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Screen media activity in youth: A critical review of mental health and neuroscience findings

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Abstract

This review has two primary objectives: (1) to offer a balanced examination of recent findings on the relationship between screen media activity (SMA) in young individuals and outcomes such as sleep patterns, mood disturbances, anxiety-related concerns, and cognitive processes; and (2) to introduce a novel multi-level system model that integrates these findings, resolves contradictions in the literature, and guides future studies in examining key covariates affecting the SMA-mental health relationship. Key findings include: (1) Several meta-analyses reveal a significant association between SMA and mental health issues, particularly anxiety and depression, including specific negative effects linked to prolonged screen time; (2) substantial evidence indicates that SMA has both immediate and long-term impacts on sleep duration and quality; (3) the relationship between SMA and cognitive functioning is complex, with mixed findings showing both positive and negative associations; and (4) the multifaceted relationship between SMA and various aspects

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Appendix A. Supporting information
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of adolescent life is influenced by a wide range of environmental and contextual factors. SMA in youth is best understood within a complex system encompassing individual, caregiver, school, peer, and environmental factors, as framed by Bronfenbrenner's ecological systems theory, which identifies five interrelated systems (microsystem, mesosystem, exosystem, macrosystem, and chronosystem) that influence development across both proximal and distal levels of the environment. This model provides a framework for future research to examine these interactions, considering moderating factors, and to develop targeted interventions that can mitigate potential adverse effects of SMA on mental well-being.

Keywords

Screen media activity; Mood; Anxiety; Sleep; Cognition

Introduction

Background and statement of objectives

Many youth (individuals aged between 10 and 24 years) are spending significant time watching videos, being engrossed in games on tablets, or messaging friends as common recreational activities [1]. In teenagers, screen media activity (SMA) consumes up to 60% of their after-school time [2], and nearly 97% of US youth have at least one electronic item in their bedroom [3]. Several meta-analyses have examined relationships between SMA and youth mental health, sleep, activity levels or other behavioral factors. Of these the majority [4–12] found some, albeit generally small associations between SMA and the target behaviors, whereas others [13–15] found no or a negligible relationship between SMA and indicators of mental and physical health. Thus, the relationship between SMA and mental health outcomes in youth is a complex [15] and multifaceted issue that has garnered significant attention among researchers and the public in recent years. The complexity may be due to the diverse nature of screen activities [16,17], the rapidly evolving landscape of digital media [18], and the differential impacts these activities may have across individuals [16]. What is emerging is a nuanced picture, with some evidence suggesting relatively trivial effects of SMA on well-being [19] or life satisfaction [20] and other results indicating stronger associations with mental health problems such as depression or anxiety [17]. More recent research suggests there may be individual differences concerning the impact of SMA. For example, sex-related differences have emerged, with girls generally demonstrating stronger associations between screen media time and mental health indicators than boys [21]; and there is some evidence that effects may differ depending on the broader socioeconomic and environmental context [22]. The COVID-19 pandemic added complexity [23], influencing screen time habits and mental health outcomes. This aim of this review is twofold. First, to provide a balanced review of the primarily the most recent findings (within the past 3 years) focused on SMA and mental health (for details of the search strings and the list of articles see Supplement). Second, to provide a multi-level system model that can be used to better integrate these findings, help to provide an explanatory framework for the apparent contradictions in the literature, and guide future studies to examine important covariates that affect the relationship between SMA and mental health.

SMA and mental health

Mood- and anxiety-related problems

Numerous studies have focused on relationships between SMA and mental health, and several meta-analyses have been published reporting some effects of SMA on mental health in general and internalizing symptoms such as anxiety and depression more specifically. Over the past decades, SMA research focus has recently changed from an emphasis on depression during the earlier period (1983–2016), to a greater focus on anxiety disorders (2020–2022), considering factors such as cognitive distortions, insomnia, loneliness, self-esteem, social support, and alexithymia [24]. In general, SMA has been associated with depressive or anxiety disorders and their symptoms [17,25], with studies reporting that greater screen time at early ages is directionally related to higher levels of internalizing symptoms several years later [26]. Similarly, greater mobile phone and wearable device use has been associated with poorer mental health outcomes, including higher internalizing symptoms [27]. Specific behaviors such as higher daily time spent on social media have been linked to a significant increase in the risk of depression in adolescents [10], more so in girls than boys [9], which is in line with another study reporting that high social media use has been found to predict more depressive symptoms, panic disorder symptoms, delinquent behaviors, and family conflict, along with lower levels of family and friend support [28]. Prolonged screen time, particularly more than 1 h per day of electronic gaming or using computers and more than 2 h per day of watching TV, has been associated with low life satisfaction among adolescents [29]. Furthermore, increased time spent engaging in newer types of screen behavior, including social media, online games, and online videos, has been associated with a higher prevalence of depression [30]. Extensive daily use of social media (over 3 h) has been associated with internalizing problems and co-occurring internalizing and externalizing problems [31]. More specifically, components of digital stress such as approval anxiety, availability stress, fear of missing out, connection overload, and online vigilance have all been linked to psychosocial distress with a medium effect size [32].

Within the context of SMA, active engagement in social media was linked to subsequent anxiety symptoms in adolescents [33]. Moreover, heavy levels of digital screen time (i.e., 3 + hours daily) was associated with declines in well-being, particularly concerning external and prosocial functioning [34]. Notably, specific uses of smartphones such as listening to music, chatting online, watching TV, and playing games have been reported to exert high to medium negative effects on subsequent mental health [35]. A general pattern indicates that excessive screen exposure is typically associated with negative effects on mental health [36], with studies suggesting that social media use is associated with poor mental health, while the associations with watching TV and playing video games are mixed. Interestingly, video games, particularly online multiplayer and augmented reality games, have been noted to help mitigate stress, anxiety, and depression among college students, though excessive use may lead to heightened stress, anxiety, and depression symptoms in individuals with gaming problems [14].

However, it is worth noting that despite these findings, the effect sizes associated with screen time and various outcomes are often modest [37]. Some researchers argue that impacts on affective well-being are generally small and mostly based on use versus non-use, rather than time spent with a medium [18,38]. A meta-analysis of 37 studies examining relationships between screen time and mental health outcomes found that effect sizes were small, and the studies demonstrated significant heterogeneity [15]. Hence, while SMA appears to have an association with internalizing concerns, albeit with small effect sizes, it is critical to consider the broader context of an individual's life, including factors such as socioeconomic status, family and friend support, and trauma history, when assessing the potential influence of screen time on mental health and neurodevelopment.

Sleep

The interplay between SMA and sleep patterns has been the focus of several studies, suggesting both immediate and longer-term impacts on sleep duration, quality, and associated cognitive functions. There are at least four studies [39–42] that found that greater use of screen media, including video and video game usage, were associated with decreased sleep duration, increased sleep onset latency, and heightened severity of sleep disturbance symptoms. This notion is further supported by Axelsson et al. [43], who found longer engagement with entertainment content to be linked to shorter sleep duration and poorer sleep quality, consistent across all times of day of SMA. Similarly, adolescents and young adults spending over two hours on smartphones per day had higher odds of sleep problems, with adolescent girls showing a significantly greater likelihood than boys [44]. Moreover, SMA usage during the COVID-19 pandemic was also associated with poorer sleep behavior such as shorter time in bed, later bedtimes, and longer sleep onset [45]. On the other hand, some have found that intense and problematic use of social media associated with less sleep, later bedtimes, and greater social jetlag, and nonactive use of social media associated with longer sleep, earlier bedtimes, and less social jetlag, although differences were modest [46]. This is consistent with an analysis of American children's health data [47] that each hour spent on digital screens was associated with only 3–8 fewer minutes of nightly sleep, accounting for less than 1.9% of the observed variability. Aside from these individuals studies, three meta-analyses [4, 11, 48] have concluded that sleep, daytime sleepiness, and COVID-related changes in sleep were significantly moderated by SMA. Thus, while many studies document a relationship between SMA and various sleep issues, others suggest direct effects of SMA are likely small and more attention should be paid to contextual factors surrounding screen time. As most studies rely on self-reported sleep measures, they may be subject to reporting bias and most do not control for other factors that might influence sleep, such as physical activity, parental monitoring, proximity of smartphone or other devices to bed, subjective or objective measurement of notifications or other factors that may directly disrupt sleep. It remains unclear whether youth with sleep problems might use screens more because they are seeking something to do when they cannot sleep, or whether the same issues that contribute to sleep problems, such as stress or mental health difficulties, also contribute to screen use. Therefore, further research is warranted to explore these relationships in more detail and with greater precision.

Cognition

Several studies have focused on the impact of SMA on cognitive functioning, particularly its relationship between gaming and attention as well as temporal discrimination. These studies found both positive, no, and negative associations. First, Foerster et al. [49] showed that youth who played video games were better prepared to allocate their attention in space and time using implicit mechanisms, an observation backed by behavioral, oculomotor, and electroencephalographic (EEG) data. Another study [50] found that youth who engaged in video gaming displayed increased sensitivity to short asynchronies and enhanced temporal discrimination. Moreover, these improvements in temporal discrimination were related to parieto-occipital processing and reductions in alpha-band (8–14 Hz) power and inter-trial phase coherence. Sauce [22] reported a small but positive relationship between gaming and measures of generalized intelligence, with children who played more video games at age 9–10 showing greater gains in intelligence two years later. Second, Liebherr et al. [51] found no significant effects of media use (measured in hours per day) on tasks involving switching of attentional demands to measure selective and divided attention. Third, several studies [52–54] have found that media-multitasking, which refers to engaging with at least two forms of SMA simultaneously, is associated with negative cognitive outcomes such as reduced abilities or tendencies to filter out distractions, increased impulsivity, and lower working memory performance. Moreover, Onyeaka [55] found that adolescents who engaged in excessive screen-time behaviors had 1.28 times higher odds of reporting serious cognitive difficulties. In the same vein, in pre-schoolers, greater screen time was found to statistically predict lower communication and problem-solving scores and poorer attention, with engaging with screen content alongside others correlating with poorer problem-solving skills, while engaging alone correlated with better problem-solving abilities [43]. These findings underline that the relationship between SMA and cognitive skills is complex and may vary based on factors such as screen content, youth’s surroundings, including family and friends, and personal traits/tendencies. Therefore, our understanding of the potential impacts of SMA on cognitive function in adolescents remains limited. Future results from the Adolescent Brain Cognitive Development (ABCD) consortium study and other large scale studies will be necessary to better characterize potential influences of SMA on various aspects of cognition.

Other relationships

Several investigators have examined the impact of SMA on various aspects of adolescent life, including life satisfaction, physical activity, diet, and academic performance. While SMA does not seem to be a strong predictor of life satisfaction across the adolescent population [20], there have been small, negative associations found between SMA and adolescent well-being [19,56]. An examination of two UK datasets suggested age- and sex-specific windows of sensitivity to use of social media in adolescence, which had a bidirectional relationship with life satisfaction [59]. The influence of digital screen engagement on psychosocial functioning, as measured by the Strengths and Difficulties Questionnaire [57], which assesses 25 attributes across five domains: emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems, and prosocial behavior [57], is likely small. Moreover, there may also be a reverse causation issue in that youth who experience significant psychosocial difficulties [58] engage in high levels of screen time.

With respect to physical activity, some studies [59] found no evidence supporting a displacement hypothesis, one proposing that SMA replaces moderate to vigorous physical activity. This aligns with findings from the ABCD study [60] showing that greater SMA was not predictive of lower participation in other recreational activities. In another study, non-active use of social media was associated with lower levels of physical activity (PA), while intense use was associated with higher odds of meeting the PA recommendation [61]. SMA has also been associated with dietary habits and body mass index (BMI). Stiglic and Viner [62] reported moderate evidence for an association between increased SMA and higher energy intake and less healthy diets. Each additional hour of total screen time per day was prospectively associated with a 0.22 higher BMI percentile at a 1-year follow-up [63] and in girls, much time spent on social media (≥5 h/day) was positively associated with BMI z-score. This relationship is further supported by research linking recreational screen time, but not educational screen use, to obesity [64]. Interventions have also attempted to modulate impacts of SMA, Pedersen's study [65], which asked participants to reduce their recreational screen use to 3 h or less per week versus a group of individuals that continued with SMA as usual for 2 weeks, reported a significant increase in children's daily time spent being non-sedentary during leisure, and participants increased their moderate-to-vigorous physical activity (MVPA) because of the intervention. Similarly, Kandola [66] found that replacing 60 min of total screen time with exercise at age 14 was associated with a reduction in emotional symptoms at 17.

Other lifestyle behaviors include use of social media positively associating with cannabis vaping initiation among US youth [67]. Moreover, high-risk gaming often co-occurs with polysubstance use [68], and time on social media is associated with the use of energy drinks and pre-workout drinks or powders [69]. SMA's association with academic performance has shown mixed results. Adelantoado-Renau and colleagues [70] reviewed 5500 studies and showed that overall screen time (including computer, internet, mobile phone, television, and video games) did not directly affect academic performance. However, more television viewing was associated with lower scores in overall academics, language, or math, and playing video games seemed to lead to lower overall academic scores. Others have reported that youth who spent > 2 h using SMA reported more behavioral and conduct problems, developmental delays, speech disorders, and learning disabilities [71]. Overall, the relationship between SMA and these aspects of adolescent life seem complex and multifaceted, with evidence being mixed and effect sizes generally small. The results highlight the need for more reliable methods of measuring media use, such as time diaries or tracking usage on respondents' devices, to provide more accurate data [15,19].

Moderators and methodological considerations influencing SMA relationships with mental health

The relationship between Screen Media Activity (SMA) and mental health outcomes is not straightforward but appears to be modulated by a variety of factors (see Table 1), including types of SMA consumed [72], methods used to measure screen time [19], sex-related differences [16], timing of exposure during the lifespan [73], and contexts in which SMA occurs, such as societal changes like the COVID-19 pandemic [23]. In addition, how "screen time" is defined and conceptualized [15] as well as the severity of the mental health outcomes being considered and motivations for media use [74] may further influence associations between SMA and mental health [18].

Contextual factors, such as socioeconomic status, parental psychological problems, and adverse childhood experiences, can impact these relationships and cognitive performances. For instance, Mannikko et al. [75] reported a relationship between parental socioeconomic status and children's digital screen usage, with externalizing behavior characteristics in youth contributing to adolescents' level of screen exposure. Other studies [76] found that parental psychological problems correlated with increased screen time in children. More specific parental problems were linked to certain screen behaviors, such as television and video watching and gaming. Wang et al. [77] found that parental phubbing, a behavior where parents are distracted by their phone messages or social media feeds, has a significant bidirectional association with youth stress or academic problems. Additional studies underscore the complex interplay between familial, peer, environmental, and socio-economic factors, including neighborhood violence and early life trauma, in the emergence of youth affective and cognitive symptoms [78–80].

Specific types of SMA, physical activity, and BMI also seem to moderate relationships between SMA and mental health and cognitive performance. For instance, Zulyniak et al. [81] found that low physical activity was associated with negative mental health. In a study by Sakib and colleagues [82], higher baseline BMI and waist circumference were associated with worse follow-up episodic memory and better vocabulary task performance. Cross-lagged panel models with latent variable modeling indicated a bidirectional association between baseline adiposity and future executive function task performance, with the hypothesized associations statistically mediated by volume of middle frontal gyrus and thickness of the left prefrontal cortex, physical activity, and/or blood pressure. Recent studies have also highlighted various factors that may affect the relationship between SMA and mental health. These include Adverse Childhood Experiences (ACEs) and their association with problematic video game and mobile phone use [83], parental control and co-viewing in low-SES families and their impact on young children's socio-emotional development [84], and the role of perceived social support in mitigating the negative mental health outcomes associated with use of social media [85]. Other moderating factors include: family function moderating the association between problematic use of the internet (PUI) and mental health symptoms [86]; emotional self-regulation strategies moderating the relationship between SMA and symptoms of depression and anxiety [85]; parenting styles moderating the association between problematic use of media and sleep [87]; age of youth moderating the relationship between use of electronic media and sleep [55] or psychosocial function [27]; gender moderating the relationship between use of digital media and suicidal ideation (stronger relationships for girls) [88]; and the buffering role of family functioning and school connectedness on the negative effects of long screen times and internet addiction on physical health, life satisfaction, and depression, respectively [84]. These moderating factors are important to consider for two reasons. First, including measurement of these factors in large studies may help to evaluate precise impacts of SMA on specific youth and could provide ways of resolving conflicts between groups claiming significant effects of SMA on mental health and those showing little to no effects. Second, if these moderating factors are modifiable, they can become targets of interventions aiming to mitigate possible adverse effects of SMA in particular groups.

Brain processing and SMA

General considerations

The relationship between brain structure, function, and SMA is multifaceted and influenced by various environmental and contextual factors. Large-scale studies like the ABCD study have revealed that cognitive or emotional processes related to SMA are not localized but represented by widespread brain networks [89]. Research has identified interconnected brain regions processing diverse aspects of SMA, and structural models have provided insights, such as an inverse association with brain volume across multiple regions [90]. Distinct neurodevelopmental subgroups have been found in the ABCD dataset, characterized by varying reward, inhibition, and emotion regulation levels [91]. Other studies have identified consistent brain-behavior-environment covariation [92] emphasizing the importance of context such as neighborhood environment, parental characteristics, quality of family life, perinatal history, cardiometabolic health, cognition, and psychopathology. Specific brain connections and structures have been linked to effects of insufficient sleep on depression and intelligence [93]. Overall, these general neuroimaging findings underscore the need to disentangle complex contextual variables to understand underlying neural mechanisms and develop targeted interventions for healthy SMA.

SMA-specific effects

The impact of SMA on brain structure and function is still a developing topic, and relatively few studies have examined these relationships with sufficiently large data to arrive at robust conclusions. In our initial study [94] of the first wave of the cross-sectional ABCD data, we used a multivariate approach to parse influences of SMA on physical activity, family conflicts, and sleep disturbances. Findings suggested that those with greater general media activity reported more sleep problems and higher family conflict. Moreover, those with greater social media versus other SMA reported greater physical activity, had less family conflict, and fewer sleep problems. In a subsequent study, we [95] found that SMA at baseline was related to internalizing psychopathology at year 2. Further, SMA related to changes in a brain structural co-development pattern similar to patterns that had been previously linked to under-age initiation of alcohol use in adults [96] and to high-frequency SMA and externalizing behaviors in children in the baseline ABCD sample [97]. These findings show that when changes in the size of certain brain areas (including the brainstem and parts of the frontal, parietal, and temporal lobes) occur concurrently, they may partially explain how baseline SMA influences future emotional or mental health problems. They further suggest developmental interplays between SMA and other possibly addictive behaviors. Song et al. [98] reported that compared to a lower-frequency-SMA-pattern group identified via clustering analysis, a video-centric-higher-frequency-SMA-pattern group showed poorer neurocognitive performance, more total behavioral problems, and more psychotic-like experiences. These associations largely persisted with age over two years, with more individuals in the video-centric higher-frequency SMA group over time. In an independent data set, the video-centric-high-frequency group was replicated in younger individuals (through age 12 years), while a social-communication-centric SMA pattern was observed in adolescents aged 13 years and older. The data support the hypothesis that an differences in brain development exists among individuals with high vs. low SMA use, characterized by slower subcortical gray-matter volume (GMV) expansion and increased cortical GMV reduction in key neural circuit regions.

Differences in brain development that could be related to SMA is consistent with prior studies linking risky behavior to imbalanced brain development. Neurodevelopmental changes in the second decade of life typically involve increased cortical control over subcortical circuits, accompanied by cortical neuronal pruning and gray-matter thinning. Alterations in this process may result in reduced cognitive control over subcortical circuits, potentially contributing to developmental imbalances. The hypothesis that risky behavior in youth is linked to imbalanced brain development [99] suggests that certain brain regions involved in decision-making and impulse control, such as the orbito-frontal cortex (OFC) and the nucleus accumbens (NAC), are not fully matured or synchronized during adolescence. Due to this imbalance, adolescents may be more likely to act on their emotions, seek rewards, and disregard potential consequences. The OFC is involved in a number of processes including inhibiting impulses and matures later than the NAC, which is involved in reward processing, motivation, and addiction. Consequently, during adolescence, the NAC is more active and sensitive to rewards, while the OFC is less active and efficient in regulating impulses. This imbalance can lead to risky behaviors such as drug use, binge drinking, unsafe sex, reckless driving, and other forms of sensation seeking, potentially negatively impacting health, well-being, and academic performance.

Chaarani and colleagues [100,101] compared individuals who played video games and those who did not and found that the former group exhibited better performance on fMRI tasks related to inhibitory control and working memory. Individuals who played video games showed greater BOLD signal in the precuneus during inhibitory control and less activation in the occipital cortex and calcarine sulcus, along with greater activation in the cingulate, middle, and frontal gyri and the precuneus during working memory tasks. Kwon et al. [102] identified greater functional connectivity of the dorsal anterior cingulate cortex (dACC) with the ventral attention network (VAN) and the default mode network (DMN) in people with problematic smartphone use. This atypical dACC-VAN functional connectivity correlated with smartphone addiction severity scores, suggesting a link between smartphone addiction and altered brain connectivity. Zhao et al. [97] found a thalamus-prefrontal cortex (PFC)-brainstem structural co-variation pattern associated with high-frequency SMA and externalizing psychopathology in both girls and boys. This pattern resembled one previously linked to alcohol use initiation before adulthood [96]. Others have observed [103] that PUI was positively correlated with regional gray-matter density (rGMD) in the right inferior parietal lobe (IPL), an area involved in inhibitory control. These investigators demonstrated that the rGMD in the right IPL mediated the association between anxiety and PUI, suggesting that individuals with higher anxiety might be more prone to PUI due to underlying cognitive mechanisms involving the right IPL. Therefore, these studies demonstrate that different types of SMA may have both positive and negative effects on brain structure, function, and mental health or vice versa. However, further research is needed to better understand the complex relationships between SMA and neural mechanisms over the course of development, as well as their potential implications for individuals' well-being as youth age.

Towards a systems model of SMA in youth

SMA in youth is often perceived as an individual activity; however, for research purposes, it is more accurate to view SMA as occurring within a system that encompasses the individual, the immediate caregiver environment, the school, peers and other environmental factors. Bronfenbrenner's ecological systems theory [104,105] is a framework for understanding human behavior within a complex system of relationships within and across multiple levels of the environment, from more proximal (e.g., immediate family, academic settings) to more distal (e.g., sociocultural values, laws, etc.). The theory proposes five interrelated systems that influence development: (1) the *microsystem* which is the immediate environment with which an individual interacts, (2) the *mesosystem* which focuses on interactions between different elements of the microsystem, (3) the *exosystem* which involves the larger social system with which the individual does not directly interact but it still impacts their behavior, (4) the *macrosystem* comprised of the broader societal and cultural context, and (5) the *chronosystem* that is centered on the dimension of time including the timing of specific events and historical context.

Within the microsystem, different types of SMA (e.g., social media, gaming, television) vary in their associations with mental health outcomes. Motivations for SMA, such as information sharing and stress relief, and the accuracy of measurement methods (e.g., time diaries, device tracking) are also important considerations for the effects of SMA on mental health. The definition of "Screen Time" also impacts these effects. The mesosystem considers the moderating role of sex on SMA effects, interactions between media types, motivations, and assessments. It connects the microsystem structures, including parental and peer factors, and interactions with other activities like sports. Factors such as peer support, family conflicts, and parental monitoring influence social media engagement and mental health. Physical activity, parental rules, and individual sex may also moderate SMA effects. The exosystem includes indirect influences like parents' screen use patterns, parental rules, psychological problems, socioeconomic status, family resilience, community resources, neighborhood safety, and norms. These factors shape children's media use and require clear delineation for research. The macrosystem encompasses cultural values, media literacy, regulation, and innovation. These factors shape youth's online preferences and behaviors, enhance critical thinking, set media standards, and create new opportunities and challenges for digital media use. The chronosystem involves age, developmental stage, and societal changes like the advent of smartphones and the COVID-19 pandemic. These factors exert complex effects and may reveal critical periods for sensitivity to SMA's effects on mental health.

Applying the Bronfenbrenner model to the effects of SMA on mental health facilitates understanding of complex interplays between individual and environmental factors that may influence outcomes. The model's core concept, which is defined as a process, can be seen in the interaction between the individual and their SMA. A recent application to negative symptoms in schizophrenia [106] can serve as an illustrative example how this may help to promote research. In this formulation, the microsystem or individual level factors comprise individual characteristics such as age, sex, and mental health status, which may affect how SMA influences mental health. The context is represented by the immediate environment, including the type of SMA and the methods used to measure it, as well as broader social factors like SES and parental psychological health. The time component is evident in influences of historical and societal changes, such as the COVID-19 pandemic, which have led to increased SMA and potentially influenced its effects on mental health. A recent extention [106] of the Bronfenbrenner model has added an biological level into the micro-system to locate brain and process-specific variables. Thus, we could augment this model, using brain structure and function related to SMA, which includes gray-matter volume as well as patterms of functional brain connectivity related to SMA. Taken together, this model puts emphasis on both objective and subjective elements is particularly relevant to SMA and mental health. Objective elements like the amounts and types of SMA can be measured, but the subjective experience of these activities, such as motivations for media use and perceived impacts on well-being, are also important. This model encourages consideration of multifaceted influences and their interrelationships, rather than isolating individual factors.

The application of this model to SMA effects on mental health can guide research design, helping to develop testable hypotheses that consider complex interplays of process, person, context, and time. It can also inform the design of interventions and policies aimed at mitigating potential negative effects of SMA on mental health, by highlighting the importance of addressing both individual and environmental factors. Table 2 summarizes the main findings from the literature within the appropriate levels of the Bronfenbrenner model. Using a systems model to better understand the implications and shape future directions for researching the impact of SMA on mental health may help to identify environmental factors that could be important moderators and also targets of intervention. For instance, families could modify the micro-system by limiting screen time and participating in collective activities. Similarly, macro-level interventions, such as public health campaigns, can aim to change societal norms around SMA. Interventions at the systems level are also vital, which could include modifications to laws and policies around SMA (exosystem), education programs to alter societal attitudes towards SMA (macrosystem), and interventions at the family or school level (microsystem). Person-centered approaches in a systems-based model may include educating individuals about SMA's risks and benefits and teaching risk management. Future strategies could involve digital tracking for accurate SMA measurement and qualitative methods for insight into motivations. Longitudinal studies are key to understanding dynamic SMA and mental health relationships, and future research may explore associations with various bioecosystem layers. The ecological systems theory could provide insights into SMA's relationship with mental health issues like anxiety and depression, considering the influence of various environments. In conclusion, understanding SMA/mental-health relationships requires considering complex interactions between individual and environmental factors, especially in our digital age. Future work should use a multipronged approach, addressing individual to societal levels, and leveraging both technological and traditional research methods. (Fig. 1).

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used chatGPT in order to clarify the writing and to help with making statements more concise. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Declaration of Competing Interest

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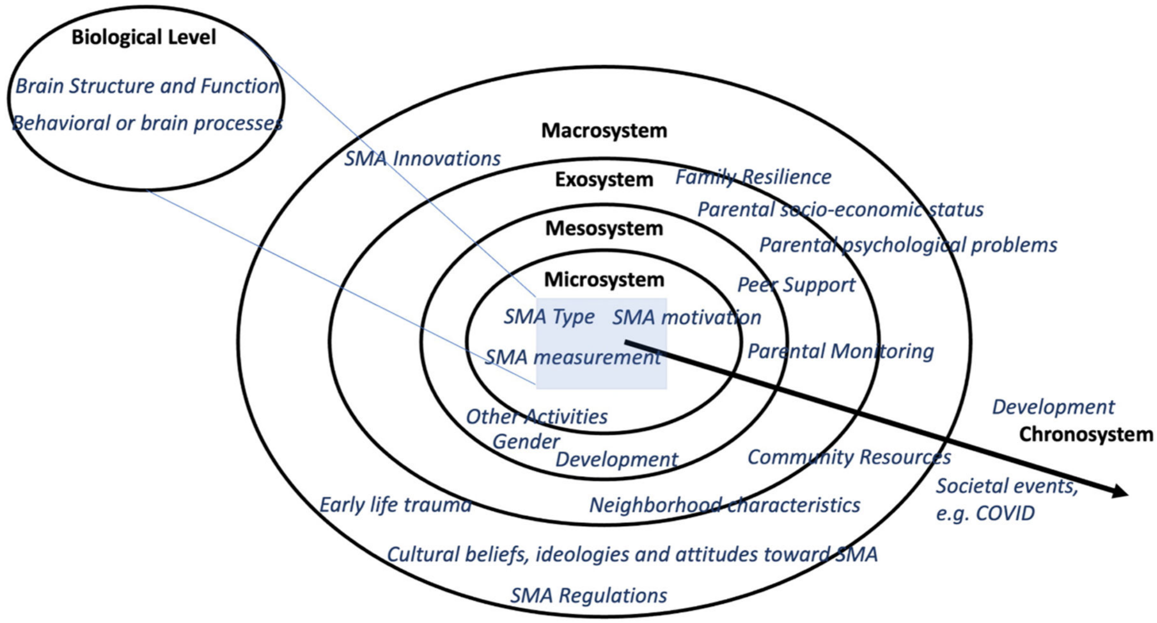

Fig. 1.

Bronfenbrenner model conceptual overview of screen media activity and mental health. According to the bioecosystem theory, mental health outcomes associated with SMA are shaped by dynamic interactions between individual-level factors and various environmental systems, which vary in their proximity to the individual. The Microsystem encapsulates the immediate environment, which can be multiple and diverse. The Mesosystem signifies interconnections or interactions between these microsystems. The Exosystem embodies the indirect environment, which potentially influences the individual. Lastly, the Macrosystem encapsulates broader sociocultural factors. These systems are proposed to function as an interactive, dynamic network, i.e. interacting with the Chronosystem (here shown as an arrow), which presents changes over time, with each level having different degrees of influence on mental health measures linked to SMA.The biological factors can be added into the micro-system as consisting of an individual level.

Table 1

Moderating factors for SMA effects on Mental Health.

Category	Moderating Factor	Ref.
Screen Media Activity Related Factors	Types of SMA	[72]
	Methods used to measure screen time	[19]
	Definition and conceptualization of “screen time”	[15]
	Timing of exposure during the lifespan	[73]
Demographic Factors	Sex-related differences	[16]
	Age of youth	[55,27]
	Gender (higher in girls)	[88]
Socioeconomic and Environmental Factors	Socioeconomic status	[75]
	Context of SMA occurrence (e.g., COVID-19 pandemic)	[23]
	Neighborhood violence and early life trauma	[78–80]
Family and Parenting Factors	Parental control and co-viewing in low SES families	[84]
	Parental psychological problems	[76]
	Parental phubbing	[77]
	Parenting styles	[87]
	Family function	[86]
	Family functioning and school connectedness	[84]
Health and Lifestyle Factors	Physical activity	[81]
	BMI	[82]
Psychological and Emotional Factors	Severity of mental health outcomes and motivation for media use	[74]
	Adverse childhood experiences	[83]
	Emotional self-regulation strategies	[85]
Support and Social Factors	Perceived social support	[85]

Table 2

Main Findings in the Literature integrated into the Bronfenbrenner Model of SMA.

Systems Level	Factors	Specific Findings in Literature
Biological	Brain structure/function, Neurodevelopmental subgroups, Brain connections and structures	Complex relationships between SMA and brain processing; Widespread networks involving cortical areas; Distinct neurodevelopmental subgroups; Specific brain connections and structures may play a role in SMA; Positive and negative effects of video games on brain function; Problematic smartphone use linked to altered brain connectivity
Microsystem	Types of SMA, Motivation for SMA, Accuracy of SMA Measurement, Definition of “Screen Time”	Association between SMA and depressive or anxiety disorders; Greater screen time linked to higher levels of internalizing symptoms; Specific uses of smartphones reported to exert negative effects on mental health; General pattern indicates excessive screen exposure typically associated with negative mental health effects
Mesosystem	Moderating role of sex on effects of SMA, Interactions between types of media, motivations, and SMA assessments, Interactions between other recreational activities and SMA, Peer support, Family conflicts, Parental monitoring of SMA, Physical activity and parental rules on social media	Higher daily time spent on social media linked to increased risk of depression in adolescents, especially girls; Prolonged screen time associated with low life satisfaction among adolescents; Complex relationship with mental health modulated by factors such as sex-related differences
Exosystem	Parents’ own screen media use patterns, Parental rules on screen media use, Parental psychological problems, Socioeconomic status, Family resilience, Community resources, Neighborhood safety, Neighborhood norms	Parental socioeconomic status related to children’s digital screen usage; Parental psychological problems correlated with increased screen time in children; Familial, peer, environmental factors complex interplay in youth affective and cognitive symptoms
Macrosystem	Cultural values, Media literacy, Media regulation, Media innovation	Cultural values shape youth’s online preferences; Media literacy enhances critical thinking; Media regulation sets standards; Media innovation creates new opportunities and challenges for youth’s SMA
Chronosystem	Age and developmental stage of the individual, Societal changes	Age and developmental stage exert complex effects; Societal changes like the advent of the smartphone and the COVID-19 pandemic influence SMA consumption and its effects