatbeh.2004.03.001

Townsend, L., Kobak, K., Kearney, C., Milham, M., Andreotti, C., Escalera, J., Alexander, L., Gill, M. K., Birmaher, B., Sylvester, R., Rice, D., Deep, A., & Kaufman, J. (2020). Development of three web-based computerized versions of the kiddie schedule for affective disorders and schizophrenia child psychiatric diagnostic interview: Preliminary validity data. *Journal of the American Academy of Child & Adolescent Psychiatry*, *59*(2), 309–325. https://doi.org/10.1016/j.jaac.2019.05.009

Twenge, J. M., Spitzberg, B. H., & Campbell, W. K. (2019). Less in-person social interaction with peers among U.S. adolescents in the 21st century and links to loneliness. *Journal of Social and Personal Relationships*, *36*(6), 1892–1913. https://doi.org/10.1177/0265407519836170

Vizcaino, M., Buman, M., DesRoches, T., & Wharton, C. (2020). From TVs to tablets: The relation between device-specific screen time and health-related behaviors and characteristics. *BMC Public Health*, *20*(1), 1295. https://doi.org/10.1186/s12889-020-09410-0

Wade, T. (2017). *Encyclopedia of feeding and eating disorders*. Springer.

Wade, N. E., Ortigara, J. M., Sullivan, R. M., Tomko, R. L., Breslin, F. J., Baker, F. C., Fuemmeler, B. F., Delrahim Howlett, K., Lisdahl, K. M., Marshall, A. T., Mason, M. J., Neale, M. C., Squeglia, L. M., Wolff-Hughes, D. L., Tapert, S. F., Bagot, K. S., & ABCD Novel Technologies Workgroup. (2021). Passive sensing of Preteens' smartphone use: An Adolescent Brain Cognitive Development (ABCD) cohort substudy. *JMIR Mental Health*, *8*(10), e29426. https://doi.org/10.2196/29426

Weinbach, N., Sher, H., & Bohon, C. (2018). Differences in emotion regulation difficulties across types of eating disorders during adolescence. *Journal of Abnormal Child Psychology*, *46*(6), 1351–1358. https://doi.org/10.1007/s10802-017-0365-7

Zheng, S., Ngo, A. L., Forman, M. R., Barcellos, A. L., Liao, L., Ferrara, A., & Zhu, Y. (2021). Associations of household food insufficiency with childhood depression and anxiety: A nationwide cross-sectional study in the USA. *BMJ Open*, *11*(9), e054263. https://doi.org/10.1136/bmjopen-2021-054263

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APPENDIX A

TABLE A1 Comparison of characteristics between included and excluded participants.

Sociodemographic characteristics	Included ($n = 9465$)	Excluded ($n = 2410$)	p
Age	9.9 (.63)	9.9 (.60)	.933
Sex (%)			
Female	48.6%	49.2%	.733
Male	51.4%	50.8%	
Race/ethnicity (%)			
White	56.9%	35.0%	<.001
Latino/Hispanic	17.7%	28.0%	
Black	15.3%	24.2%	
Asian	5.4%	5.8%	
Native American	3.0%	3.7%	
Other	1.7%	3.3%	
Household income (%)			
$24,999 or less	16.6%	33.7%	<.001
$25,000 to $49,999	19.6%	23.6%	
$50,000 to $74,999	17.8%	15.4%	
$75,000 to $99,999	14.5%	7.9%	
$100,000 to $199,999	23.9%	14.1%	
$200,000 and greater	7.6%	5.3%	
Parent's highest education			
College education or more	83.7%	35.1%	<.001
High school education or less	16.3%	64.9%	
BED diagnosis (baseline) (%)			
Non-BED	99.4%	99.2%	<.549
BED	.6%	.8%	
Food insecurity (baseline) (%)			
Food secure	91.0%	88.0%	.005
Food insecure	9.0%	12.0%	
Average daily screen time (baseline) (h), mean (*SD*)	3.9 (3.1)	4.4 (3.2)	<.001
ACEs (number of ACEs) (baseline), mean (*SD*)	1.9 (1.7)	1.8 (1.6)	.101
Change in depression symptoms (baseline to year 1), mean (*SD*)	1.7 (1.9)	1.6 (1.8)	.260

Note: ABCD propensity weights were applied based on the American Community Survey from the US Census.