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Early Adolescents' Wellbeing in the Digital Age: A Social Ecological Approach Based on the
Adolescent Brain Cognitive Development (ABCD) Study

THESIS

submitted in partial satisfaction of the requirements
for the degree of

MASTER OF ARTS

in Social Ecology

by

Jessica Maya Hernandez

Thesis Committee:
Professor Candice Odgers, Chair
Associate Professor Stephen Schueller
Assistant Professor Kristina Uban

2020

DEDICATION

To

my father, mother, grandmother and brother,
without your continued support throughout this journey I would not be
where I am today.

To my amazing mentors, colleagues, and friends, near and far,
I'm forever grateful to those who have helped me
persevere through the highs and lows.

To the youth of all walks of life from the current and future generations
who continue to inspire this work;
may the opportunities be endless, and your wellbeing remain prioritized.

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ABSTRACT OF THE THESIS

Early Adolescents' Wellbeing in the Digital Age: A Social Ecological Approach Based on the Adolescent Brain Cognitive Development (ABCD) Study

By

Jessica Maya Hernandez

Master of Arts in Social Ecology

University of California, Irvine, 2020

Professor Candice Odgers, Chair

Adolescents' rising depressive and anxiety symptoms paired with near constant use of mobile technologies, and more recently social media, has triggered concerns around this relation and synchronous trend. Yet, evidence has been limited to warrant causal effects and most prior research has examined these factors in isolation. Given that multiple factors are likely to determine both adolescents' mental health and how they interface with technology ecosystems, there is a need for a broader understanding of how the interactions influence outcomes during this developmental period. This study utilizes data from a recent national sample of early adolescents (N = 11,875) to examine multilevel correlates of internalizing behaviors through the lens of the digital age. Analyses and interpretations are framed around a Social Ecological Framework (SEF) to evaluate and compare associations of factors across the tiered domains of the framework. These include individual factors (e.g. screen time, cognitive functioning), family factors (e.g. family conflict and parental monitoring), social factors (e.g. peer relationships), and community-level factors (e.g. neighborhood safety). Results indicate small positive associations between screen time and internalizing problem behaviors among early adolescents, yet social ecological factors such as family conflict, and neighborhood safety yielding stronger associations with internalizing

behaviors. Adolescent sex and racial/ethnic difference also pose an important role in the association between screen time and mental health. The findings suggest that multiple social ecological factors beyond technology use may influence internalizing behaviors to a greater extent during early adolescence.

Keywords: Early adolescence, internalizing behaviors, screen time, social ecological framework

INTRODUCTION

1.1. Background

Adolescence is a period in human development involving complex physical, cognitive, and social changes. Over the past century, the industrialization of modern societies has developed and integrated technologies at an exponential rate and adolescents are among the largest adopters of these tools (Rideout and Robb, 2019; Twenge, Martin, and Spitzberg, 2019). Recent advances in mobile technologies have allowed for a novel approach to social connectedness and productivity, which the current generations of youth do not know a life without. While rapid integration of technologies has amplified many aspects of development through opportunities for equitable access to education (Ito et al., 2013) and social connectedness (Allen et al., 2014; Rideout and Fox, 2018), there is a co-occurring phenomenon in the rise of mental health problems in youth, specifically throughout the period of adolescence. Recent findings distinguish decreases in externalizing behaviors (e.g. substance use and conduct disorders) and increases in internalizing behaviors (e.g. depression and anxiety) (Bose et al., 2018; Mojtabai and Olfson, 2020) among adolescents, which warrants further focus on the rise in problematic internalizing behaviors.

As the use of mobile technologies and social media platforms becomes ubiquitous among adolescents, researchers have examined the co-occurring link between the rise in technology use, or more commonly known as *screen time*, and associations of depressive and anxiety symptoms. This has caused alarm to the research, parent, and youth communities due to frequent citing of troubling correlations between the increases in screen time, depression, and anxiety (Twenge, 2020; Masih and Rajkumar, 2019; Haidt and Allen, 2020). Among the studies that have shown positive associations between screen time and mental health problems (Kircaburun et al., 2018; Lemola, Perkinson-Gloor, Brand, Dewald-Kaufmann, and Grob, 2015; McBride, 2017; Sampasa-

Kanyinga and Lewis, 2015; Stiglic and Viner, 2019; Twenge and Campbell, 2018; Twenge, Martin, and Campbell, 2018), broader reviews of the literature reveal inconsistencies among the results and relatively small effect sizes yielding statistical implications (Orben and Przybylski, 2019; Odgers and Jensen, 2020; Best, Manktelow, and Taylor, 2014). An important finding to note are demographic differences, such as age, race, and ethnicity, among prevalence rates of depression and suicide. Specifically, as suicidal behaviors increase across all adolescents, prevalence rates among girls have been increasing at a steeper rate compared to boys (Twenge et al., 2018; Twenge, 2020). Adolescent girls from marginalized and underrepresented groups also present with increasing rates of related internalizing mental health problems (Sapiro and Ward, 2019; Office of Minority Health, 2019). In parallel to these findings, adolescent girls are also more likely to report greater time spent online, specifically African American girls (Jackson et al., 2009), yet correlational differences between subgroups of adolescents do not yield strong evidence for the direct cause for poor mental health outcomes and perhaps reveal potential opportunities (Odgers, 2018).

To better understand the unique influence of screen time on mental health which deviates from a traditional “one-size-fits-all” model, social and relational factors that have been previously cited as predictors of mental health among adolescence (Mazza et al., 2009), compounded with various other ecological risk factors during this developmental period should be analyzed in a singular model to identify the multilevel interactions. Taking an approach which pulls from the previously found risk factors of internalizing behaviors among adolescents into a domain-based model can allow for an interpretation of the associations between factors that are more proximal and distal to supporting adolescent’s wellbeing and will create a better understanding of how technology use will have an impact across ecologies critical for development.

The Social Ecological Framework (SEF) is an interdependent model which holds from the basis of systems theory indicating that one domain will affect another and has been recently applied to systems affected by the digital age (Stokols, 2018). Traditionally, these domains include *individual, interpersonal, institutional, community* and *policy* factors and are nested within the individual with varying degrees of proximity to the individual. The SEF derives from Bronfenbrenner's ecological systems theory of human development and emphasizes the importance of understanding young individual outcomes through the interactions of the various individual and environmental ecologies surrounding a developing child (Bronfenbrenner, 1981). Ecological and contextual factors are important considerations in adolescent socioemotional development and health (Viner et al., 2012; Lynch and Cicchetti, 1998) and may be key to a better understanding of the risk and resiliency factors around behavioral outcomes. Moreover, early adolescence is a unique period of transition from childhood and a period of development that is understudied when looking at technological risks and affordances on mental health. The transitional period is paired with dynamic social and relational changes across adolescent's surrounding ecologies (e.g. family, school, community), and the digital ecology is no exception. The SEF offers to capture these associations in a comprehensive manner incorporating the digital environment.

Individual Level Factors. Research has focused on metrics of technology use frequency, or screen time, which often show comparable relations to related (e.g. academic achievement, family stability etc.) and unrelated factors (e.g. eating potatoes) of mental health outcome measures (Orben and Przybylski, 2019). Screen time is also often used to cumulatively capture consumption of the diverse and rapidly changing technology ecosystems, such as television, videos, text messaging, and of most recent popularity, social media. It is important to understand the differing effects mixed digital media has during adolescence as technology continues to rapidly evolve.

Currently, little evidence supports or is able to inform direct causal effects that increased screen time on mental wellbeing in adolescents (Odgers and Jensen, 2020). Prior research shows correlations between cognitive functioning and internet addiction behaviors in adolescents (Park et al., 2011), yet due to the limitations around sample representation and study design of many internet addiction research studies, interpretation of directionality still seems limited (Kuss and Lopez-Fernandez, 2016). The use of social media platforms as the most arguably popular form of digital media among current adolescents (Pew Research Center, 2018) has underscored a complex relation to mental health such that the mixed findings in the literature calls for further investigation (Best et al., 2014, Orben and Przybylski, 2019). More recently, factors related to adolescent wellbeing have been shown to overlap between offline and online risks (Przybylski and Bowes, 2017), therefore disentangling the causal relations and reciprocal association still pose a challenge. On an individual level, traditional risk factors for problematic internalizing behaviors may be translated to the online environments but the magnitude of negative influence that adolescent's digital ecology has is still largely unknown.

Family Level Factors. Family relationships are critical throughout development and evolve during adolescence. The parent-adolescent relationship is especially dynamic as adolescents seek greater autonomy, and parents often feel loss of control (Branje, 2018). The *displacement hypothesis* posits youth are increasingly replacing time normally spent interacting face-to-face with family with time spent with digital media (Van den Bulck and Van den Bergh, 2000), thus amplifying the changing dynamics of parental monitoring with diverse online environments. Moreover, research has also shown family stability has also been a factor shown to contribute to the mental health of early adolescents, where greater conflict among the home environment elevates stress levels and long term internalizing behavioral effects have been found (Gaertner, Fite, and Colder, 2010). Familial risk factors of mental health problems have also been linked to

decreases in parental engagement therefore poorer mental health outcomes in adolescence into adulthood and should be considered within this domain (Van Loon et al., 2013; Chilcoat et al., 1996).

Social Level Factors Beyond the family context, peers become an important support system and critical for socioemotional learning during adolescence (Gaertner, Fite, and Colder, 2010). Peer relationships in school environments are an integral part of the transitions from middle, high, and post-secondary school trajectories which is often an indicator of wellbeing. Adolescents with strong peer relationships also tend to report fewer internalizing symptoms (Feldman, Rubenstein, and Rubin, 1988; Helsen, Vollenbergh, and Meeus, 2000) and stronger predictability of decreased internalizing symptoms with simultaneous family support (Young et al., 2005). As approximately 95% of adolescents now report having access to a mobile device (Pew Research Center, 2018), the *stimulation hypothesis* (Valkenburg and Peter, 2011) counters the displacement hypothesis and states that interpersonal interactions online in fact yield positive psychosocial and developmental effects. This becomes an important component to adolescent social development that must be considered to better understand the effects of the digital age on mental health outcomes.

Community Level Factors. The environment surrounding a child's primary residence and school remains an important predictor of adolescent wellbeing. Perceived neighborhood safety studies have shown associations with youth and family mental health outcomes (Minh et al., 2017; Meltzer et al., 2007; Aneshensel and Sucoff, 1996). Features of community and environmental factors such as early exposure to drugs and violence which also remains associated with problematic behaviors throughout adolescence and persisting into adulthood (Aneshensel and Sucoff, 1996; Chen, Storr, and Anthony, 2009; Chen, 2010). In the digital age, there is a sense of community in both online and offline spaces and similar risks of safety and violence can also be

mirrored in the digital ecological context. Potential protective factors of online communities and its interaction with the physical community present during adolescence may have effects on overall wellbeing and need to be further explored.

Across the SEF's broader domains, there are potential moderating effects that the ubiquitous use of technology has on developments, especially in a transitional period of early adolescence as screen time and mental health vulnerabilities simultaneously increase. Socioeconomic and cultural considerations across the interactions of these domains also remain understudied and less understood. The population of current adolescents in the U.S. are among the most diverse (Federal Interagency on Child and Family Statistics, 2018) and the interaction among digital media across these contexts may have differing effects on adolescent wellbeing. Minority children and adolescents are more likely to consume digital media than white youth counterparts (Rideout, Foehr, and Roberts, 2010) and are also more likely to live in households below the poverty line and in areas where there is less perceived neighborhood safety. Recent studies also reveal elevated prevalence rates of minority adolescents with depression, anxiety, and suicidality (Office of Minority Health, 2019; Thomas et al., 2011; Anderson and Mayes, 2010). These specific contexts must also be considered when understanding associations of these ecological factors on adolescent mental health in the age of constant connectedness through technology.

1.2. Present Study

Using the Social Ecological Framework to organize risk factor domains surrounding adolescent mental health outcomes in the digital age, this study will examine the pattern of associations across the multiple levels among a cohort of early adolescents in the United States gathered as a part of the Adolescent Brain Cognitive Development (ABCD) Study (Volkow et al., 2018; abcdstudy.org). The aims of this study are three-fold: (1) To evaluate the broader

associations between multiple measures of screen time and internalizing behaviors in early adolescence, (2) to compare the strength of the association between internalizing symptoms and other social ecological factors previously known to associate with poor mental health outcomes and, in doing so, put into context documented associations with screen time, and (3) to explore differences among adolescents who identify differently based on racial and ethnic status on the multi-level associations between on mental health symptoms and individual, family, school, and community factors in early adolescence. The hypotheses for the aims of this study are as follows:

H1a: Adolescents who are reported to have greater levels of internalizing behaviors using the Child Behavioral Checklist (CBCL; Achenbach, 2009) will also report greater screen time, and in particular greater reported use of Social Media. It is expected that this association will remain small, yet positive.

H1b: The positive association between screen time and internalizing behaviors will be stronger (moderated) among females than among males.

H2: Compared to adolescent screen time, factors previously indicative of poor mental health outcomes such as poor family dynamics, peer relationships, and neighborhood safety will demonstrate stronger associations with internalizing behaviors.

Exploratory: Stratifying by race and ethnicity, screen time frequency will vary across groups and will result in variation in its association to internalizing behaviors. It is expected that associations between other indicators of internalizing behaviors will also vary across racial and ethnic groups. More specifically, it is predicted that African American and Hispanic adolescents will report greater screen time, and in particular social media use, and will also show a stronger association to internalizing behaviors.

This study adds to the current understanding of associations between digital technology use and adolescents' mental health by: (1) capturing a recent cohort of adolescents embedded in the digital ecosystems and examining associations with their mental health, (2) using theoretically-based factors previously known to associate with internalizing behaviors and compare these associations to screen time to further characterize how adolescent screen time is associated with socioemotional development , and (3) explore differences among subgroups of adolescents to address further amplified or diminishing risks of using technology as a tool for development and support for a groups with greater vulnerabilities. This study extends prior heavily debated research findings surrounding the effects of digital technology on adolescent mental health by considering the complex interactions between the various ecologies that surround adolescents during this developmental period.

2. METHODS

2.1. Sample and Design

Participants of this study are enrolled in the longitudinal ABCD Study and the baseline deidentified data were retrieved through the National Institutes of Mental Health Data Archive (NDA) database (Data Release 2.0.1., accessed September 9, 2019). The ABCD study's epidemiological approach to recruitment allowed for a diverse cohort of early adolescents and at least one caregiver (N=11,875 parent-child dyads) across 22 catchment sites in the US (Volkow et al., 2018). Youth participants were ages 9-10 years old ($M = 9.91$, $SD = 0.62$) at the time of recruitment and completed the baseline protocol, which included multimodal measures of physical health, mental health, substance use, neuroimaging, biospecimen sampling, neurocognition, and cultural and environmental measures (Zucker et al., 2018; Barch et al., 2018; Uban et al., 2018).

A data use agreement and IRB protocol (HS# 2019-5203) at the University of California, Irvine has been set in place for the use of the de-identified dataset for this analysis. Variables relating to this present study have been selected *a priori* based on prior studies evaluating the multiple factors associated with internalizing problem behaviors in early adolescence (OSF, osf.io/5j7yt).

2.2. Measures

Individual Level

Internalizing Behaviors. The 118-item Child Behavioral Checklist (CBCL) (Achenbach, 2009) was administered to parents about their child's behavior. The subscale composite t-score of overall internalizing problem behaviors is reported and t-score of ≥ 64 is considered the clinical cutoff score for this measure.

Screen Time. Adolescent participants completed a screen time report on specific technology use on weekends and weekdays. Technology mediums were categorized into time spent watching TV, watching videos (e.g. YouTube), playing video games, texting, visiting social media, and video chatting (e.g. Skype, FaceTime, etc.). Responses ranged from "0 = None; .25 = < 30 minutes; 0.5 = 30 minutes; 1 = 1 hour; 2 = 2 hours; 3 = 3 hours; 4 = 4+ hours". Individual digital media type will be analyzed to characterize associations of social media use compared to other forms of media. A composite score was calculated using a sum score of screen time for weekdays and weekends separately and a combined weekly average across all screen media.

Cognitive Functioning. A neurocognitive assessment derived from the NIH toolbox was administered to adolescent participants. The composite cognition score includes fluid and crystallized intelligence measures. Fluid intelligence includes tests that measure problem solving and encoding novel episodic memories such as the Toolbox Pattern Comparison Processing Speed

Test, List Sorting working Memory Test, Picture Sequence Memory Test, Flanker Task, and Dimensional Change Card Sort Task. Crystallized intelligence tests adolescent's responses to abilities more dependent on experiences, education and culture, and cumulative verbal knowledge which are tested through the Toolbox Picture Vocabulary Task and Oral Reading Recognition Task (Akshoomoff et al., 2013).

Demographics. For the purposes of the present study, the term “parent” will capture all forms of caregivers of the adolescent in this study. Parents completed an extensive demographics survey adapted from the PhenX Toolkit (Hamilton et al., 2011; PhenX Toolkit, 2016). Variables for this study include child biological sex given at birth, child's race and ethnicity, and parental education.

Family Level

Family History of Mental Illness. Parents of adolescents completed a comprehensive family history assessment, which included history of mental health problems. For the purposes of this study analysis, the item “Has ANY blood relative of your child ever been to a doctor or a counselor about any emotional or mental problems, or problems with alcohol or drugs?” has been included to assess family history risk associated with adolescent's mental health outcomes.

Family Income. As a component of the parent demographic survey, family household income was reported by 91.5% of parents (missing $n = 1023$). This item asks, “What is your total combined household income for the past 12 months?” and was reported on a Likert scale from “1- Less than \$5,000” to “10 - \$200,000 and greater”. For the current study, the income reported was combined to yield three categories: (1) less than \$50,000, (2) between \$50,000 and \$100,000, and (3) greater than \$100,000.

Family Conflict and Dynamics. Adolescents reported on family conflict and general parental monitoring are measured using items of the Youth Family Environmental Scale (FES) (Moos and Moos, 1994) and a parental monitoring survey (Chilcoat and Anthony, 1996), respectively. The FES conflict subscale included items which highlights family dynamics in the context of conflict and respondents answered True or False. The Parental Monitoring survey highlights parent-adolescent relationships and aspects of parental involvement. Responses range from “1-Never” to “5-Always or Almost Always”. A sum score Family Conflict and mean score for Parental Monitoring were calculated.

Social Level

Peer Relationships. As part of a resiliency questionnaire, adolescents were asked about the quantity of friendships as a measure of social adjustment. Items included questions distinguishing friendship by sex and closeness, such as “How many friends that are boys/girls do you have?” and “How many CLOSE friends that are boys/girls do you have?”. A composite score of total number of friends and close friends, collapsing sex factors, were calculated and used for analyses.

Community Level

Neighborhood Environment. Parents reported on neighborhood safety and crime from a 3-item survey regarding their perception of their home neighborhood safety adapted from the PhenX toolkit (PhenX Toolkit, 2016; Echerverria et al., 2004; Mujahid et al., 2007). The items included in this measure evaluated walking safety, violence, and crime in the neighborhood of residence. A mean score was calculated, and lower scores indicate lower levels of neighborhood safety.

2.2. Statistical Analysis

Analyses were performed in R Version 3.6.2 (R Core Team, 2017) using RStudio (R Studio Team, 2020). Descriptive demographic statistics were assessed of internalizing problem behaviors and screen time across characteristics of child sex, racial and ethnic background, and family socioeconomic status. Bivariate Pearson product-moment correlations were then conducted to test the association of internalizing problem behaviors, screen time, and other factors previously known to be risk factors on the varying ecologies surrounding early adolescence on internalizing behavior outcomes. Multiple regression analyses were conducted to assess the strength of associations across the multilevel domains to compare to the effects of screen time. Dependency of data due to the merging across 22 catchment sites is accounted for using robust clustered standard errors to address heteroskedastic effects. The multiple regression model was also conducted with a moderator analysis by adolescent sex to address sex differences. Exploratory analyses were conducted to investigate associations within stratified groups of race/ethnicity levels. These analyses mirror the bivariate correlational and regression modeling described above.

3. RESULTS

3.1. Descriptive Statistics

Full Sample. The ACBD adolescent cohort consists of 47.8% females ($N = 5681$), with 52% identified as White, 20.3% Hispanic, 15% African American, 2.2% Asian, 9.1% Multiracial, and 1% Other (includes American Indian Alaska Native, Native Hawaiian Pacific Islander and others). While considerably ethnically and racially diverse, it is recommended to avoid labeling this study as a nationally representative sample of adolescents in the U.S. due to external limitations within study design including under-recruitment of rural families due to limited

research facilities and self-selection bias typically associated with participating in research (Compton, Dowling, & Garavan, 2019). Mean difference within demographic variables (e.g. family income, parental education, and race/ethnicity) can be seen in Table 1, which characterizes the variation of average internalizing behaviors and screen time among adolescents coming from varying levels of family income, race and ethnic backgrounds, and parental influence of the highest achieved educational level.

A bivariate zero-order correlation across the multi-level risk factors was conducted in Table 2. The correlations show the magnitude of associations across the social ecological factors to compare to internalizing behaviors and screen time. Results reveal that factors related to family history of mental illness ($r = 0.19$), family conflict ($r = 0.09$), parental monitoring ($r = -0.09$), and neighborhood safety ($r = -0.11$) have stronger correlations to internalizing behaviors compared to that of social media use (weekday $r = 0.00$; weekend $r = 0.02$) and cumulative screen time for weekdays ($r = 0.05$) and weekends ($r = 0.06$). Associations between internalizing behaviors and other specific screen time mediums (e.g. video games, texting, viewing video, video chatting, and TV) can be seen in Figure 1 and also reveals that overall social media use is not as strongly associated as other uses of screen time for this early adolescent cohort. To further characterize the use of social media, the data shows that the majority (83.8%) of the early adolescents of this study report *not* using social media at all. Due to age constraints of many social media platforms (ages 13+), this is not unexpected, yet it is worth noting given recent reports of high use of social media among younger youth (Rideout and Robb, 2019). When stratified by social media users (dummy coded “1”) and non-social media users (dummy code “0”), the associations with internalizing behaviors are non-significant within this early adolescent cohort (weekday $r = 0.00$, $p = 0.66$; weekend $r = -0.01$, $p = 0.19$). Among the adolescents who report at least some use of social media

(greater than 0 hours), associations between the frequency of weekday social media use and internalizing behaviors remains non-significant ($r = 0.02$, $n = 1900$) and the association with weekend social media use ($r = 0.07$, $n = 1954$) is weak but statistically significant (Figure 1 – “Social Media Users Only”). Further breakdown of screen time frequencies can be found in the Supplementary Table S1 to characterize use across all types of screens.

Sex-Based Differences. First, findings of this data reveal that there are significant sex differences in overall level of internalizing problem behaviors ($t = -9.87$, $p < 0.001$). Deviating from prior research indicating that youth females exhibit greater depressive and anxiety symptomatology compared to youth males (Twenge, 2020), this data shows early adolescent males exhibiting overall higher levels of internalizing behavior ($M = 49.4$, $SD = 10.7$) compared to the early adolescent females ($M = 47.4$, $SD = 10.5$). When examining the multilevel correlations separately based on sex (Figure 2), small yet significant associations across overall screen time for weekend ($r = 0.06$, $p < 0.001$) and weekday ($r = 0.08$, $p < 0.001$) among adolescent males, while for females these results are non-significant. Further expanding on the sex differences of across various screen types and frequency of use, association between internalizing behaviors and weekday social media use and video games yielded a non-significant finding in an interaction with adolescent sex. Yet significant sex differences arise in the association between frequency of television viewing on weekends [$F(3, 11832) = 41.0$, $p < 0.001$] and total weekend screen time [$F(3, 11817) = 47.0$, $p < 0.001$], where adolescent males show strongest positive association to frequency of weekend television viewing ($\beta = 0.07$, 95% CI = [0.03, 0.10], $p < 0.001$) and screen time ($\beta = 0.07$, 95% CI = [0.03, 0.10], $p < 0.001$) on internalizing behavior symptoms. Among the early adolescents who only report using social media (> 0 hours), results reveal that adolescent males show the strongest positive association to internalizing behaviors with increased use on

weekends ($r = 0.13, p < 0.001$), compared to girls who report greatest use during the weekday showing trends of a negative association to internalizing behaviors (Figure 3).

3.2. Multiple Regression Models

Three models were conducted to further address overall key associations between screen time and theoretically based risk factors for adolescent internalizing behaviors (Table 4). Model 1 ($N = 9483$) represents an unadjusted model with no covariates, while Model 2 ($N = 9450$) includes covariates of adolescent sex, age, race/ethnicity, and parental education in the regression model. Standardized coefficients, β , Model 1 reflect the results of the bivariate correlation, with standard errors of the models clustered to account for the non-independence of observations due to the fact that data were drawn from, and students were clustered within 22 study catchment sites. Within the restrictive model accounting for demographic covariates (Model 2), total weekend screen time remains significant ($\beta = 0.05, 95\% \text{ CI} = [0.02, 0.08], p = 0.01$) and find that weekday social media use and internalizing behaviors show small associations ($\beta = -0.02, 95\% \text{ CI} = [-0.05, 0.01], p = 0.03$). It is worth pointing out that the significant finding between internalizing behaviors and weekday social media use includes “0” within confidence intervals, which is a confound to these results. When removing the robust clustering of standard errors to account for study site, this association becomes non-significant. Family history of mental health issues ($\beta = 0.17, 95\% \text{ CI} = [0.15, 0.19], p < 0.001$) and family conflict ($\beta = 0.06, 95\% \text{ CI} = [0.04, 0.08], p < 0.001$) remains positively associated with internalizing behaviors with larger effect sizes compared to screen time, while parental monitoring behaviors ($\beta = -0.05, 95\% \text{ CI} = [-0.07, -0.03], p < 0.001$), family income levels ($\$50\text{K} - \$100\text{K}: \beta = -0.14, 95\% \text{ CI} = [-0.20, -0.08], p < 0.001$; $> \$100\text{K}: \beta = -0.24, 95\% \text{ CI} = [-0.30, -0.17], p < 0.001$), peer relationships ($\beta = -0.03, 95\% \text{ CI} = [-0.05, 0.00], p = 0.02$), and

neighborhood safety ($\beta = -0.11$, 95% CI = [-0.13, -0.08], $p < 0.001$) are negatively associated with internalizing behaviors. The results suggest that family, peer and neighborhood environment factors maintain significant relations to internalizing behaviors in a fully controlled model with a greater effect size compared to screen time.

To focus on the early adopters of social media use within this cohort of adolescents, Model 3 (Table 4) has been conducted ($N = 1297$) which reveals no significant associations to any screen time or social media use to internalizing behaviors, unlike those seen in Models 1 and 2. Model 3 shows that family factors such as history of mental health problems ($\beta = 0.19$, 95% CI = [0.14, 0.24], $p < 0.001$) and family conflict ($\beta = 0.07$, 95% CI = [0.01, 0.12], $p = 0.02$) remains a positive correlate to internalizing behaviors, and parental monitoring ($\beta = 0.07$, 95% CI = [-0.13, -0.02], $p = 0.03$), family socioeconomic status (\$50K -100K: $\beta = -0.25$, 95% CI = [-0.39, -0.10], $p < 0.001$; > \$100K: $\beta = -0.39$, 95% CI = [-0.56, -0.22], $p < 0.001$) and neighborhood safety ($\beta = -0.14$, 95% CI = [-0.19, -0.18], $p < 0.001$) maintain negative associations to adolescent internalizing behaviors.

Internalizing behavior indicators were also placed as interaction models by adolescent sex, which reveals significant moderating effects between internalizing behaviors and weekend screen time ($\beta = 0.08$, 95% CI = [0.01, 0.14], $p = 0.03$) which indicates stronger positive relations for adolescent males compared to females in a restrictive model accounting for demographic covariates of age, parent education, and race/ethnicity (Figure 4). This interaction effect becomes non-significant when looking among only adolescents who report frequency greater than 0 hours of social media use above and beyond the social ecological factors, consistent with the main effects for Model 3 of the original regression analysis. For full results of all main effects and interactions by adolescent sex in this regression model, please see Supplemental Table S2.

3.3. Exploratory Analyses

Race/Ethnicity Group Stratification. Exploratory analyses show significant mean differences between racial and ethnic groups on various measures of screen time. In Figure 5, findings show Black early adolescents spend the most time on screens (total weekday $M = 5.39$, $SD = 3.98$; total weekend $M = 6.77$, $SD = 4.70$), across all different screen types, with multiracial (total weekday $M = 3.64$, $SD = 3.20$; total weekend $M = 4.74$, $SD = 3.69$), and Hispanic (total weekday $M = 3.61$, $SD = 2.96$; total weekend $M = 4.72$, $SD = 3.48$), adolescents also reporting greater screen time use compared to White adolescent counterparts (total weekday $M = 2.85$, $SD = 2.57$; total weekend $M = 3.98$, $SD = 3.04$). The correlations in Figure 6 reveal that social media in particular is a positive correlate to internalizing behaviors among Asian adolescents (weekday $r = 0.14$; weekend $r = 0.18$), and reversely shows a negative association among adolescents who identify as Other racial groups (weekday $r = -0.03$; weekend $r = -0.06$), such as Native Hawaiian, American Indian, and others. It is to be noted the small sample size of adolescents identifying as Asian and of other racial background, therefore the interpretation of these results must be taken with caution.

Adjusted multiple regression models were conducted including covariates of adolescent sex, age and parental education across all stratified groups of race/ethnicity. Although reported screen time frequency across Black and Hispanic adolescents are heightened, we see non-significant associations to internalizing behaviors. Asian adolescents show positive significant association with weekend social media use ($\beta = 0.24$ 95% CI = 0.02, 0.46], $p < 0.001$) and negative association with weekday total screen time ($\beta = -0.27$, 95% CI = [-0.48, -0.06], $p = 0.03$), meanwhile multiracial adolescents show trends of significant negative association with weekday social media use ($\beta = -0.10$, 95% CI = -0.21, 0.02], $p = 0.01$) and positive association ($\beta = 0.11$,

95% CI = [-0.01, 0.22], $p = 0.04$) to weekend social media use to internalizing behavior symptoms. To address the mismatch of the p -values and confidence intervals among the multiracial adolescent subgroup, it is worth noting again that when not accounting for robust standard error clustering for study site, these findings become non-significant, which may be reasoning for these results. Also, smaller subsample sizes across the groups and should be taken into consideration when interpreting the results. Among adolescents who reported “Other”, the only significant indicator of internalizing behavior is family mental health history, where other variables across domains remain non-significant. Results of the regression models of each stratified group can be seen in Supplementary Table S3.

4. DISCUSSION

This current study examines whether adolescent mental health indicators are associated with screen time, with a focus on social media use, and how the size of these associations compares to social ecological factors with a stronger theoretical basis for effects on wellbeing. Although previous research message an alarming link between increased screen time and a decline in mental health among adolescents (Twenge, 2020), the ubiquity of screen-based tools for developing youth must be better understood in a broader context of risks and resilience to wellbeing. Researchers have addressed this through longitudinal study design (Odgers and Jensen, 2020) and rigorous statistical modeling (Orben and Przybylski, 2019), yet to my knowledge, this is the first study design to characterize the relation between screen time and internalizing behaviors in comparison to theoretically driven indicators of adolescent outcomes identified through a social ecological-based framework.

Overall, the results revealed the positive effect size to be small between overall weekend screen time across early adolescents, aligning with much of the prior work in this field. Social media in particular was not heavily endorsed being used by this particular cohort of early adolescents, and even when looking among those who do use social media, the results show null findings across its association to the adolescents' internalizing behaviors. Compared to indicators within social ecological framework on potential determinants of adolescent's internalizing behaviors, screen time shows a smaller magnitude of effect size compared to these other indicators, such as family history, family dynamics (e.g. conflict and monitoring), family income, peer relationships and neighborhood safety. This finding suggests that various other ecological factors influencing adolescent behavior remains a stronger correlate to internalizing behaviors in early adolescence and that looking across social ecological domains is important for understanding potential risks for developing future mental health problems.

Contrary to previous research on sex differences among adolescent internalizing behaviors and the hypothesis posed for the current study, in this cohort of early adolescents it is shown that males interestingly have a higher average reported internalizing behaviors. While accounting for the many potential indicators of internalizing symptoms during this time of development, results show that overall weekend screen time is more strongly associated with reported internalizing behaviors among males compared to females. This interaction effect does not hold true among the subset of adolescents in this cohort who report at least > 0 hours or more time using social media, which suggests there may be an effect of use case of these platforms and not necessarily the frequency of use. This is particularly interesting given the attention on elevated risks of internalizing problems and suicide surrounding girls especially during early adolescence and these findings may suggest there are mechanisms within early adolescent males' ecologies that must be

further investigated to better understand the higher trends in internalizing behaviors during this time in development.

Finally, this study explored the associations across all multi-domain indicators of internalizing behaviors and its comparison to screen time and social media use stratified by adolescent's race and ethnicity. While the research around racial and ethnic differences and intersectional risk factors among mental health factors and technology use remains under-investigated, this study was positioned to probe potential differences within this diverse cohort of adolescents. In alignment to prior research, Black adolescents use technology at the highest frequency, especially social media use, and similar trends shown among Hispanic and multiracial adolescents. Yet, when analyzing the associations to internalizing behaviors, Asian adolescents show a stronger positive association to screen time and social media use, in contrast to the non-significant associations among Black and Hispanic adolescents. Due to the nature of sampling in this study, this is not a nationally representative sample and is shown in the variation of sample sizes between groups. While it should be cautioned to make any firm interpretations from these results, this exploratory analysis highlights another gap in the literature about representation and potential unique effects of technology during this time of transition from childhood into adolescence across varying cultural backgrounds.

Limitations. There are several limitations of the current study worth highlighting. First, this is a cross-sectional analysis, therefore causal claims cannot be made. The results of this study are to be interpreted with bidirectional possibilities and relational inferences across the social ecological indicators of internalizing behaviors and the unique role that screen time plays in the intersecting ecologies during adolescence. Secondly, traditional social ecological frameworks include *institutional* factors, which may include details about the school environment which was

not included in this study. A more comprehensive look at the school and community ecologies such as school achievement and area zip code descriptives may provide context for the effects on internalizing behaviors and screen time. Third, the measures of screen time are quantitative by nature, and research has indicated that perhaps the quantity of time has become an unreliable measurement of the effects on mental health among youth (Odgers and Jensen, 2020; Orben, 2020). Due to the limitations of the measures that have already been set forth in the baseline measures of the study, further exploration on how adolescents are utilizing screen time (e.g. actively engaging in posts on social media versus passively scrolling through media) is not captured. Lastly, as mentioned previously, this is not a U.S. nationally representative sample, which limits the generalizability of results and analysis of the exploratory aim of this study must be interpreted with caution.

Future Directions. Despite these limitations, the implications of the current study afford opportunities for a better understanding of how constant use of screen-based technology among adolescents is associated with potential mental health indicators in various levels of proximity to the individual. As the ubiquitous use of these technology-based tools continue to unfold into a digital ecology integral to the development to all youth, contextual factors, both online and offline, must be considered when understanding mental health risks such as increases in problematic internalizing behaviors during the transition from childhood into adolescence. Next steps related to this study may include utilizing the longitudinal nature of the broader ABCD study design and looking across the developmental trajectories of participants, alongside with a more robust look into specifics around screen time and how adolescents report to use different screen mediums, especially social media. Expanding on more proximal indicators of mental health such as brain development by way of neuroimaging data and more distal indicators such as the school and

environmental contexts will allow for mechanistic approach into the effects of screen time, specifically social media, on the development throughout adolescence.

Another unique feature of this line of research is that it will be an especially important role of the continued investigation of this study in conjunction with the significant impacts that COVID-19 and social justice reform has posed on developing youth. Adolescence being the period of critical socioemotional learning, screen time has replaced much of the in-person interactions that have been traditionally seen as a key indicator of mental health and development. Early reports indicate that technology has provided social and educational support that may have otherwise been lost or severely hampered by the effects of the pandemic (Goldschmidt, 2020). While the risks remain high for internalizing behaviors during times of elevated stress and environmental changes, it has become increasingly evident that there are unique opportunities that technology and social media can have to elevate voices of youth and support their mental health, especially during a time of physical distancing and social justice reform. Increased efforts to appropriately represent the diversity of youth in the U.S. and focused understanding on the impacts of social media and other screen mediums to particular subgroups will allow for opportunities to create an inclusive and supportive digital ecosystem that will address the unique mental health and developmental needs of adolescents.

Conclusion. There are potential implications to policy and guidelines for youth, parents, educators, researchers and policymakers as we continue forwards in a digital society. Taking a social ecological-based approach to understanding adolescent mental health and the impacts that social media, and overall screen time, will be critical to informing and creating a more supportive digital ecosystem for a diverse population of youth.

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Table 1. Descriptives of internalizing behaviors and screen time across adolescent’s demographic factors

Demographic Variables	Internalizing Behavior	Weekday Screen Time (hours)	Weekend Screen Time (hours)	N (%)
	Mean (SD)	Mean (SD)	Mean (SD)	
<i>Family Income</i>				
< \$50,000	49.6 (11.4)	4.65 (3.75)	5.72 (4.23)	3219 (27.1)
\$50,001 ~ \$100,000	48.8 (10.4)	3.40 (2.83)	4.54 (3.41)	3070 (25.9)
> \$100,000	47.4 (9.92)	2.54 (2.39)	3.77 (2.93)	4562 (38.4)
<i>Parent Education</i>				
< HS diploma	48.0 (11.5)	4.10 (3.29)	4.92 (3.73)	592 (5.0)
HS diploma / GED	47.7 (10.8)	4.87 (3.80)	5.86 (4.42)	1131 (9.5)
Some College	49.7 (11.2)	4.44 (3.44)	5.65 (4.01)	3078 (25.9)
Bachelor’s Degree	48.5 (10.6)	3.20 (2.78)	4.40 (3.40)	3014 (25.4)
Post Graduate Degree	47.8 (10.0)	2.43 (2.30)	3.61 (2.83)	4043 (34.1)
<i>Family History of Mental Illness</i>				
Yes	49.9 (10.7)	3.37 (3.01)	4.54 (3.52)	7226 (68.9)
No	45.8 (10.1)	3.62 (3.19)	4.75 (3.76)	4187 (35.3)
<i>Race/Ethnicity</i>				
White	48.6 (10.4)	2.85 (2.57)	3.98 (3.04)	6178 (52.0)
Black	46.7 (10.9)	5.39 (3.98)	6.77 (4.7)	1780 (15.0)
Hispanic	49.0 (10.9)	3.61 (2.96)	4.72 (3.48)	2409 (20.3)
Asian	45.7 (9.8)	2.24 (2.37)	3.33 (2.78)	255 (2.2)
Multiracial*	49.5 (10.7)	3.62 (3.20)	4.74 (3.69)	1080 (9.1)
Other**	49.3 (10.5)	3.92 (3.69)	5.01 (4.09)	119 (1.0)

Note: * “Multiracial” includes adolescents who identified with more than one race; ** “Other” includes American Indian, Alaska Native, Native Hawaiian, Pacific Islander, and those who did not identify with any of the given options.

Table 2. Zero-sum order bivariate correlations of social ecological indicators of early adolescent mental health in the digital age.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
<i>Outcome</i>													
1. Internalizing Problems	-												
<i>Individual factors</i>													
2. Social Media Use (Weekday)	.00	-											
3. Social Media Use (Weekend)	.02	.75*	-										
4. Total Screen Time (Weekday)	.05*	.44*	.40*	-									
5. Total Screen Time (Weekend)	.06*	.35*	.46*	.75*	-								
6. Cognitive Functioning	-.03*	-.07*	-.07*	-.14*	-.11*	-							
<i>Family Factors</i>													
7. Family Mental Health History	.19*	-.03†	-.02	-.04*	-.03†	.05*	-						
8. Family Income	-.09*	-.13*	-.13*	-.29*	-.23*	.15*	.10*	-					
9. Family Conflict	.09*	.08*	.07*	.18*	.17*	-.09*	.01	-.13*	-				
10. Parental Monitoring	-.09*	-.02†	-.01	-.15*	-.13*	.10*	.01	.13*	-.24*	-			
<i>Social Factors</i>													
11. Peer Relationships	.02	.08*	.07*	.13*	.16*	-.01	.00	.01	.04*	-.02†	-		
12. Close Peer Relationships	-.05*	.10*	.11*	.05*	.07*	-.02	-.01	-.01	-.01	.11*	.28*	-	
<i>Community Factors</i>													
13. Neighborhood Safety	-.11*	-.08*	-.08*	-.14*	-.13*	.07*	.02**	.36*	-.07*	.05*	.00	-.03*	-
Mean	48.5	.11	.13	3.46	4.62	47.7	.63	2.12	2.05	4.38	13.1	14.0	11.7
Std. Dev	10.6	.42	.52	3.10	3.63	11.2	.48	.84	1.95	.52	17.8	18.9	2.93
Sample Size (N)	11864	11847	11845	11833	11828	10489	11413	10857	11849	11852	11846	11840	11825

Note: † $p < 0.01$, * $p < 0.001$; First column (#1) is bolded to highlight the associations of social ecological indicators to adolescent internalizing behaviors. Total screen time was calculated by a cumulative sum of reported time spent on different screen media (e.g. TV, YouTube, Video Games, Social Media, Video Chat, and Texting). Social Media Use represented in this correlation matrix includes those who did not endorse using social media. (#7) Family Mental Health History takes into account parent reports of any family member with a history of seeking out any help related to mental health issues. (#11 & #12) Peer composite scores were calculated by collapsing endorsed friendships across boys and girls.

Table 3. Mean differences in various uses of screen time and interaction of sex on internalizing behaviors.

	Females	Males	Internalizing Behavior
	Mean (SD)	Mean (SD)	<i>F</i>
Interaction			
<i>Screen Time (Weekday)</i>			
Social Media	0.13 (0.45)	0.09 (0.39)	0.48
Video Games	0.63 (0.92)	1.20 (1.25)	0.17
TV	1.11 (1.09)	1.13 (1.11)	4.75*
Video (e.g. YouTube)	0.84 (1.12)	0.98 (1.19)	1.33
Texting	0.25 (0.59)	0.18 (0.51)	6.13*
Video Chatting	0.20 (0.51)	0.16 (0.48)	1.99
Total	3.16 (2.99)	3.74 (3.17)	4.54*
<i>Screen Time (Weekend)</i>			
Social Media	0.16 (0.56)	0.11 (0.46)	0.62
Video Games	0.78 (1.07)	1.64 (1.39)	0.20
TV	1.63 (1.27)	1.64 (1.29)	13.6***
Video (e.g. YouTube)	1.04 (1.27)	1.26 (1.36)	4.68*
Texting	0.29 (0.67)	0.21 (0.60)	8.38**
Video Chatting	0.25 (0.62)	0.20 (0.60)	5.56*
Total	4.15 (3.52)	5.06 (3.68)	12.8***

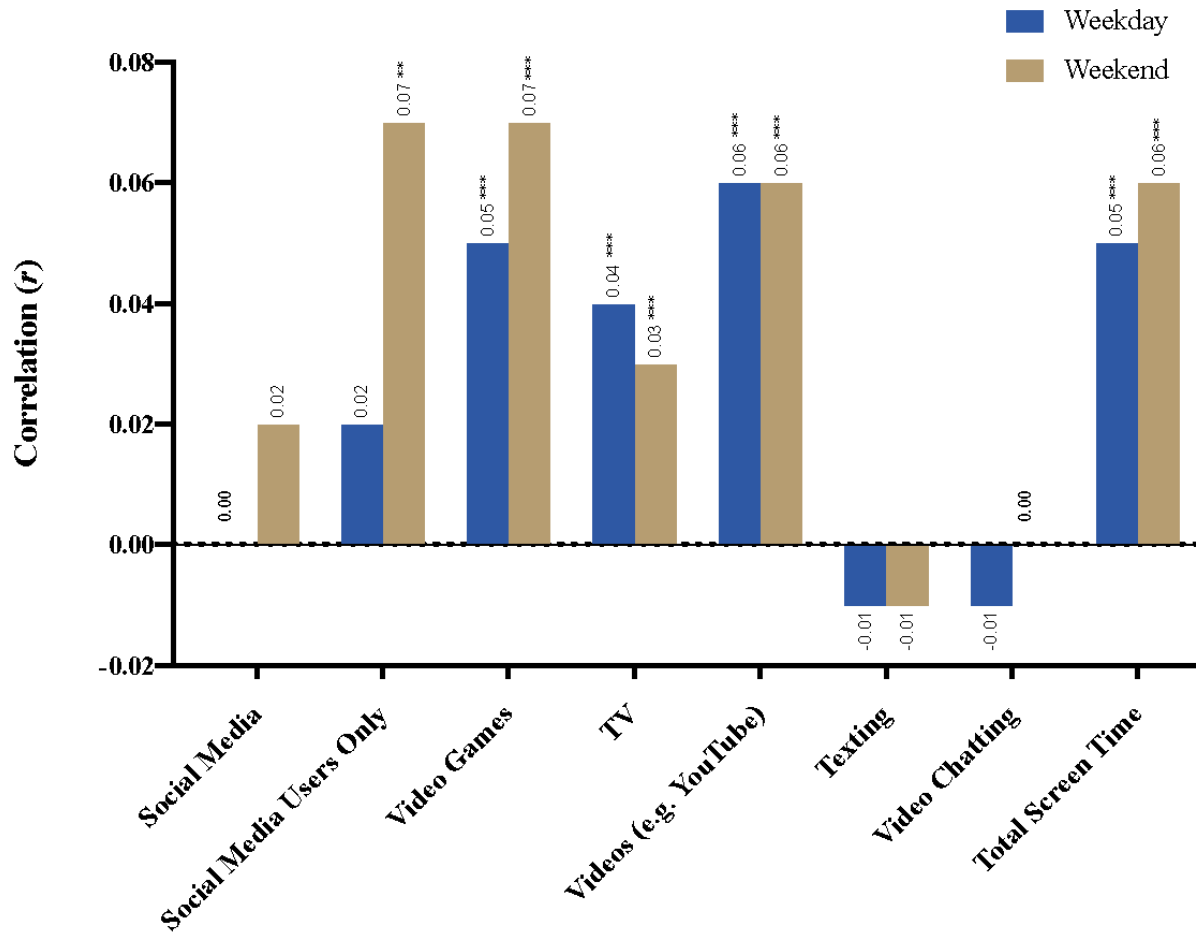
Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; *F*-test indicates significant differences between specific screen time and internalizing behaviors among females and males. In bold shows significant differences ($p < 0.001$) of screen time frequency between males and females.

Table 4. Multiple regression models of social ecological factor associations to early adolescent internalizing behaviors.

Internalizing Behavior Indicators	Model 1: Unadjusted				Model 2: Adjusted				Model 3: Social Media Users Only			
	<i>B</i>	SE	β	<i>p</i>	<i>B</i>	SE	β	<i>p</i>	<i>B</i>	SE	β	<i>p</i>
<i>Individual Factors</i>												
Social Media Use (Weekday)	.08	.22	.00	.73	-.58	.27	-.02	.03	-.62	.58	-.05	.28
Social Media Use (Weekend)	.33	.17	.02	.06	.43	.29	.02	.14	.82	.66	.07	.22
Total Screen Time (Weekday)	.17	.03	.05	.00	-.04	.07	-.01	.57	-.04	.12	-.02	.70
Total Screen Time (Weekend)	.18	.03	.06	.00	.16	.06	.05	.01	.05	.17	.02	.75
Cognitive Functioning	-.03	.01	-.03	.01	-.01	.01	-.01	.19	.00	.03	.00	.89
<i>Family Factors</i>												
Family Mental Health History	4.11	.42	.19	.00	3.80	.35	.17	.00	4.33	.92	.19	.00
Family Conflict	.48	.05	.09	.00	.34	.04	.06	.00	.37	.14	.07	.02
Parental Monitoring	-1.82	.18	-.09	.00	-.97	.22	-.05	.00	-1.66	.75	-.07	.03
*Family Income \$50K -100K	-.82	.36	-.04	.02	-1.46	.31	-.14	.00	-2.72	.60	-.25	.00
*Family Income > \$100K	-2.20	.40	-.10	.00	-2.52	.40	-.24	.00	-4.35	.93	-.39	.00
<i>Social Factors</i>												
Peer Relationships	.01	.01	.02	.11	-.02	.01	-.03	.02	-.03	.02	-.05	.11
Close Peer Relationships	-.03	.01	-.05	.00	.00	.01	-.00	.50	.01	.01	-.03	.23
<i>Community Factors</i>												
Neighborhood Safety	-.41	.04	-.11	.00	-.39	.04	-.11	.00	-.51	.14	-.14	.00

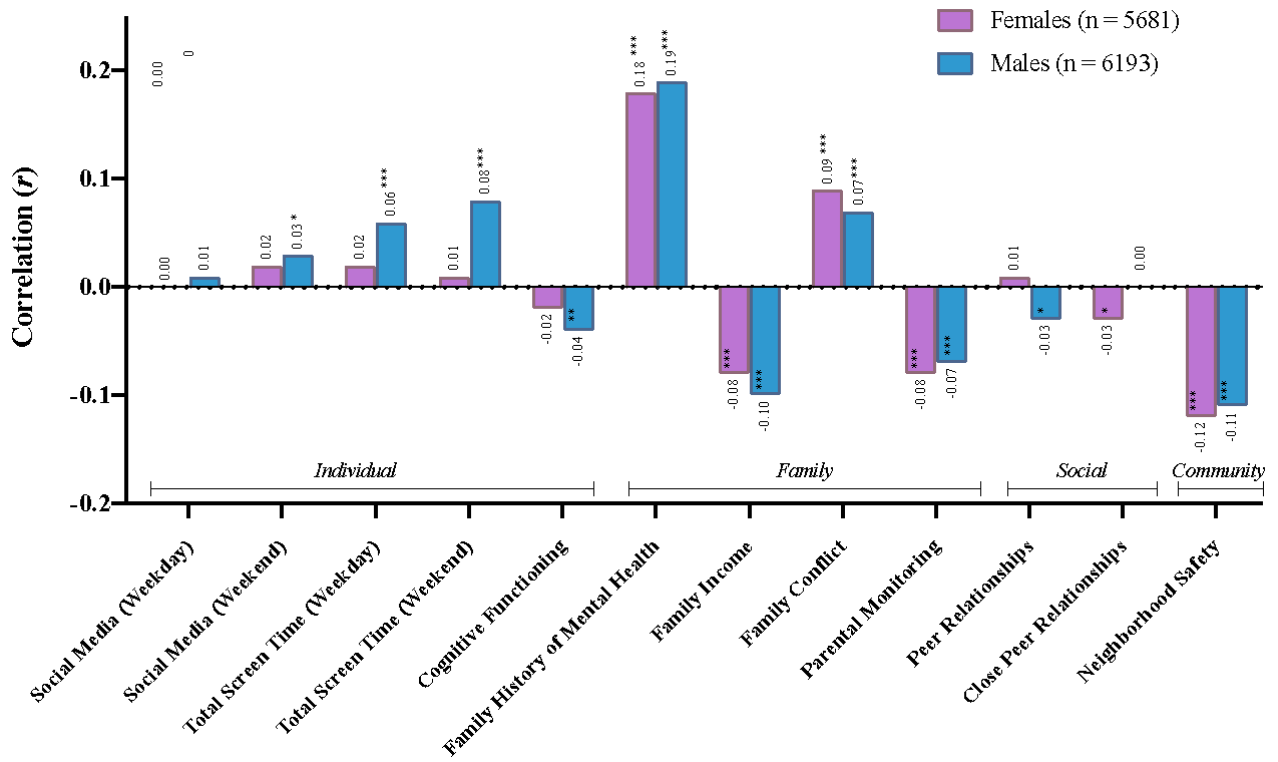
Note: *B* is the unstandardized regression coefficient and β indicates standardized regression coefficient for the multiple regression models. Statistical significance of $p < 0.05$ is denoted in **bold**; *italic* fonts denote non-significance when model is conducted without accounting for study site, thus producing a confound in confidence intervals of standardized coefficients. All models were conducted with cluster-robust standard errors (SE) to account for the heteroskedastic effects of the study catchment site. Model 1 ($N = 9483$) indicates the unadjusted analysis conducted without covariates. Model 2 ($N = 9450$) includes covariates *adolescent sex, age, race/ethnicity, and parental education* in a multiple regression model. Model 3 ($N = 1297$) is the adjusted model with covariates and the social media use variable includes only adolescents who indicated use of social media, thus excluding those who reported no social media use. *Family income was anchored by families reporting less than \$50K in annual household income (<\$50K).

Figure 1. Correlates of Specific Digital Media Types and Internalizing Behaviors.



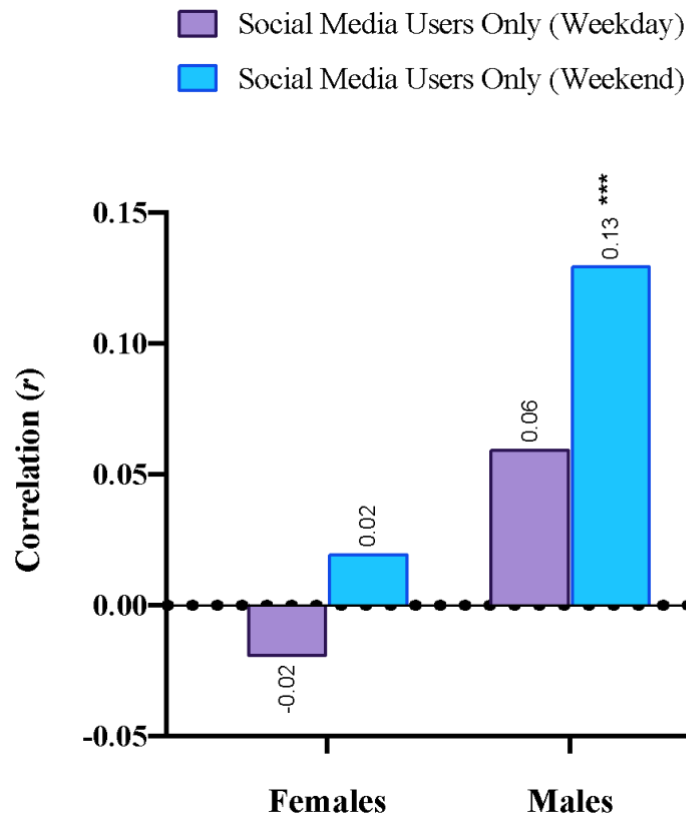
Note: ** $p < 0.01$, *** $p < 0.001$. The variable labeled “Social Media” includes all responses of those who do and do not report using social media with frequency ranging from “0 = None; .25 = < 30 minutes; 0.5 = 30 minutes; 1 = 1 hour; 2 = 2 hours; 3 = 3 hours; 4 = 4+ hours”; “Social Media Users Only” removes individuals who report spending “0-None” on social media with the assumption that these individuals do not use this screen time media which assess the association among users of social media and their internalizing behaviors.

Figure 2. Correlates of Internalizing Behaviors by Adolescent Sex.



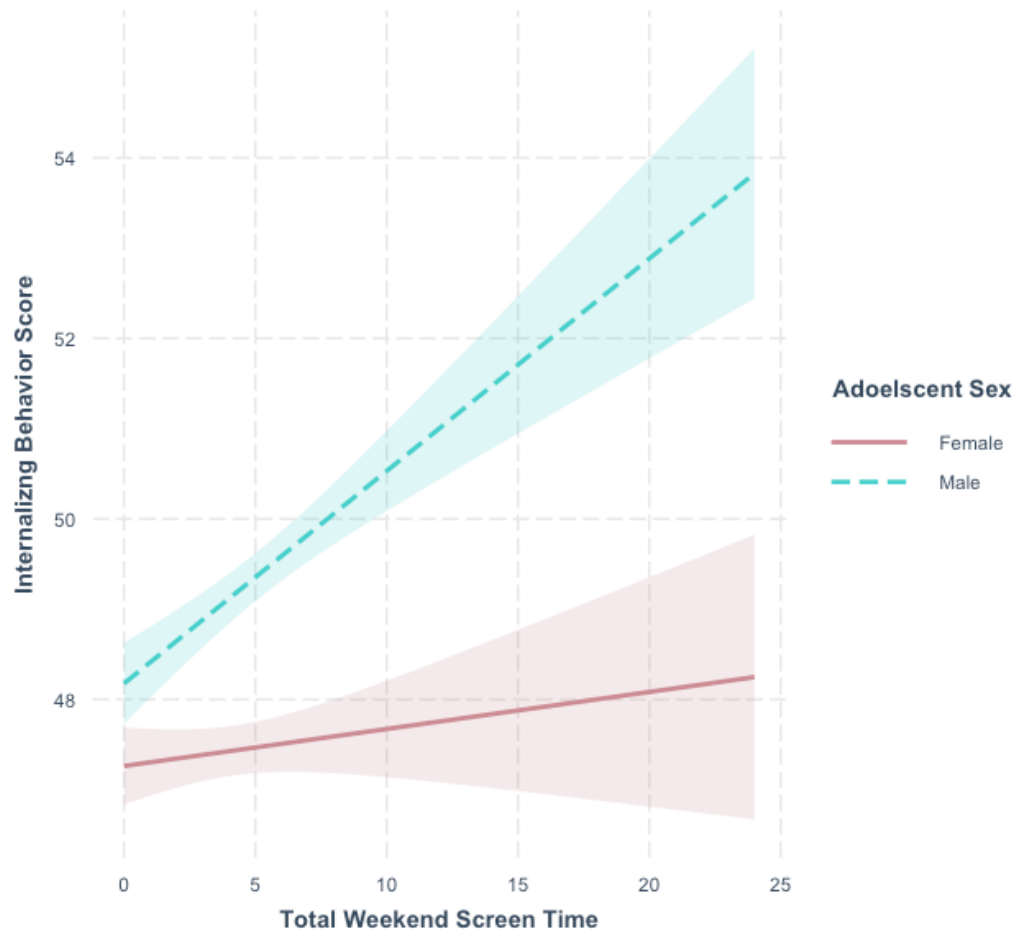
Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. For this correlation, Social Media Use is all reported frequencies of use, including those who report no use of social media (e.g. "None").

Figure 3. Associations among social media users only and internalizing behaviors by adolescent sex.



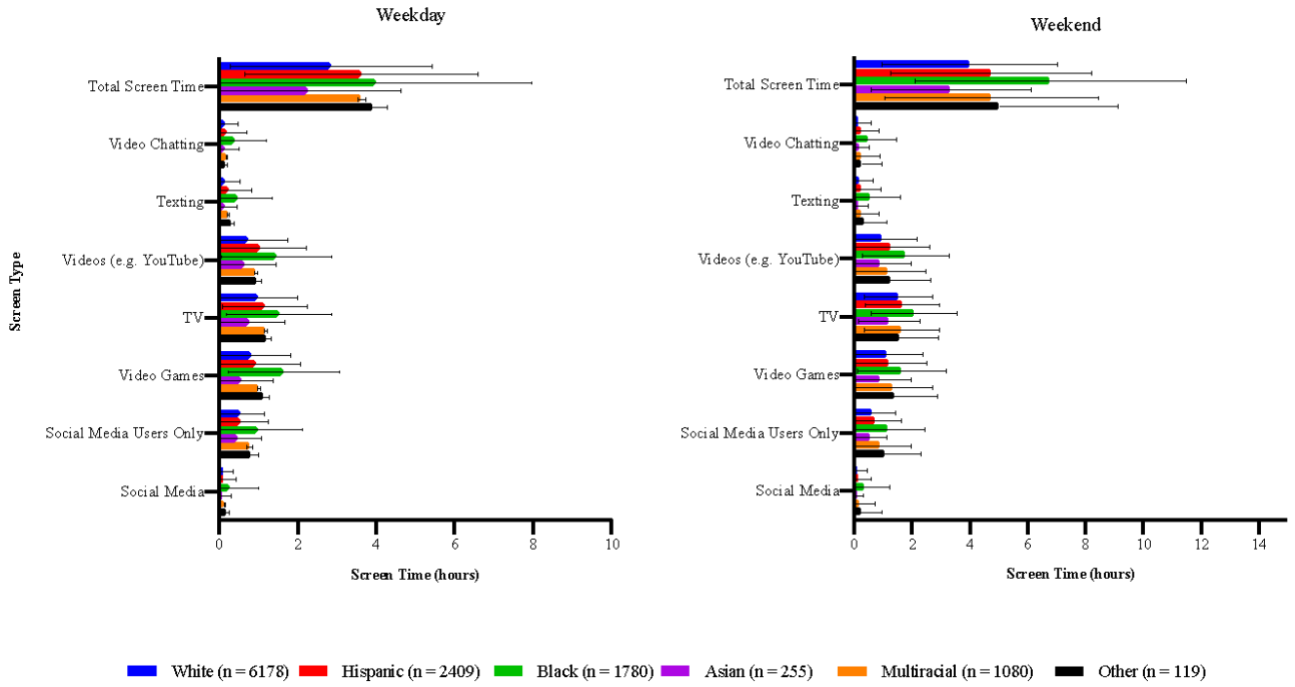
Note: *** < 0.001. This figure represents early adolescents who report using social media, captured by those who indicate > 0 minutes of use. Bivariate correlations frequency of social media use relating to internalizing behaviors significantly among boys using social media more frequently on the weekends compared to girls and on weekdays.

Figure 4. Interaction effect of weekend screen time on internalizing behaviors by adolescent sex.



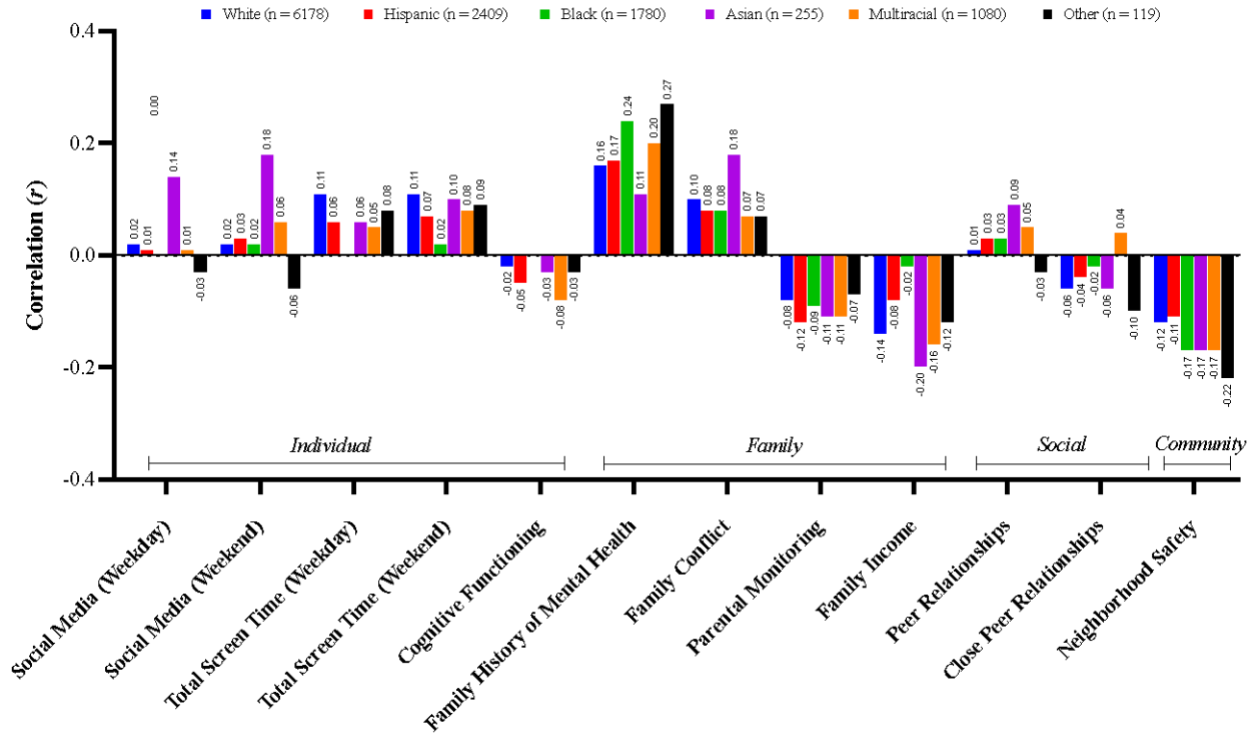
Notes: 95% confidence intervals are represented surrounding trend lines, and standard errors are clustered by study site. This graph shows that frequency of overall weekend screen time has a stronger positive association to internalizing behaviors among adolescent males compared to females.

Figure 5. Average screen use frequency by adolescent race/ethnicity.



Note: Error bars denote standard deviation.

Figure 6. Exploratory: Internalizing behavior indicator correlations by adolescent race/ethnicity.



Note: Variation in sample size between each subgroup of race/ethnic background should be taken into account when interpreting the results of this correlation, in particular the larger effect sizes shown among Asians' social media use and internalizing behaviors may be due to a smaller sample.

APPENDIX

Supplemental Tables

Table S1. Adolescent screen time frequencies of various screen media.

	No Use	< 30 min.	30 min.	1 hr.	2 hrs.	3 hrs.	≥ 4 hrs.	Missing
<i>N (%)</i>								
Weekday								
Social Media	9947 (84)	1003 (8.5)	501 (4.2)	202 (1.7)	81 (0.7)	42 (0.4)	71 (0.6)	33
Video Games	2854 (24)	1998 (17)	2466 (21)	2040 (17)	1105 (9.3)	532 (4.5)	850 (7.2)	35
TV	1515 (13)	1458 (12)	2766 (23)	3001 (25)	1632 (14)	681 (5.7)	795 (6.7)	32
Video (e.g. YouTube)	3168 (27)	1961 (17)	2321 (20)	1971 (17)	997 (8.4)	529 (4.5)	898 (7.6)	35
Texting	7491 (63)	2630 (22)	1021 (8.6)	360 (3.0)	140 (1.2)	71 (0.6)	135 (1.1)	32
Video Chat	8114 (69)	2135 (18)	963 (8.1)	365 (3.1)	106 (0.9)	62 (0.5)	97 (0.8)	38
Weekend								
Social Media	9888 (84)	910 (7.7)	522 (4.4)	250 (2.1)	91 (0.8)	64 (0.5)	120 (1.0)	35
Video Games	2298 (19)	1590 (13)	2131 (18)	2203 (19)	1367 (12)	838 (7.1)	1416 (12)	37
TV	817 (6.9)	897 (7.6)	1719 (15)	3133 (27)	2400 (20)	1199 (10)	1678 (14)	37
Video (e.g. YouTube)	2879 (24)	1555 (13)	2076 (18)	1984 (17)	1232 (10)	727 (6.1)	1393 (12)	34
Texting	7606 (64)	2249 (19)	1058 (8.9)	457 (3.9)	183 (1.5)	102 (0.9)	191 (1.6)	34
Video Chat	8131 (69)	1863 (16)	1004 (8.5)	432 (3.6)	139 (1.2)	95 (0.8)	174 (1.5)	42

Table S2. Sex-based interaction effects of internalizing behavior indicators by the social ecological domains.

Internalizing Behavior Indicators	Adjusted				Adjusted – Social Media Users Only			
	<i>B</i>	SE	β	<i>p</i>	<i>B</i>	SE	β	<i>p</i>
<i>MAIN EFFECTS</i>								
<i>Individual Factors</i>								
Social Media Use (Weekday)	-.84	.48	-.03	.08	-.86	.69	-.06	.21
Social Media Use (Weekend)	.84	.46	.04	.07	.94	.79	.08	.23
Total Screen Time (Weekday)	.01	.09	.00	.97	-.13	.15	-.05	.41
Total Screen Time (Weekend)	.02	.11	.01	.89	.04	.18	.02	.84
Cognitive Functioning	.00	.01	.00	.91	.00	.04	.00	.95
<i>Family Factors</i>								
Family Mental Health History	3.39	.49	.15	.00	4.28	1.14	.19	.00
Family Conflict	.36	.05	.07	.00	.25	.17	.05	.14
Parental Monitoring	-1.10	.25	-.05	.00	-1.54	.93	-.07	.10
*Family Income \$50K-100K	-1.29	.48	-.06	.01	-4.44	1.00	-.18	.00
*Family Income > \$100K	-2.24	.64	-.10	.00	-5.05	1.60	-.21	.00
<i>Social Factors</i>								
Peer Relationships	.02	.02	.02	.42	-.02	.04	-.04	.55
Close Peer Relationships	-.02	.01	-.03	.01	.00	.01	.00	.89
<i>Community Factors</i>								
Neighborhood Safety	-.42	.06	-.11	.00	-.52	.17	-.14	.00
<i>INTERACTION EFFECTS</i>								
<i>Individual Factors x Sex</i>								
Social Media Use (Weekday)	.42	.75	.01	.58	.22	.82	.01	.79
Social Media Use (Weekend)	-.70	.77	-.02	.36	.03	1.13	.00	.98
Total Screen Time (Weekday)	-.07	.10	-.02	.52	.17	.24	.06	.48
Total Screen Time (Weekend)	.24	.12	.08	.03	.01	.21	.01	.95
Cognitive Functioning	-.02	.02	.00	.17	-.02	.05	-.05	.68
<i>Family Factors x Sex</i>								
Family Mental Health History	.74	.44	.03	.09	.05	1.17	.00	.96
Family Conflict	-.02	.08	.00	.76	.27	.26	.04	.30
Parental Monitoring	.02	.26	.04	.44	-.23	.75	-.05	.76
*Family Income \$50K -100K	-.28	.86	-.01	.75	3.99	1.71	.12	.02
*Family Income > \$100K	-.49	.88	-.02	.58	1.46	2.11	.04	.49
<i>Social Factors x Sex</i>								
Peer Relationships	-.05	.02	-.07	.01	-.02	.04	-.04	.64
Close Peer Relationships	.04	.02	.04	.05	.05	.03	.06	.12
<i>Community Factors x Sex</i>								
Neighborhood Safety	.07	.08	.04	.39	.00	.20	.00	.99

Notes: Interaction effects of gender was conducted in the models, with male dummy coded as 1 and female as 0. Adjusted models include covariates age, parental education, and race/ethnicity. **Bold** denotes significant *p*-value and robust clustering of standard errors (SE) account for study sites.

Table S3. Adjusted multiple regression model of internalizing behavior indicators stratified by adolescent race and ethnicity.

Internalizing Behavior Indicators	<i>White</i> n = 6178		<i>Hispanic</i> n = 2409		<i>Black</i> n = 1780		<i>Asian</i> n = 255		<i>Multiracial</i> n = 1080		<i>Other</i> n = 119	
	β	SE	β	SE	β	SE	β	SE	β	SE	β	SE
<i>Individual Factors</i>												
Social Media Use (Weekday)	.00	1.01	-.04	.97	-.02	.44	-.12	7.12	-.10	.84	.25	5.04
Social Media Use (Weekend)	.00	.76	.05	.71	.02	.47	.24	2.08	.11	.94	-.47	5.03
Total Screen Time (Weekday)	.02	.09	-.05	.14	-.03	.08	-.27	.52	-.02	.14	.08	.63
Total Screen Time (Weekend)	.04	.09	.09	.15	.06	.08	.13	.39	.00	.13	.30	.46
Cognitive Functioning	.00	.01	-.02	.02	.01	.03	.04	.06	-.08	.03	-.06	.14
<i>Family Factors</i>												
Family Mental Health History	.15	.40	.16	.64	.24	.91	.21	1.23	.17	.60	.36	3.05
Family Conflict	.07	.08	.07	.17	.09	.12	.10	.32	.00	.19	-.10	.59
Parental Monitoring	-.02	.33	-.07	.49	-.06	.46	-.12	1.66	-.09	.75	.07	2.10
*Family Income \$50K-100K	-.06	.61	-.06	.48	-.07	.34	-.20	1.90	-.09	.77	-.05	1.97
*Family Income > \$100K	-.12	.62	-.12	.88	-.01	.82	-.34	2.01	-.10	.94	-.02	3.41
<i>Social Factors</i>												
Peer Relationships	.03	.01	-.04	.02	.02	.02	-.03	.05	.01	.02	-.13	.05
Close Peer Relationships	-.03	.01	.02	.02	-.04	.02	.00	.02	.08	.03	-.13	.07
<i>Community Factors</i>												
Neighborhood Safety	-.09	.07	-.09	.08	-.13	.09	.00	.30	-.13	.16	-.19	.56

Notes: Models are adjusted with covariates (*adolescent sex, age, and parent education*), and each model run separately by race/ethnic stratified groups. Reported are the standardized coefficients (β) and robust clustering of standard errors (SE) to account for study sites. Significant results at the $p < .01$ level are denoted in **bold** font. *Italic* fonts denote non-significance when model is conducted without accounting for study site, thus producing a confound in confidence intervals of standardized coefficients.