An exploration of the impact of smartphones in childhood on mind health in young adulthood

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Introduction

As digital technology becomes increasingly integrated into the lives of younger generations across the globe, its impact on mind health and wellbeing has emerged as a critical issue requiring urgent attention. The advent of smartphones, in particular, has transformed how individuals engage with the world, offering unprecedented access to information and virtual communication. However, these benefits are accompanied by growing concerns about the developmental and psychological consequences of early smartphone exposure.

This working paper primarily utilizes comprehensive mind health and wellbeing profiles and technology use data from over 130,000 young adults aged 18-24, predominantly from 59 countries from the Global Mind Project to provide a perspective on the implications of childhood smartphone use on mind health and wellbeing in adulthood, facilitating evidence-based policy decisions around smartphone use and regulation in childhood. The paper is structured into two sections to achieve this:

1) The first section examines trends in mind health and wellbeing, focusing on Generation Z, the first digital generation. The analysis of data from 131,037 18–24-year-olds reveals a systematic decline in mind health with younger ages of first smartphone ownership, particularly among biological females, driven by increases in suicidal thoughts, feelings of aggression, and hallucinations.

2) The second section explores the contributing factors associated with the relationship between early smartphone usage and poorer mind health and wellbeing, emphasizing the contribution of social media, disruption of sleep and the heightened likelihood of interpersonal traumas, such as cyberbullying and sexual abuse or assault, particularly in girls from Western countries. We show that these factors collectively account for approximately half of the observed trend.

Terminology: Mental wellbeing and mind health

While the terms 'mind health', 'mental health' and 'mental wellbeing' are often used interchangeably, they have different associations and connotations in people's minds. The World Health Organization (WHO) defines mental health and wellbeing as follows:

> *'Mental health is a state of mental wellbeing that enables people to cope with the stresses of life, realize their abilities, learn well and work well, and contribute to their community.'*

However, many people tend to conflate the term 'mental wellbeing' with their mood or happiness, while this is just one facet of our mental wellbeing. In addition, the term is often used in academic circles to predominantly reflect the positive psychology aspects of wellbeing (e.g. life meaning, purpose), and does not fully capture the full spectrum of mental functioning. Conversely, 'mental health' as a term is typically used to reflect mental challenges or clinical disorders such as depression and anxiety. In contrast, 'mind health' refers to the overall health of our mental processes, emotions, and cognitive abilities and therefore has a more functional association in people's mind. It spans the full range from what would be considered mental illness, includes feelings of happiness and, in the aggregate, encompasses the capacity to navigate life's challenges and function effectively in daily life. The term mind health is thus better aligned with the outcomes of the MHQ assessment that we report here, which encompasses 47 aspects of mental function assessed on a life impact scale that span the dimensions of Mood & Outlook, the Social Self (or relational aspects), Adaptability & Resilience, Drive & Motivation, Cognition and Mind-Body Connection (or physical aspects).

Section 1: The Relationships between Smartphones in Childhood and Mind Health as a Young Adult: The emergence of a new profile of symptoms

Background

Historically, psychological wellbeing, which refers to aspects of mood and positive feeling, has been characterized by a U-shaped curve across the lifespan in the western world, with higher levels of wellbeing typically observed in childhood and late adulthood, and a dip during midlife (Blanchflower 2021; Steptoe, Deaton, and Stone 2015; Stone et al. 2010). However, recent evidence from the Global Mind Project and others suggests this U-shaped curve has collapsed (Blanchflower 2023; Sapien Labs 2023b, 2024). For example, multiple sources have documented a decline in adolescent and young adult mental health over the past few decades, with increasing rates of anxiety, depression, and other indicators of distress (Askari et al. 2023; Butterworth et al. 2022; CDC 2020; Keyes et al. 2019; Krokstad et al. 2022; Lu and Keyes 2023; McCurdy and Murphy n.d.; Twenge et al. 2019). Correspondingly, the Global Mind Project has shown that aggregated metrics of mind health, are declining with successively younger generations not just in the west but across the internet-enabled world of every country and continent studied (Figures 1A, 1B; Table 1; Supplementary Table 1), (Sapien Labs 2023b, 2024, 2025). Across the global Internet-enabled population, 45% of 18–24-year-olds struggle with their mind health at a level that has functional consequences, and with symptomatic distress that would be considered of clinical concern. In the United States (US) and India where Global Mind data is also available for 13–17-year-olds, the majority (56%) are struggling, a 7-fold increase compared to their grandparent's generation (Figure 1C).

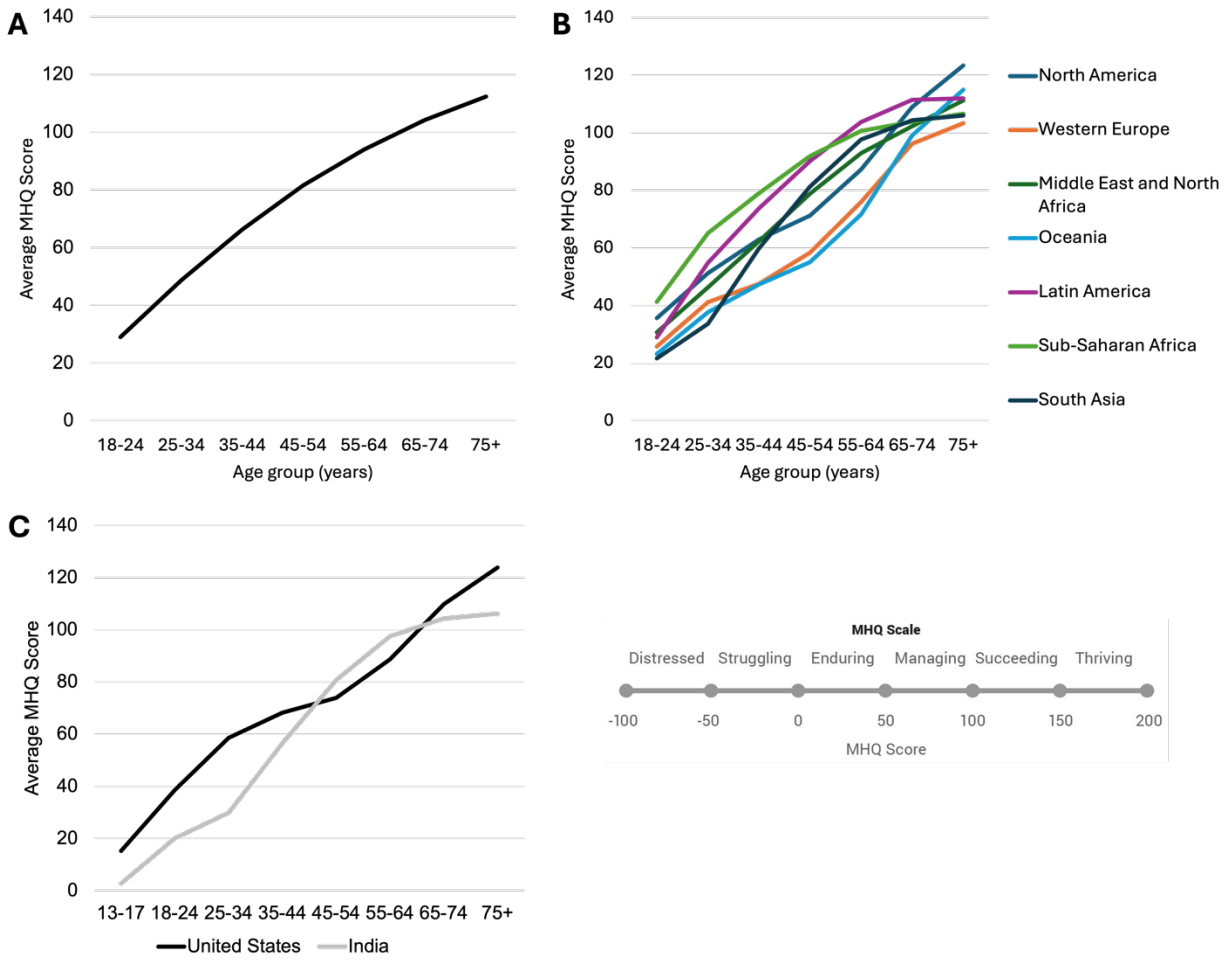


Figure 1: *Trend of lower mind health in younger generations compared to older generations. Numbers from graphs shown in Supplementary Table 1. (A) Global trend in average MHQ scores in adults aged 18-24 through to 75+ (N = 761,462; 2024). (B) Comparison of average MHQ scores for younger (age 18-24) and older ages (age 55-64) across different regions of the globe. See Figure 2 for the countries included in each region (N = 761,462; 2024). Percentage Distressed/Struggling for each age and region group shown in Table 1. (C) Average MHQ scores in the US (black) and India (grey), showing the trends down to age 13-17 (India: N = 19,847; US: N = 4,423). Note: The MHQ scale from -100 to +200 showing the different score categories from Distressed to Thriving.*

Table 1: Percentage Distressed/Struggling for each age group, overall and for each region in younger generations compared to older generations. Data also shown for US and India including 13-17 data.

Country/Region	13-17	18-24	25-34	35-44	45-54	55-64	65-74	75+
Global		44.8%	34.0%	25.2%	18.4%	13.6%	9.3%	6.4%
North America		40.9%	32.0%	26.7%	24.7%	17.6%	8.5%	4.3%
Western Europe		45.8%	36.4%	33.7%	28.4%	20.2%	10.9%	7.8%
Middle East and North Africa		42.8%	33.4%	25.1%	17.3%	12.0%	8.8%	5.5%
Oceania		46.8%	40.0%	35.7%	31.5%	22.8%	12.1%	5.3%
Latin America and Caribbean		45.7%	32.5%	23.7%	17.0%	11.9%	8.4%	7.6%
Sub-Saharan Africa		36.4%	25.2%	19.6%	15.3%	11.5%	10.8%	9.2%
South Asia		49.5%	42.4%	27.8%	17.1%	10.9%	8.3%	7.1%
US	52.6%	39.0%	28.4%	25.2%	23.9%	17.1%	8.7%	4.4%
India	60.8%	50.7%	45.1%	30.6%	18.4%	11.5%	8.4%	6.9%

What has changed to cause this global decline?

One factor that corresponds to this time period is the rapid proliferation of technology and the ubiquity of smartphones and social media, especially amongst youth (Common Sense Media 2021; Data Reportal 2024; Our World in Data 2024; Pew Foundation 2022; Poushter 2016; Silver 2019). For example, according to the Global System for Mobile Communications Association's (GSMA) annual State of Mobile Internet Connectivity Report 2024, over half (57%) of the global population (4.6 billion people) now owns a smartphone (GSMA 2024) with the typical internet user spending 6 hours and 40 minutes online each day (Data Reportal 2024). Estimates from the US suggest 48% of 18–29-year-olds are online 'almost constantly' (Pew Foundation, 2022) with teens aged 13-18 spending on average 8.4 hours a day on entertainment screen use, while 8–12-year-olds spend an average of 5.3 hours (Common Sense Media, 2021). These statistics, together

with the trends of declining mental health in youth has generated significant debate regarding the impact of technology on mental health and wellbeing. For example, numerous studies have examined the impact of screen time and social media on mental health and wellbeing with often varied and opposing findings and opinions (Odgers 2018; Orben et al. 2022; Orben and Przybylski 2019; Twenge 2020; Twenge, Martin, and Campbell 2018). In general, smaller effects are reported when males and females are combined (Orben and Przybylski 2019) whereas larger effects are observed when females are analyzed separately or when analysis is limited to social media rather than all digital media (Twenge et al. 2020).

The age at which one gets their first smartphone is one of the biggest difference across generations suggesting the possibility of developmental effects. GenZ, today's adolescents and young adults, are the first generation raised as digital natives. Grass roots campaigns such as Wait Until 8th in the US and Smartphone Free Childhood in the United Kingdom (UK) have been campaigning for parents to delay giving their child a smartphone because of the potential harms, but there is still only limited evidence on the impacts of giving a child a smartphone earlier in childhood. Studies to date are small scale, often county specific and have shown conflicting results (Dempsey, Lyons, and McCoy 2019, 2020; Gerosa and Gui 2023; Gerosa, Losi, and Gui 2024; Jaalouk and Boumosleh 2018; Sun et al. 2023). For example, one study investigating the impact of smartphone ownership on sadness and sleep outcomes in 263 children from 2012 to 2017 found no statistically significant associations (Sun et al. 2023) while another study found a statistically significant and negative relationship between early mobile phone ownership and academic outcomes and mental wellbeing (Dempsey et al. 2019). There is therefore a need to better understand the relationship between the age at which children first own a smartphone and their mind health outcomes using large-scale, global data that can capture a multidimensional picture of both mind health, and broader life context including age of smartphone ownership.

The Global Mind Project

The Global Mind Project is a unique initiative that acquires data from the literate Internet-enabled world to systematically examine the evolving landscape of mind health in the context of multidimensional determinants that reflect the social, cultural, technological and environmental world in which we live and work. This project adopts a global perspective, with outreach conducted across over 70 countries in 17 languages to capture variations in mind health across different demographic and sociocultural contexts. It utilizes an online, self-report tool called the Mind Health Quotient (MHQ) to capture 47 different aspects of mind health and generates a single composite metric, the MHQ score, as well as sub-scores across six dimensions of mind health: Mood and Outlook, Social Self, Mind-Body Connection, Drive and Motivation, Cognition, and Adaptability and Resilience (Newson, Hunter, and Thiagarajan 2020; Newson, Pastukh, and Thiagarajan 2022; Newson, Sukhoi, and Thiagarajan 2024; Newson and Thiagarajan 2020). The Global Mind project therefore provides an opportunity to explore the association between mind health and technology habits at larger scale, in particular the age at which someone gets their smartphone during childhood, across a large-global sample, whilst also considering the impacts from a multidimensional perspective, and taking into account the wider ecosystem of lifestyle and life experience factors. In this first section, we focus on 18-24-years-olds and how the age at which they first owned their smartphone in childhood impacts their mind health.

Methods

Data acquisition

Data used in section 1 of this working paper are taken from the Global Mind Project. Data were obtained between January 2023 to October 2024 from 131,037 internet-enabled 18–24-year-olds (63% females, 37% males) who were predominantly from 59 countries across North America, Western Europe, Latin America and the Caribbean, Oceania, South Asia, Middle East, North Africa and Sub-Saharan Africa (Figure 2). Participants were recruited as part of the ongoing Global Mind Project through online advertisements placed on

Facebook and Google that targeted age-sex groups (18-85+) and geographical regions across broad based interests and key words (Taylor et al. 2023). Participants were directed to the MHQ website (https://sapienlabs.org/mhq/) and completed the anonymous self-report MHQ assessment for the purpose of getting their mind health scores and personalized report.

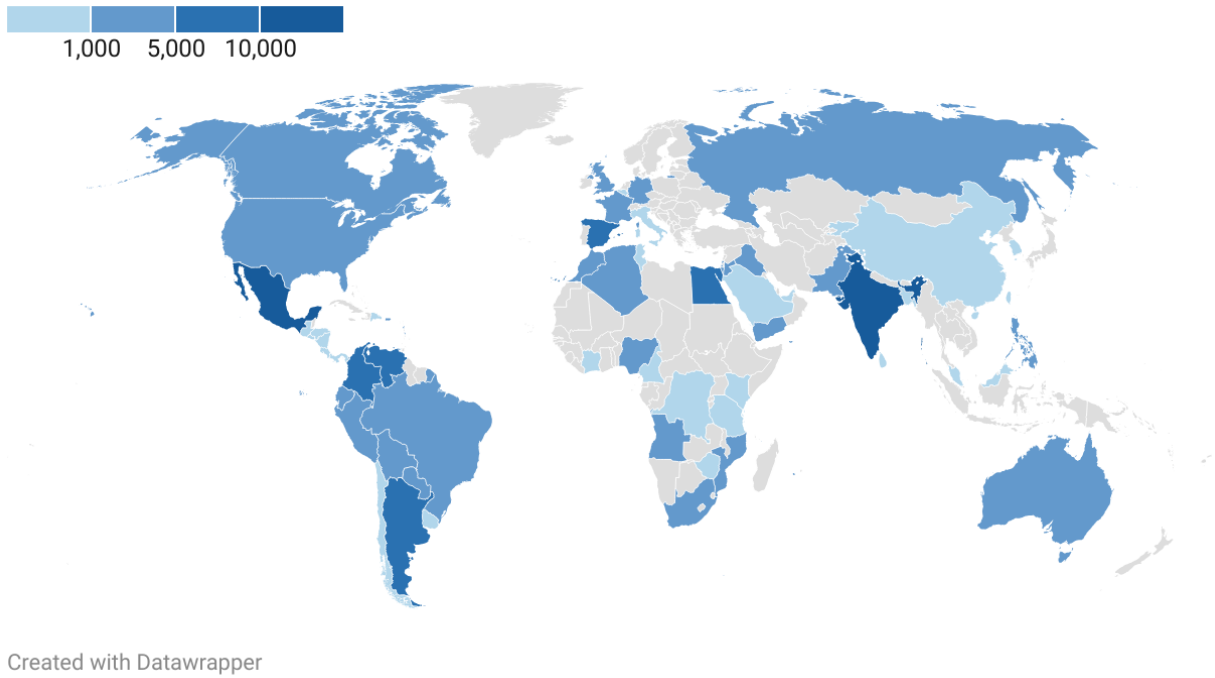


Figure 2: *Illustration of the countries and sample sizes included in this analysis. Values and regional groupings shown in Supplementary Table 2.*

Presently, 1,000-2,000 people complete the assessment each day and are added to a dynamic database. In addition to the scored questions on mental feeling and function, respondents answer various demographic, lifestyle, and life experience questions including age of smartphone ownership: '*At what age did you get your own smartphone with Internet access that you could carry with you?'*.

The Global Mind Project is a public interest project that has ethics approval from the Health Media Lab Institutional Review Board (HML IRB), an independent IRB that provides assurance for the protection of human subjects in international social and behavioral

research (OHRP Institutional Review Board #00001211, Federal Wide Assurance #00001102, IORG #0000850).

The MHQ

The MHQ captures 47 aspects of mind health including symptoms across 10 major mental health disorders as well as items derived from Research Domain Criteria (RDoC) (Newson and Thiagarajan 2020). Items were determined based on a comprehensive coding of mental health symptoms assessed in questions across 126 different mental health questionnaires and interviews. Within the MHQ, each of these 47 items are rated by respondents using a 1-9 life impact scale (i.e. a Likert scale with 9 positions) reflecting the impact on one's ability to function. For the items on a spectrum from positive to negative (spectrum items such as self-image), the rating scale is defined as follows: a 1 rating on the 9-point scale refers to *Is a real challenge and impacts my ability to function*, the 9 rating refers to *It is a real asset to my life and my performance,* and the 5 rating refers to *Sometimes I wish it was better, but it's ok*. For the items with varying degrees of problem severity (problem items such as suicidal thoughts): the 1 rating on the 9-point scale refers to *Never causes me any problems*, the 9 rating refers to *Has a constant and severe impact on my ability to function,* and the 5 rating refers to *Sometimes causes me difficulties or distress but I can manage*. Respondents rate these elements based on their current perception of themselves.

Ratings from these 47 items are aggregated into a score (the MHQ score) that positions individuals in six categories from *Distressed* to *Thriving* (Newson et al. 2024). The score is based on an algorithm that thresholds ratings as negative and positive based on the impact to function and applies a nonlinear transformation of the scale such that increasing negative impact to function is amplified. The resulting MHQ scores fall on a positive-negative continuum. The MHQ score has been shown to have strong sample-to-sample consistency as well as criterion validity using data from 179,298 people across eight English-speaking countries. This includes demonstration that, in the aggregate, average

number of clinical symptoms and clinical diagnoses increase systematically as MHQ scores decrease, and that MHQ scores are linearly related to work productivity, including absenteeism and presenteeism (Newson et al. 2022, 2024).

Dimensional scores are aggregate scores constructed from subsets of the 47 items in the assessment using the same scale as the MHQ and similar principles. For instance: Social Self includes ratings of elements such as *Self-image*, *Self-worth & confidence*, *Relationships with others*, and *Social interaction & cooperation* as well as problems such as *Feeling of aggression towards others* and *Suicidal thoughts & intentions*. Mood & Outlook includes ratings of asset items such as *Stability & calmness*, *Emotional control,* and *Outlook & optimism* as well as problem items such as *Fear & Anxiety*, *Feelings of sadness, distress or hopelessness* and *Mood Swings*. Adaptability & Resilience includes ratings of items such as *Adaptability to change*, *Emotional resilience*, *Creativity & problem solving,* and *Ability to learn*.

Data exclusion criteria

Only those respondents who stated that they found the MHQ easy to understand were included in this analysis. This exclusion criterion was applied by only selecting respondents who answered "Yes" to the final question in the MHQ which asks them "Did you find this assessment easy to understand?". Also excluded were those assessments completed in under 7 minutes (the minimum time needed to read and respond to the MHQ), and those where response ratings had a standard deviation of less than 0.2, indicating that the same rating value was selected across all 47 rating items.

Data analysis and statistics

Average MHQ scores, dimensional scores, and average ratings for each of the 47 problems and mental capabilities assessed, were calculated separately for females and males for each age of smartphone ownership for the global data in its entirety (131,037 18-24-year-olds, 63% females, 37% males). These same averages were also calculated for seven

geographical groupings: North America (*N* = 6,192; 3,756/61% females, 2,436/39% males), Western Europe (*N* = 15,357; 10,036/65% females, 5321/35% males), Latin America (*N* = 49,560; 30,197/61% females, 19,363/39% males), South Asia (*N*= 23,788; 15,135/64% females, 8,653/36% males), Sub-Saharan Africa (*N*= 11,246; 7,120/63% females, 4,126/37% males), Middle East and North Africa (*N*= 18,304; 11,545/63% females, 6,759/37% males) and Oceania (*N*= 1,904; 1,208/63% females, 696/37% males).

Results

Relationship between age of smartphone ownership and mind health

For young adults aged 18-24, and aggregated across all regions, owning a smartphone before age 13 was associated with significantly lower MHQ scores and higher probability of scores in the lowest *Distressed* or *Struggling* ranges (MHQ scores<0), compared to first owning a smartphone after age 13 (Figure 3A and 3B; Supplementary Table 3). In particular, those who reported owning their first smartphone at ages 5 or 6 had sharply lower MHQ scores with almost 70% of females and 50% of males having MHQ scores in the *Distressed* or *Struggling* range compared to 51% (females) and 38% (males) of those who reported owning their phone at age 13. 18-24-year-olds who reported owning their first smartphone from age 13 onwards did not show significantly different MHQ scores, although approximately 50% of females and 40% of males still had MHQ scores in the *Struggling* or *Distressed* range. Notably, the *Social Self* dimension of mind health, which encompasses how we see ourselves and our capacity to relate to others, showed the most pronounced decline with younger age of smartphone ownership (Figure 3C, 3D).

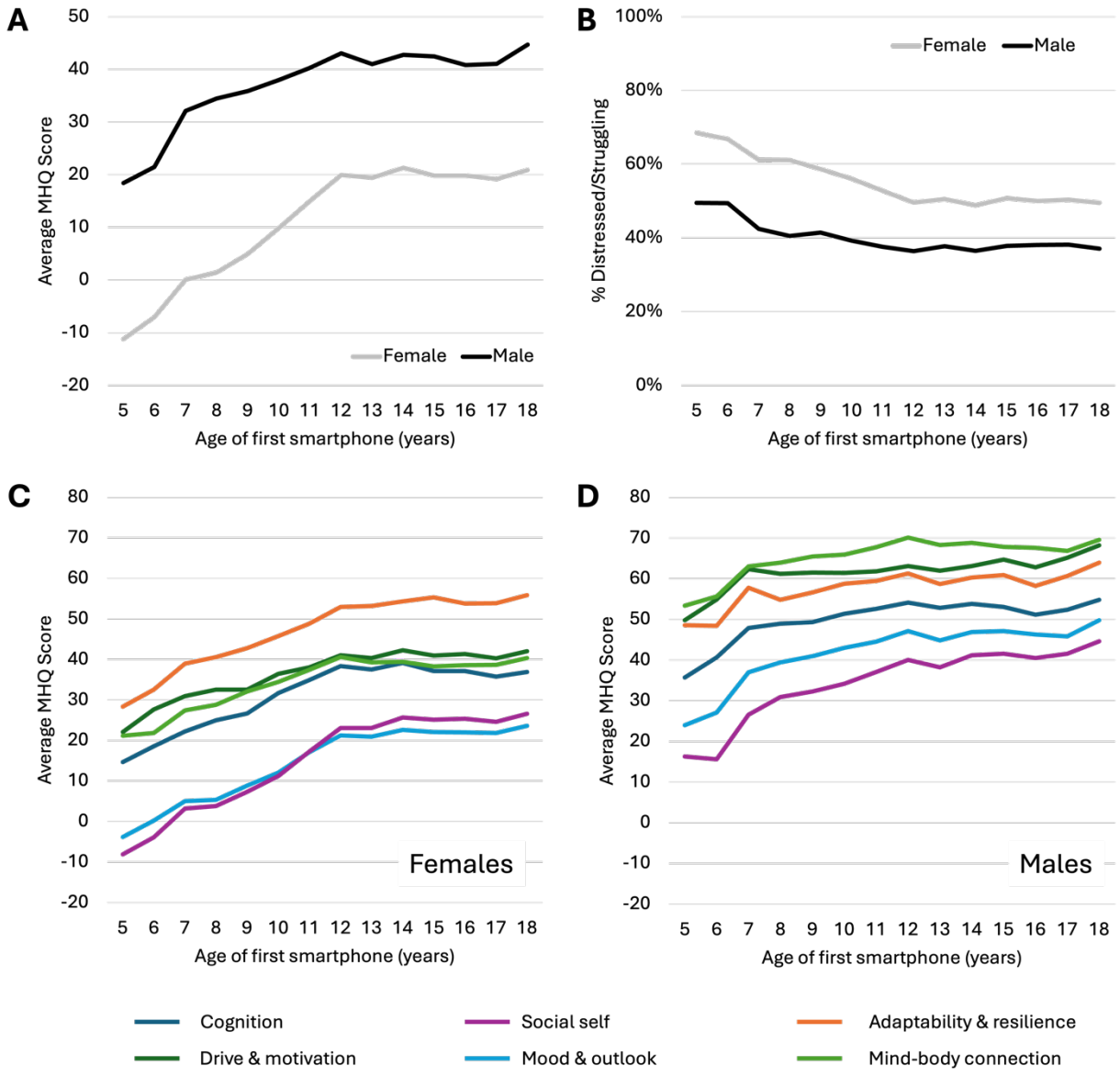


Figure 3: *Relationship between age of smartphone ownership during childhood and mind health at age 18-24 (global). Values shown in Supplementary Table 3. (A) Relationship between average MHQ scores in 18–24-year-olds and age of smartphone ownership during childhood for males (black) and females (grey; all regions aggregated). (B) Relationship between the % Distressed/Struggling (MHQ scores<0) in 18–24-year-olds and age of smartphone ownership during childhood for males (black) and females (grey; all regions aggregated). (C) Relationship between average MHQ scores for each of the 6 dimensions in female 18–24-year-olds and age of smartphone ownership during childhood (aggregated across regions) (D) Relationship between average MHQ scores for each of the 6*

dimensions in male 18–24-year-olds and age of smartphone ownership during childhood (aggregated across regions).

This trend was evident across Internet-enabled populations globally and was consistent across all regions of the world (Trend in females shown in Figures 4A & 4B. Males shown in Supplementary Table 4). In addition, the trend was observable in both males and females, though it was markedly more pronounced among females. Females not only demonstrated a steeper decline in MHQ scores with earlier age of smartphone ownership but also consistently exhibited lower MHQ scores relative to their male counterparts overall.

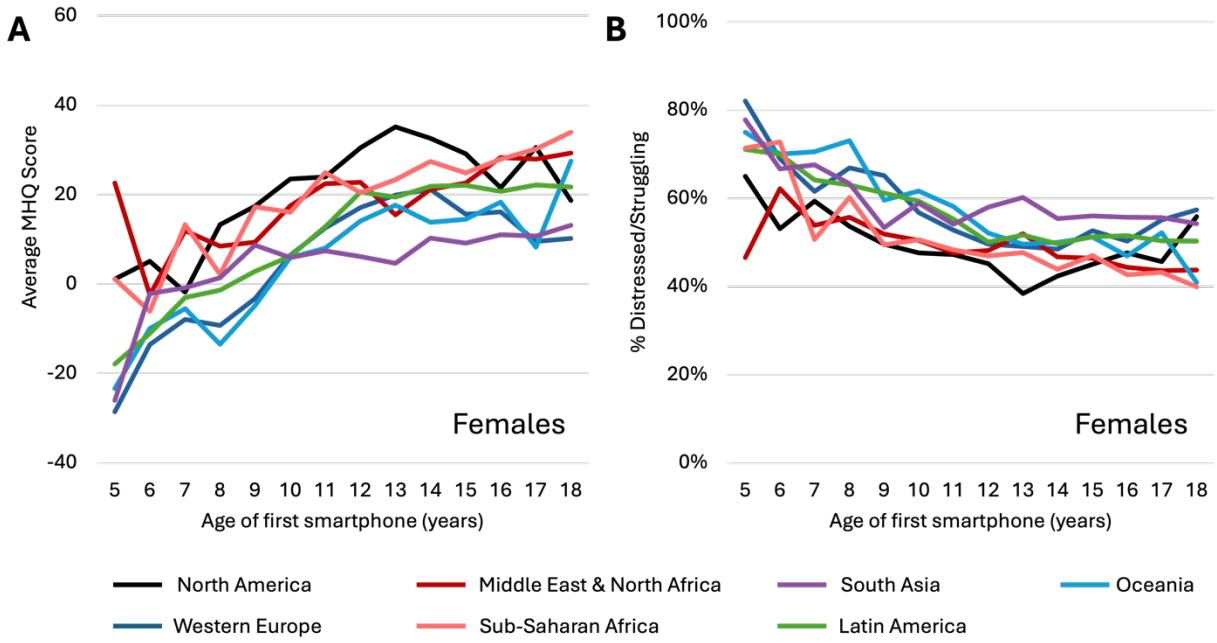


Figure 4: *Regional relationship between age of smartphone ownership during childhood and mind health at age 18-24. Values shown in Supplementary Table 4. (A) Relationship between average MHQ scores in females aged 18–24-year-olds and age of smartphone ownership during childhood across the 7 different regions. (B) Relationship between the % Distressed/Struggling (MHQ scores<0) in females 18–24-year-olds and age of smartphone ownership during childhood across the 6 regions. Trends for males shown in Supplementary Table 4.*

Relationship between age of smartphone ownership and individual MHQ items

Of the 47 aspects of mind health captured by the MHQ, 30 were significantly associated with age of first smartphone ownership in females and 15 were significantly associated with age of first smartphone ownership in males ($p<0.001$; Supplementary Table 5). For females aged 18-24, the capacities of positive self-image, self-worth and confidence, sleep quality, emotional resilience, and emotional control declined with a younger age of first smartphone (Figure 5A; Supplementary Table 6). Correspondingly, problems with suicidal thoughts were most steeply and significantly higher in females aged 18-24 who reported getting their first smartphone at a younger age, followed by problems with aggression towards others, a sense of being detached from reality, repetitive & compulsive actions, and hallucinations (Figure 5B).

In males aged 18-24, the ranking of capacities and problems most impacted by age of smartphone ownership was slightly different. In particular, males who reported getting their smartphone at a younger age had diminished capabilities of relationships with others, outlook & optimism, stability & calmness, self-worth & confidence, and empathy (Figure 5C). In addition, young adult males who had got their first smartphone at a younger age had increased problems with suicidal thoughts, feelings of sadness, distress & hopelessness, guilt & blame, restlessness & hyperactivity, and hallucinations (Figure 5D).

It is of significance that while these problems in both males and females (with the exception of suicidal thoughts in females) tend to level off for age of first smartphone after age 13, reflecting the pattern of overall MHQ scores shown above, the decline of capacities persists even for age of first smartphone from 13 to 17. Thus, while the sharpest gains can likely be had by delaying the age of first smartphone to 13, there are population benefits even for further delays.

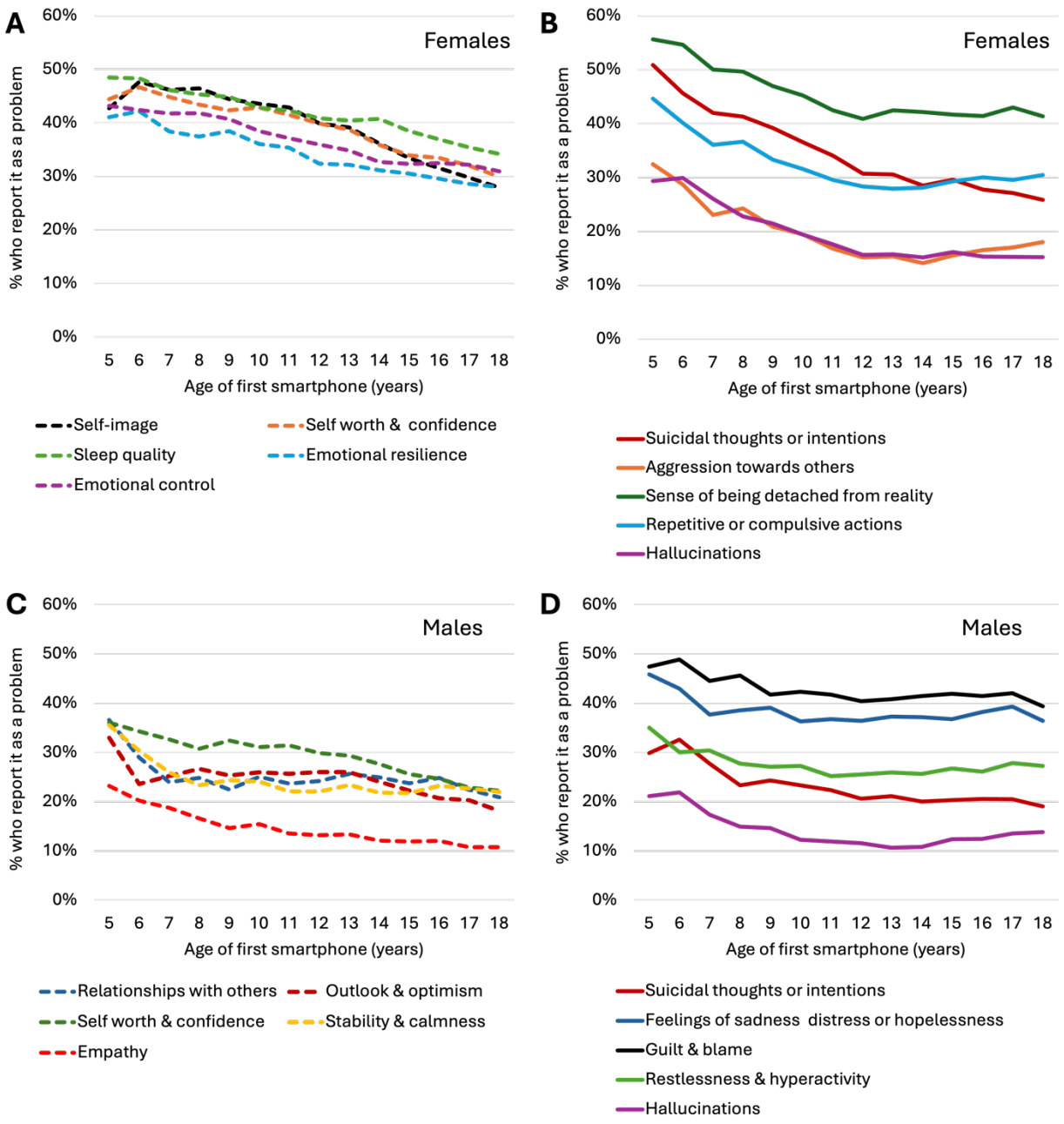


Figure 5: *MHQ items showing the biggest difference between younger vs older age of first smartphone ownership for females (A, B) and males (C,D). Top 5 Spectrum items are shown in (A) and (C). Top 5 problem items are shown in (B) and (D). Values shown in Supplementary Table 6.*

Smartphone ownership trends

Estimates of smartphone ownership trends by country will be influenced by internet penetration rates which vary widely across the globe (World Bank 2024). In this data, globally (which represents only those who have a smartphone), the average age of first smartphone ownership among 18–24-year-olds was 13. Notably in the US it was 12.6 for 18–24-year-olds and 11.7 for 13–17-year-olds, while in India it was 15.9 for 18–24-year-olds but 13.2 for 13-17 olds, a full 2.5 years younger (see Supplementary Table 7 for the average age of smartphone ownership for each country, together with the internet penetration percentages). In addition, it is also notable that the age of first smartphone is rapidly getting younger (Common Sense Media 2021; Ofcom 2024), reflecting the penetration of both broadband, and greater affordability of data and smartphones (Table 2).

Table 2: Comparison of average age of smartphone ownership in males and females aged 13-17 and aged 18-24.

	Males		Females	
Country	**Age 13-17 (years)**	**Age 18-24 (years)**	**Age 13-17 (years)**	**Age 18-24 (years)**
United States	11.9	12.8	11.5	12.4
India	13.3	15.7	13.1	16.1

Discussion

The findings of this study highlight a significant relationship between the age of first smartphone ownership in childhood and mind health outcomes in early adulthood, as measured by the MHQ. This association between age of smartphone ownership and mind health indicates a cumulative impact of smartphone ownership and usage that is in line with other evidence that suggests that owning a smartphone from a younger age results in more problematic and pervasive smartphone use as individuals grow older (Gerosa et al. 2024).

Altogether, across the globe, a younger age of smartphone ownership in childhood is associated with a progressive erosion of various important capacities from self-worth, optimism, emotional resilience, emotional control and empathy and a corresponding progressive rise in suicidal thoughts, aggression, hallucinations, and a sense of being detached from reality. It is of substantial importance that these factors are not the commonly observed or measured symptoms of sadness or anxiety. Rather they represent a new pattern of symptom profiles that seem to be unique to our technology-driven world, with serious implications for society, particularly with respect to a diminished capacity for cooperative social endeavours, and an increased potential for violence. In the US for example, the Centers for Disease Control and Prevention (CDC) has reported rising rates of suicide and violence among adolescents (CDC 2023b, 2023a). In addition, at a country level, Social Self scores (the dimension that diminishes most steeply with younger age of smartphone ownership) is negatively correlated with country reported rates of violent assault (Sapien Labs 2022).

Differences in biological sex in the observed trends warrant particular attention. Females appear more vulnerable to the negative effects of early smartphone use, possibly due to differences in how digital technology is utilized (Leonhardt and Overå 2021; Svensson, Johnson, and Olsson 2022; Twenge and Martin 2020). For example, while boys may engage more in gaming, girls are more likely to use social media, which has been associated with higher rates of appearance-related anxiety, social comparison, and relational conflict (Caner, Efe, and Başdaş 2022; Steinsbekk et al. 2021). These sex-specific patterns, together with differences in developmental sensitivity (Orben et al. 2022), underscore the need for targeted interventions to address the unique risks faced by different demographic groups.

The declining age of smartphone ownership is also a global trend, with children in Western Europe and Latin America acquiring devices earlier than those in regions such as South Asia, Sub-Saharan Africa, and the Middle East. What's more, the generational shift is clear: today's adolescents receive smartphones at younger ages than their slightly older peers,

reflecting the increasing penetration and ubiquity of digital technology. While this trend underscores the potential for digital inclusion, it also amplifies the urgency of addressing its implications during critical developmental periods. As noted by Gerosa et al, '*Early smartphone receipt does not appear to confer a technology advantage; rather, the portability of smartphones and their constant supply of audiovisual stimuli may encourage their exclusive and pervasive use, especially if this begins earlier in life' (Gerosa et al. 2024)*.

What causes the impacts of younger age of first smartphone?

The cumulative negative effects of earlier smartphone ownership can potentially be attributed to several mechanisms. For example, smartphone ownership at a young age often coincides with critical developmental milestones, during which excessive digital engagement may displace opportunities for face-to-face social interaction and skill-building. Social behavior requires the mastery of nuanced cues such as facial expressions, tone of voice, and body language, which are often absent or distorted in virtual communication. As children spend increasing amounts of time in digital environments they may miss out on the "field practice" necessary for developing and sustaining social bonds. This displacement effect may lead to diminished social confidence, poorer self-image, and weaker interpersonal relationships, contributing to the observed decline in the Social Self dimension.

However, early smartphone ownership potentially also increases exposure to risks such as cyberbullying, online harassment, and inappropriate content (Charmaraman et al. 2022; Common Sense Media 2022; Ybarra, Mitchell, and Oppenheim 2022; Young 2024). These experiences are disproportionately reported by females, particularly in Western countries, and are strongly linked to long-term psychological harm, including heightened feelings of aggression, suicidal ideation, and emotional instability. The disruption of sleep, a well-documented consequence of smartphone use, exacerbates these challenges by impairing emotional regulation and cognitive functioning, further contributing to poorer mental health outcomes (Amez et al. 2020; Burnell et al. 2024; Dibben et al. 2023; Maurya et al.

2022; McCaffrey et al. 2024; Sá et al. 2023). In Section 2 we explore what could be behind the relationships between poorer mind health at age 18-24 and earlier age of smartphone ownership in childhood.

Section 2: How does a younger age of smartphone drive the diminished mind health in young adulthood?

Background

In Section 1 we showed that 18–24-year-olds who owned a smartphone at an earlier age during childhood had diminished capacities and increased problems relative to those who owned their smartphone at an older age. The problems with the strongest associations included suicidal thoughts, aggression towards others, hallucinations and a sense of being detached from reality. In this second section we aim to untangle what could be driving this association by 1) exploring to what extent other life context and interpersonal factors, that are known to be associated with poor mind health, are downstream of the age of first smartphone ownership and 2) evaluating their relative contributions using a modelling approach.

A growing body of literature has linked smartphone use to adverse lifestyle changes, including reduced sleep quality (Amez et al. 2020; Burnell et al. 2024; Dibben et al. 2023; Maurya et al. 2022; McCaffrey et al. 2024; Sá et al. 2023), increased consumption of unhealthy foods (Balhara 2022; Barros et al. 2023; Gonçalves et al. 2019; La Marra, Caviglia, and Perrella 2020; Ryu, Jang, and Oh 2022; Teo et al. 2018) and more sedentary activity (Fennell, Barkley, and Lepp 2019; Jeong et al. 2023; Xiang et al. 2019). Beyond lifestyle factors, heavy smartphone usage may also impact social and emotional development by altering relationships with family and friends (Kim et al. 2019; Merkaš, Bodrožić Selak, and Žulec Ivanković 2024). In addition, smartphone usage is also closely tied to a social media account, subjecting the child/adolescent to unhealthy social comparisons and judgement, while early smartphone exposure can also introduce children to age-inappropriate content and increase the risk of exposure to interpersonal traumas (e.g. cyberbullying, sexual abuse/assault) (Charmaraman et al. 2022; Young 2024).

This section therefore explores how the age of first smartphone ownership intersects with multiple key lifestyle and interpersonal factors that are critical for mind health: physical exercise, sleep sufficiency, and consumption of ultra-processed or "junk" food, as well as age of opening a social media account, closeness to the family, friendship quality, and experiences of two interpersonal traumas; cyberbullying and sexual abuse/assault. We look at the associations between various lifestyle and interpersonal factors by age of first smartphone in 18–24-year-olds and determine through regression models which of these may offer causal explanation.

Methods

Data used in Section 2 of this working paper is the same as that used in Section 1. All other details relating to data acquisition and exclusion criteria were the same as in Section 1. In order to explore other factors associated with the relationship between age of smartphone ownership and mind health outcomes, we utilized data relating to other lifestyle and interpersonal factors. These data were obtained from the following questions in the MHQ:

Lifestyle factors:

Ultra-processed food (UPF) consumption: *'How often do you eat processed, packaged, or fast food that is not made from fresh ingredients? e.g. McDonalds, Dominos, microwave meals, processed canned food, deli meats/cold cuts, noodles in a cup, packaged crisps/chips, sweets/candies, sodas/fizzy drinks'*. Answer options included: *Several times a day; Once a day; A few times a week; A few times a month; Rarely/never*

Sleep sufficiency: *'In general, I get as much sleep as I need:'* with answer options of: *All of the time; Most of the time; Some of the time; Hardly ever*.

Physical exercise: *'How regularly do you engage in physical exercise (30 minutes or more)?'*. Answer options included: *Every day*; *Few days a week*; *Once a week*; *Less than once a week; Rarely/Never*.

Interpersonal factors:

Closeness to family: *'How would you describe your relationships with your adult family?'*. Answer options included: *I don't have any family; I don't get along with most of them and prefer not to see them often; I get along OK with them but we are not close; I am very close to some of them but not all; I am very close to many of my family members*.

Close friends who help out: *'Do you have friends who would help you out when you are sick or have a problem (e.g. bring food, watch kids)?'*. Answer options included: *Yes; No; Not sure*.

Age of first social media account: 'At what age did you get your first social media account?' Answer options included: *I have never had any social media accounts, 1;2 ;3; 4; ;5 6; 7; 8; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19; 20; 21-25; 26-30; 31-35; 36-40; 41+*

Trauma and adversity: *'Did you experience any of the following during your childhood (before age 18)? Answer options included:*

Life threatening or debilitating injury or illness;
Sudden or premature death of a parent or sibling;
Parental Divorce or family breakup;
Prolonged physical abuse, or severe physical assault;
Prolonged sexual abuse, or severe sexual assault;
Physical violence in the home between family members (e.g. between parents);
Cyberbullying or online abuse;
Prolonged or sustained bullying in person from peers;
Prolonged emotional or psychological abuse or neglect from parent/caregiver;
Lived with a parent/caregiver who was an alcoholic or who regularly used street drugs;
Extreme poverty leading to homelessness and/or hunger;
Involvement or close witness to a war;

Displacement from your home due to political, environmental or economic reasons;
Serious injury, harm, or death you caused to someone else;
Suffered a loss in a major fire, flood, earthquake, or natural disaster;
Threatening, coercive or controlling behavior by another person;
Forced family control over major life decisions (e.g. marriage);
Caring for a parent or sibling with a major chronic disability or illness;
Parent/ Caregiver/Sibling with mental illness or who committed suicide;
Parent/Caregiver/Sibling went to prison;
I did not experience any of the above during my childhood;
Prefer not to say.

For the purpose of this study, we examined 2 specific interpersonal traumas including: *Cyberbullying or online abuse; Prolonged sexual abuse, or severe sexual assault*

Regression Analysis

A regression analysis was conducted on a subset of the Global Mind data collected between July 1, 2023 to November 30, 2024, from 64,779 18–24-year-olds (63% females, 35% males,2% preferred not to say) (Figure 2) and excluded individuals who were 18 or older when they first acquired smartphones and/or first acquired a social media account.

We ran a linear regression model where the outcome was the MHQ score and the primary coefficient of interest was the slope of the age at first smartphone ownership variable. This slope (or beta co-efficient) would be expected to change with the addition of other factors (variables) on the causal pathway between age at first smartphone ownership and MHQ. The other factors added to the model included: (i) age at first social media account, (ii) closeness to family (iii) Having close friends who help out, (iv) *Cyberbullying or online abuse,* (v) Prolonged sexual abuse or severe sexual assault*;* and (vi) sleep sufficiency and (vii) UPF consumption.

Since we wanted to gauge the relative importance of each factor in both explaining the age at smartphone-MHQ relationship, as well as to determine the importance of each factor to the R^2, we used two variants of a linear regression model. In the first approach, we included each factor first- i.e., right after the inclusion of the age of smartphone variable. This specification will in general provide an upper bound on the relative importance of the particular factor. In the second approach, we included the factor after the inclusion of every other factor. This specification should provide the "residual" importance of a specific factor after every other factor has been accounted for, i.e. accounting for all o the multi-collinearity in among the variables.

Approach 1: First addition

$$MHQ = \beta_{01} + \beta_{1,sph} Age\_sph + u_a \quad (1)$$
$$MHQ = \beta_{02} + \beta_{2,sph} Age\_sph + \beta_{agesoc} Agesocialmed + u_b \quad (2)$$
$$MHQ = \beta_{03} + \beta_{3,sph} Age\_sph + \beta_{famrel} Famrel + u_c \quad (3)$$
$$MHQ = \beta_{04} + \beta_{4,sph} Age\_sph + \beta_{friendhlp} Friendhlp + u_d \quad (4)$$
$$MHQ = \beta_{05} + \beta_{5,sph} Age\_sph + \beta_{cyber} Cyberbully + u_e \quad (5)$$
$$MHQ = \beta_{06} + \beta_{6,sph} Age\_sph + \beta_{sexab} Sexabuse + u_f \quad (6)$$
$$MHQ = \beta_{07} + \beta_{7,sph} Age\_sph + \beta_{upf} UPF + u_g \quad (7)$$
$$MHQ = \beta_{08} + \beta_{8,sph} Age\_sph + \beta_{sleep} Sleep + u_h \quad (8)$$

$\beta_{1,sph}$ represents the slope of the age at smartphone ownership (Age_sph) and MHQ relationship. For variant 1 in our model we add, separately, each additional factor as shown above. There are two statistics we compute to gauge the importance of a factor. First, the percent change in Beta after adding (in equation 2) the age at first social media posting ($Agesocialmed$) is given by: $\left(\left(\beta_{1,sph} - \beta_{2,sph}\right) \times 100 / \beta_{1,sph}\right)$. Second, we estimate the change in R^2 between the two models (for example, equation 1 and equation 2, equation 1 and equation 3, and so on).

Our **second approach** is similar to the first, except that we add each factor last—i.e., after the addition of all other factors.

For example, with the age at social media variable, Equation 9 when every factor except social media is included, and equation 9' where we also include social media.

$$MHQ = \beta_{02} + \beta_{2,sph} Age\_sph + \beta_X^{'} X_{-agesocmed} + u_b \quad (9)$$

$$MHQ = \beta_{02} + \beta_{2,sph} Age\_sph + \beta_X^{'} X_{-agesocmed} + \beta_{agesoc} Agesocialmed + u_b \quad (9')$$

Here the vector of variables, $X_{-agesocmed}$ represents all of the factors except for the age at first social media posting.

The statistics calculated are otherwise similar to approach 1 above.

The analysis computed two statistics obtained from the regression when adding each successive group of variables as follows:

1) the percent change in (β) that represents the slope of the relationship between the age at smartphone ownership and mind health.
2) The change in R^2 from the regression.

Results

Lifestyle factors

Ultra-processed food consumption (UPF)

Here we show the association between the age of first smartphone ownership during childhood and the frequency of UPF consumption in young adults aged 18–24 years. Young adults who owned a smartphone at an earlier age during childhood were more likely to report they consumed UPF 'Several times a day' or 'Once a day' compared to those who owned their smartphone from a later age during childhood (Figure 6A, 6B). This trend was present across both males and females. Furthermore, the pattern was observed across all Internet-enabled regions, with particularly pronounced effects in North America and Latin America.

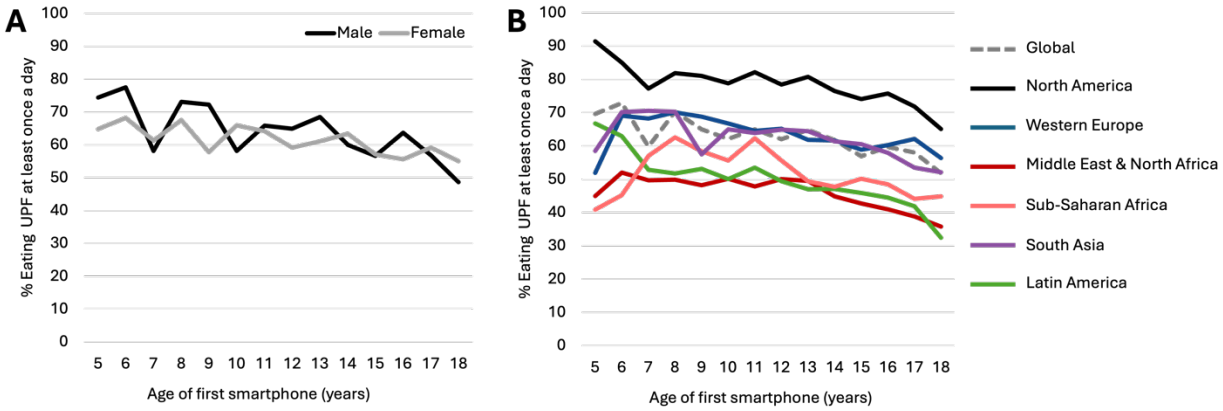
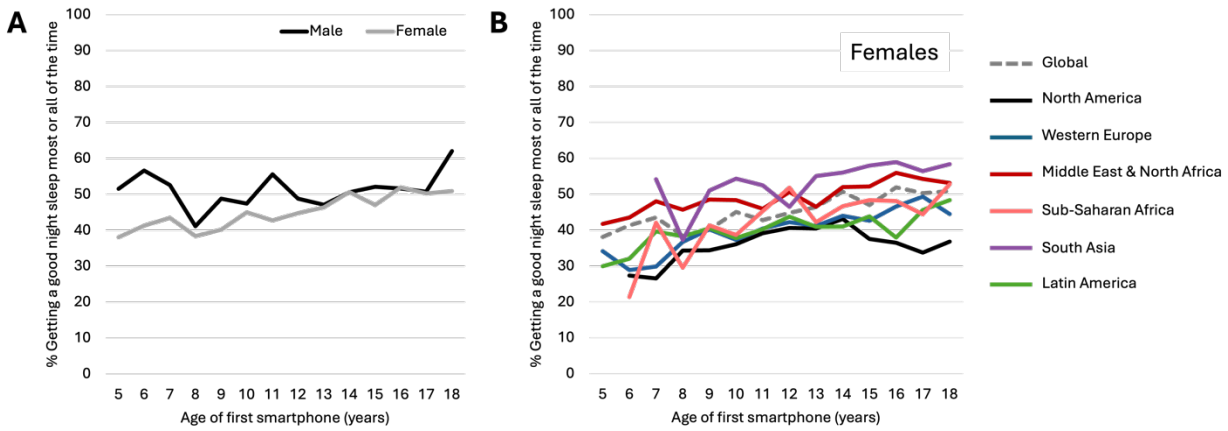


Figure 6: *Relationship between age of smartphone during childhood and UPF consumption frequency at age 18-24. (A) Global trend in males (black) and females (grey) at age 18-24. (B) Regional trend (males and females combined). Values shown in Supplementary Table 8.*

Sleep Sufficiency

Here we show the association between the age of first smartphone ownership during childhood and the reported frequency of good sleep among 18–24-year-olds. We found that females, aged 18-24 who owned a smartphone at a younger age during childhood were more likely to experience poor or insufficient sleep as shown by the percentage who indicated that that they slept well either 'All of the time' or 'Most of the time' (Figure 7A). This trend was not observed in males, highlighting a biological sex disparity in the impact of early smartphone use on sleep patterns (Figure 7A; see Supplementary Table 9) in line with other studies (Amez et al. 2020). This trend in females was present in most regions and particularly pronounced in Western Europe and Sub-Saharan Africa (Figure 7B).



595

596 ***Figure 7:*** *Relationships between age of smartphone ownership in childhood and sleep*
597 *sufficiency at age 18-24. (A) Global trend in males (black) and females (grey) at age 18-24.*
598 *(B) Regional trend in females aged 18-24. Values for males and females shown in*
599 *Supplementary Table 9.*

600

601 *Physical exercise*

602 Here we show the association between age of first smartphone in childhood and the
603 exercise frequency of 18–24-year-olds. There was no significant association between the
604 age of first smartphone ownership and the percentage who reported exercising regularly
605 (Every day or a Few days a week) in young adulthood in either males or females (Figure 8A,
606 8B; Supplementary Table 10).

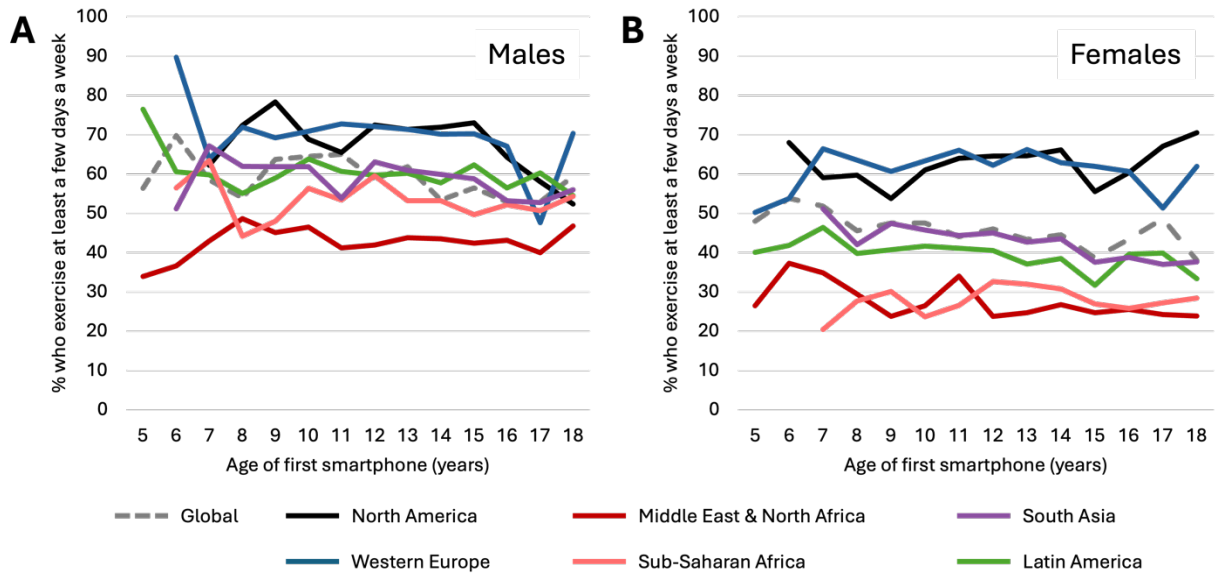


Figure 8: *Relationships between age of smartphone ownership in childhood and frequency of physical exercise at age 18-24. (A) Global and regional trend in males at age 18-24 (B) Global and regional trend in females at age 18-24. Values shown in Supplementary Table 10.*

Interpersonal factors

Closeness to Family

Here we show the association between age of smartphone in childhood to perceived closeness to family at age 18-24. Globally, young adults, and females more so than male, were slightly more likely to be close to their families ('very close to some family members but not all' or 'very close to many family members') if they got a smartphone at an older age (Figure 9A; Supplementary Table 11). At a regional level, this trend held for some regions (e.g. Latin America and the Caribbean) (Figure 9B). However, others (e.g. North America) had an inverted U-shaped pattern, with closeness to family declining for those who first owned a smartphone after the age of 13. These findings suggest that cultural and regional factors may interact with the timing of smartphone ownership to influence family relationships, highlighting the complexity of this dynamic.

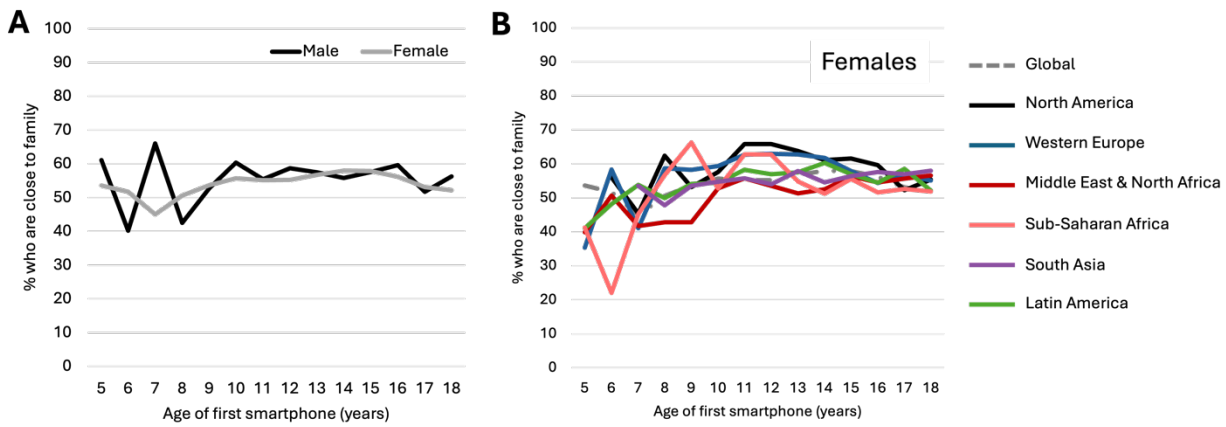


Figure 9: *(A) Relationship between age of smartphone ownership in childhood and family closeness at age 18-24 for males (black) and females (grey) globally. (B) Relationship between age of smartphone ownership in childhood and family closeness for females aged 18-24 globally and across regions. Values shown in Supplementary Table 11.*

Friendships

Here we show the relationship between the age of first smartphone ownership during childhood and the likelihood of having close friends who would help one out at age 18–24. Globally, young adults, and females in particular, were more likely to report having friends who would help them out if they received their first smartphone at an older age (Figure 10; Supplementary Table 12). This increasing trend was most prominent among females in the Middle East (Figure 10B). In contrast, an inverted U-shaped pattern was observed in Western Europe and North America where females who received smartphones after age 13 reported a lower likelihood of having close friends who would help them out while there was no relationship in South Asia. These findings again suggest that the timing of smartphone ownership interacts with cultural and social factors to influence the quality and accessibility of close friendships.

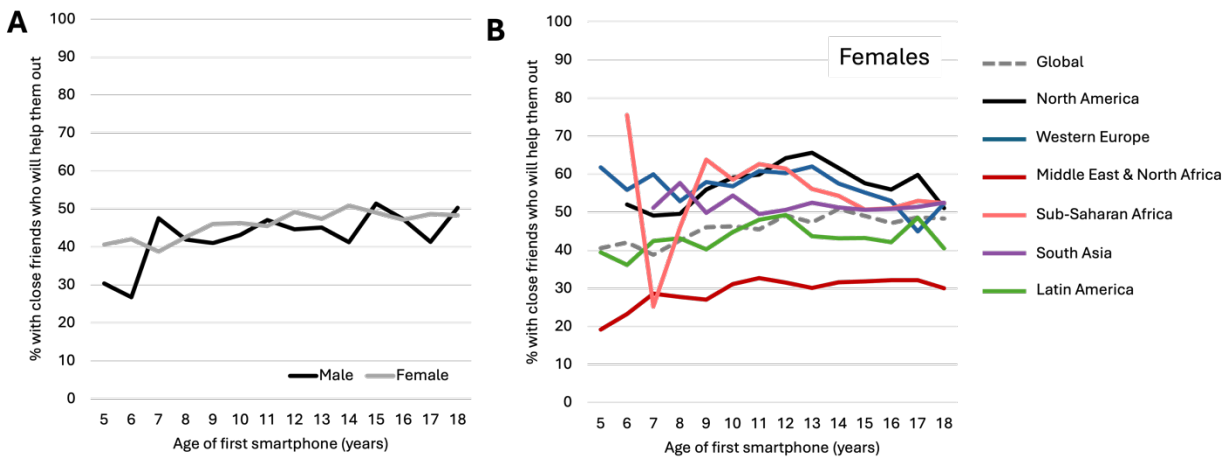


Figure 10: *Relationship between age of smartphone ownership in childhood and likelihood of having a friend who will help them out at age 18-24. (A) Global trend in males (black) and females (grey) aged 18-24. (B) Regional trend in females aged 18-24. Values shown in Supplementary Table 12.*

Age of social media account

Here we show an association between the age of first smartphone ownership and the age at which someone gets a social media account. Across all regions and for both males and females, the younger the age of smartphone ownership, the younger the age of social media account. This trend was present for both males and females, and across all regions (Figure 11A, 11B; Supplementary Table 13). It is worth noting that while most social media platforms set the minimum age for account creation at 13, children who receive smartphones at a younger age often do not wait until 13 and instead report creating social media accounts as early as age 10 on average.

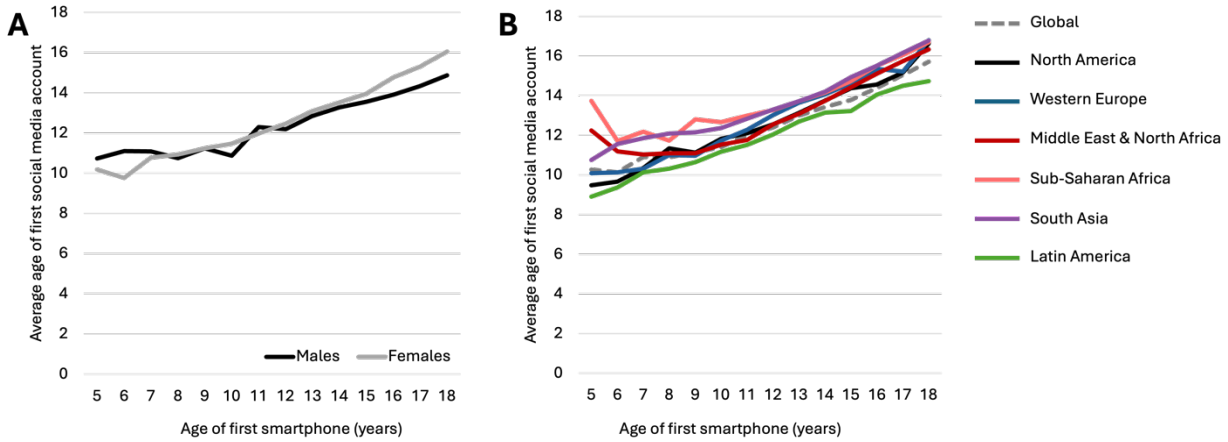


Figure 11: *Relationship between age of smartphone ownership and age of first social media account. (A) Global trend in males (black) and females (grey) at age 18-24). (B) Regional trend (males and females combined). Values shown in Supplementary Table 13.*

Cyberbullying:

Here we show the association between the percentage of 18–24-year-olds who reported having experienced cyberbullying and the age at which their owned their smartphone during childhood. In many regions, earlier age of smartphone ownership was associated with a greater likelihood of having experienced cyberbullying by age 18-24 (Figure 12; Supplementary Table 14). This trend was particularly pronounced in North America and Western Europe and was stronger in females than males.

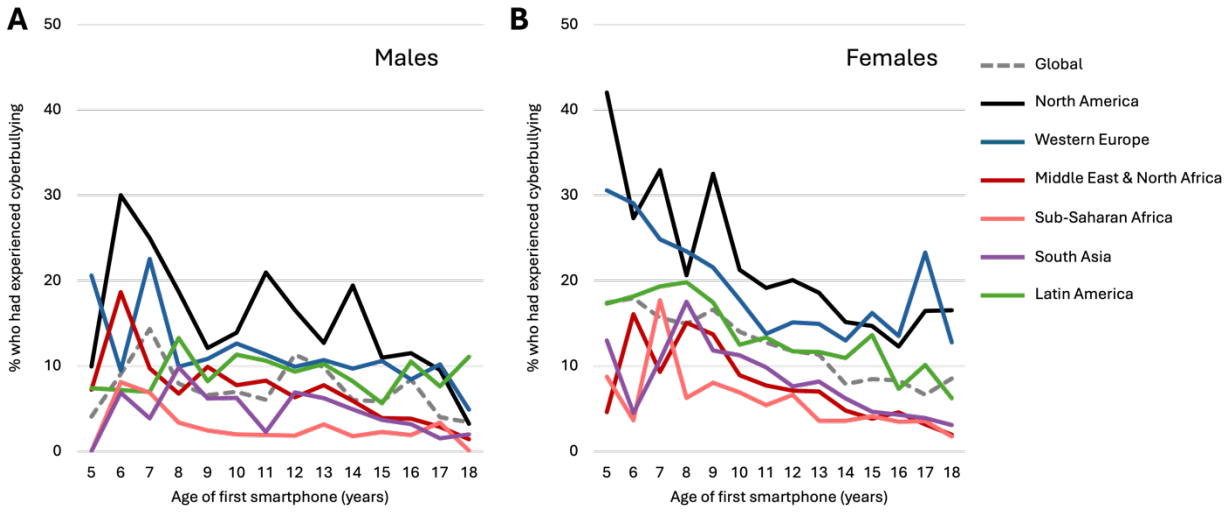


Figure 12: *Relationship between age of smartphone ownership in childhood and the likelihood of having experienced cyberbullying by age 18-24 in males (A) and females (B) globally and across the different regions. Values shown in Supplementary Table 14.*

Sexual abuse & assault

Here we show the association between the percentage of 18–24-year-olds who reported having experienced sexual abuse or assault and the age at which their owned their smartphone during childhood. In females in North America in particular, an earlier age of smartphone ownership was associated with a greater likelihood of having experienced sexual abuse or assault by age 18-24 (Figure 13; Supplementary Table 15). This trend was not present in other regions, or in males.

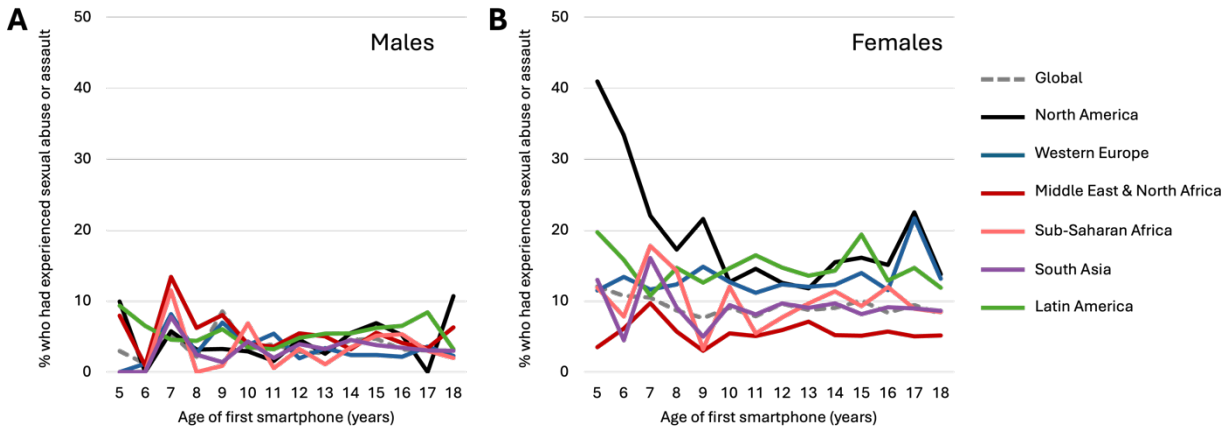


Figure 13: *Relationship between age of smartphone ownership in childhood and the likelihood of having experienced sexual abuse/assault by age 18-24 in males (A) and females (B) globally and across the different regions. Values shown in Supplementary Table 15.*

Overall contribution of lifestyle and interpersonal factors

We next looked at how much these factors contribute to the overall trend of diminished mind health with younger age of first smartphone using regression models. Here we report

the percentage change in the beta co-efficient (β), or slope, as well as the change in R^2 associated with the age of first smartphone variable with the addition of the following variables (i) age of first social media account; (ii) inter-personal trauma (cyberbullying, sexual abuse/ assault); (iii) social relationships (with friends and family); (iv) lifestyle (UPF consumption and sleep sufficiency). A change in slope with the addition of the aforementioned factors suggests that the factor is likely to contribute along the causal pathway that links the age of smartphone ownership during childhood with mind health at age 18-24. A change in R^2 indicates that the factor contributes to MHQ scores independent of any multi-collinearity with other variables in the model. Table 3 shows the percentage change in the beta coefficient for the age of first smartphone variable and change in R^2 for the overall population and for each region separately in regression models when each factor is added first. Table 4 shows equivalent results where each factor is added last, which controls for any multicollinear effects of other variables in the model. At a Global level, age of social media account appears to explain 34% to 41% of the association between age of first smartphone ownership and mind health when added last and first respectively setting an upper and lower bound. Similarly poor family relationships explained 4.2% to 13.4%, sleep challenges explained 9.9% to 12.3% and cyberbullying explained 3.9% to 10.6% (Table 3). Age of social media contributed 19.5% to 71% of the age of smartphone effect in the Core Anglosphere (USA, UK & Oceania) and 38.8% to 41.7% in Western Europe but only 7.5% to 25.3% in South Asia. Similarly, sleep contributed 0% to 31.5% in the Core Anglosphere, 22% to 34% in South Asia and 0% to 32% in the Middle East and North Africa but only in the range of 8% to 15% in other regions. The contributions of family relationships were relatively consistent across regions in the range of 13% to 19%. The contributions of UPF and sexual abuse at a global level were substantially smaller to negligible at 1.4% and 0.08% respectively. This was so across all regions except the Core Anglosphere where sexual abuse contributed 13.5%, consistent with the associations shown above in Figure 13. Altogether these factors accounted about 56% of the total effect of age of first smartphone indicating that other factors not captured here are at play.

When looking at the change in R^2, we find that family relationships and sleep contribute the most to mind health or MHQ scores over and above the impact associated with age of first smartphone, as indicated by the largest change in R^2 ranging from about 0.07 to 0.15 for family relationships and 0.05 to 0.11 for sleep. On the other hand, the age at social media posting that explained a substantial part of the age of smartphone effect, explains almost a minimal portion of the overall MHQ over and above age of first smartphone. In Table 4, where the factors are added last, the results are qualitatively similar, even when accounting for all other factors. Thus, while sleep and family relationships explain some of the effects of the effects of age of first smartphone on mind health, they also have independent effects. The limited effect of UPF suggests that the effects of UPF on mind health (Bala et al. 2025) are not related to age of first smartphone per se, though an association with patterns of smartphone use cannot be ruled out.

Table 3: Percentage change in the beta coefficient for the age of first smartphone variable and R^2 for the overall population and for each region separately in regression models where the age at social media variable is added first.

Geography	Statistic	Age social media	Family relationship	Friends help	Cyber bullying	Sexual	UPF	Sleep
Overall	% change in β_sph	40.98	13.41	2.40	10.60	1.44	0.08	12.33
	R2	0.00	0.12	0.07	0.02	0.03	0.00	0.07
Core Anglosphere	% change in β_sph	70.86	19.19	3.84	36.88	13.69	-0.92	31.67
	R2	0.01	0.15	0.08	0.06	0.04	0.00	0.11
Western Europe	% change in β_sph	41.68	11.08	2.06	12.80	4.37	0.44	15.89
	R2	0.01	0.14	0.08	0.05	0.03	0.00	0.11
Middle east/North Africa	% change	27.77	17.42	16.27	18.96	-4.10	3.56	32.75

	in β_sph							
	R2	0.00	0.14	0.06	0.02	0.01	0.00	0.11
Latin America	% change in β_sph	30.17	14.67	1.25	6.66	0.88	0.00	8.95
	R2	0.01	0.14	0.07	0.02	0.03	0.00	0.06
Sub-Saharan Africa	% change in β_sph	44.93	11.48	-1.56	7.14	-0.89	4.35	-6.36
	R2	0.00	0.07	0.03	0.01	0.01	0.00	0.08
South Asia	% change in β_sph	25.27	19.69	1.20	17.86	-1.76	1.34	34.93
	R2	0.00	0.14	0.09	0.01	0.01	0.00	0.08

Table 4: Percentage change in the beta coefficient for the age of first smartphone variable and R^2 for the overall population and for each region separately in regression models where the specified factor (in column) is added last.

Geography	Statistic	Age social media	Family relationship	Friends help	Cyber bullying	Sexual	Processed food	Sleep
Global	% change in β_sph	34.32	4.23	1.18	3.91	-3.34	0.17	9.95
	R2	0.00	0.07	0.03	0.01	0.01	0.00	0.04
Core Anglosphere	% change in β_sph	19.50	0.00	0.00	0.00	0.00	0.01	0.00
	R2	0.00	0.07	0.04	0.02	0.01	0.00	0.06
Western Europe	% change in β_sph	38.82	2.59	-1.27	1.67	2.10	0.44	16.06
	R2	0.00	0.06	0.03	0.02	0.01	0.00	0.05
Middle east/North Africa	% change	0.00	0.00	0.01	0.00	0.00	0.00	0.02

	in β_sph							
	R2	0.00	0.07	0.03	0.03	0.01	0.00	0.06
Latin America	% change in β_sph	32.96	6.83	0.12	2.71	-3.57	0.00	7.09
	R2	0.00	0.08	0.03	0.01	0.01	0.00	0.03
Sub-Saharan Africa	% change in β_sph	55.56	0.00	0.00	0.00	0.00	0.00	0.00
	R2	0.00	0.04	0.02	0.00	0.01	0.00	0.06
South Asia	% change in β_sph	7.50	6.76	2.32	6.76	-9.23	0.02	21.73
	R2	0.00	0.08	0.04	0.00	0.00	0.00	0.04

The impact of family closeness on age of smartphone

As this regression analysis showed that family closeness had the largest influence outside of social media (which is specifically dependent on a smartphone) we assessed whether family closeness conversely influenced the age at which children were given a smartphone. Figure 14 shows the relationship between mind health at age 18-24 (shown by the average MHQ score) and the age of smartphone ownership during childhood for those respondents who were close to their family, compared to those who were not close to family. Although MHQ scores were significantly lower for those who reported they were not close to or did not get along with their family compared to those who were close to many family members, a similar decline in mind health of almost 40 points was observed for both groups as age of smartphone decreased from age 16 to age 5. We next performed a similar regression analysis as above using closeness to family as the base variable and assessing how much adding the variable age of first smartphone influenced the beta coefficient. However, there was only a decrease of 0.04% after adding the age of first

smartphone indicating that families that are not close are not more likely to give their children smartphones at a younger age.

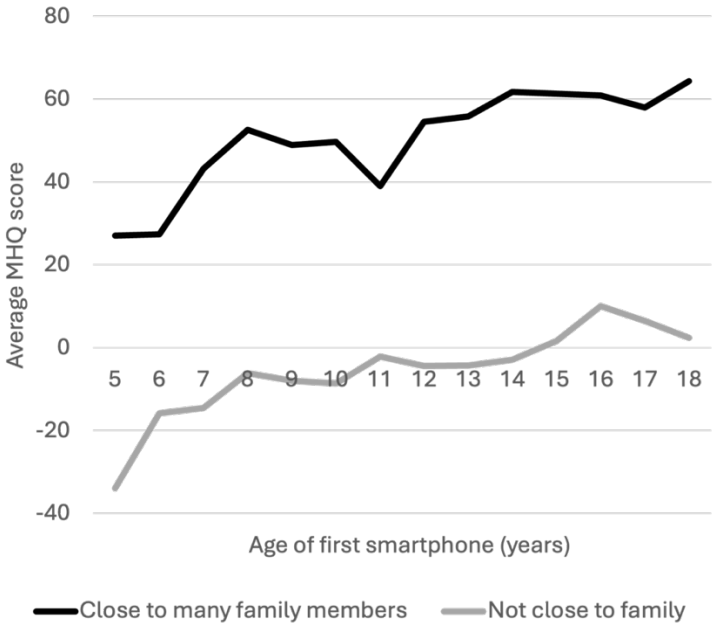


Figure 14: *Relationship between MHQ Score at age 18-24 and age of smartphone ownership in childhood for respondents who reported they were close to many family members (black) and those who reported they were not close to family (grey) (global). Values shown in Supplementary Table 16.*

Discussion

Altogether we show that the timing of smartphone ownership during childhood interacts with multiple dimensions of lifestyle and interpersonal experience, which collectively influence mind health trajectories in 18–24-year-olds. Particularly, age of first social media account explained 25% to 70% of the age at smartphone ownership effect overall (based on effect when added first in the regression), with the biggest contribution in the Anglosphere and smallest effect in South Asia. This was followed by family relationships (11 to 20%) and sleep, which contributed 12% globally with the biggest contribution in South Asia (35%). Cyber-bullying contributed 10% globally, with substantially higher contribution in North America (37%). It is important to clarify that these number only

represent how much these factors are likely contributing on account of early age of smartphone during childhood, and not their contribution arising from patterns of smartphone use in adulthood or their total contribution to mind health which will be higher. Overall, these results suggest that the age of social media account lies on the causal pathway of the association between age at smartphone and mind health. However, it is the variation in social factors (i.e., relationship with family and friends) that explains the greatest share of the variation in mind health. While the impact of a younger age of smartphone on MHQ scores in adulthood are partly mediated through a decrease in family closeness, the converse is not true. That is, those with families that were not close were not more likely to give their children smartphones at a younger age. Therefore, while restrictions on age at social media use, such as those recently implemented in Australia, may cushion the deleterious effects of an early age of smartphone ownership on mind health, better relationships between young adults (18-24) and their family and sleep are extremely important for improving overall mind health and points to a large cultural component, and possibly time spent online by parents at the exclusion of engagement with their children. Below we provide a perspective on why and how each of the contributing factors that impact mind health may be influenced by the age of first smartphone.

Age of social media account

Girls are often considered to be heavier users of social media platforms and more susceptive to its impact on mind health (Twenge and Martin 2020), while other evidence suggests that the age of first smartphone ownership can influence the way adolescents approach social media (Gerosa et al. 2024). Here we showed that the age of social media had the biggest explanatory power of the effects of age of first smartphone on mind health in adulthood. As well as the interpersonal risks discussed below , evidence also suggests that social media, especially when it is problematic or other focused, is associated with lower self-esteem in some adolescents, especially in females and those with smaller social networks (Lim, Lau, and Li 2021; Steinsbekk et al. 2021; Tibber, Zhao, and Butler

2020). Given the association between age of smartphone ownership and age of social media account, this may also contribute to why age of smartphone ownership has the most profound impact on the dimension of Social self (as shown in Section 1). In addition, the minimum age for a child to create a social media account varies by platform, but most set the age at 13 years old in compliance with regulations such as the Children's Online Privacy Protection Act (COPPA) in the United States (Federal Trade Commission 1998). However, despite these guidelines, many younger children access social media with or without parental consent. For example, in the UK, 80% of children age 12 have a social media account (OFCOM 2023) while in the US 38% of 8-12-year-olds have used social media and nearly one in five (18%) now say they use social media "every day"(Common Sense Media 2021). Here we found that children who receive smartphones at a younger age tend to create social media accounts earlier, often before the minimum age of 13, with some starting as young as 10, a trend observed across genders and regions.

Sleep

The relationship between poor mind health and disrupted sleep is well established. In addition, smartphone use has been widely implicated in disrupted sleep patterns through a number of routes (Amez et al. 2020; Brautsch et al. 2023; Burnell et al. 2024; Dibben et al. 2023; Lemola et al. 2015; Maurya et al. 2022; McCaffrey et al. 2024; Sá et al. 2023). For example, excessive smartphone use, especially during the evening and night-time hours, and checking or using smartphones during the night are associated with displacement of sleep time, delayed bedtimes, fragmented sleep, reduced sleep duration, and can lead to re-entrainment of the body's natural circadian rhythm. Importantly, the cumulative effects of poor sleep hygiene can contribute to a significant sleep debt, or 'social jet lag' over time (Touitou 2013). The effect of early age of smartphones on poor sleep in adulthood in females but not males is consistent with other studies (Amez et al. 2020). This suggests that, similar to with UPF consumption, unhealthy sleep habits established by girls during adolescence, shaped by early smartphone ownership, may persist into young adulthood, contributing to a cumulative sleep debt and ongoing impacts on mind health at ages 18-24.

Family Closeness and Friendships

There has been considerable debate about the impact of smartphone usage on family and friendship dynamics. The ubiquity of smartphones by today's adolescents has fundamentally reshaped how friendships develop and operate compared to previous generations, with social media and messaging platforms playing a central role in communication and connection. However, although this has created new opportunities for social interaction, it has also raised concerns about the consequence on the development of social skills such as empathy, conflict resolution, and emotional regulation which need to be practiced and developed in the real world. For example, a recent report found that 13 year old girls report greater levels of aggression and anger compared to 17 year olds, a trend that can in part be attributed to earlier age of smartphone ownership (Sapien Labs 2025). Similarly, in family settings, smartphones have introduced new sources of conflict, such as disputes over screen time, privacy, and parental restrictions (Kim et al. 2019; Merkaš et al. 2024), although it is important to note that both parents and child practices are relevant in a family setting. For example, Practices like 'phubbing' - ignoring family members in favor of smartphone use - have been linked to feelings of neglect and disconnection within households (Solecki 2022). On the other hand, smartphones also offer opportunities for families to stay connected across distances, highlighting their dual role as both a unifying and divisive tool. Here, and in line with this complexity, we show a nuanced interplay between the timing of smartphone ownership, cultural context, and social relationships. In particular, we find that, globally, young adults, and particularly females, were more likely to report being close to their families and having friends who would help them if they received their first smartphone at an older age. However, these patterns varied regionally, with cultural and social factors influencing outcomes. For instance, while older smartphone ownership was linked to greater family closeness in regions like Latin America, North America displayed an inverted U-shaped trend, with family closeness decreasing when smartphones were first owned after age 13. Similarly, while older smartphone ownership correlated with stronger friendships globally, regions like Western Europe and North America showed a decline in close friendships for those

receiving smartphones after age 13. This may arise due to greater conflict between child and parents for withholding a smartphone when all of their peers and being excluded from online social interactions of their peers.

Cyberbullying & sexual abuse/assault

Previous research has shown that adolescent encounter multiple different types of threats on social media such as cyberbullying, sexual harassment, racism, unauthorized distribution of sensitive material, phishing attempts, misinformation, the sale or distribution of drugs, and harmful or dangerous social media challenges (Lahti et al. 2024). Early adoption of smartphones among children and adolescents therefore introduces substantial interpersonal risks from a young age. For example, it's well known that the internet can expose children to content that is unregulated or inappropriate (Common Sense Media 2022) and offers a substantial departure from the family- and community-centric experiences of the past Here we examined two specific forms of interpersonal trauma, cyberbullying and sexual abuse/assault, both of which are often associated with smartphone use, particularly through social media platforms and which have a negative impact on mind health (Sapien Labs 2023a).

Cyberbullying, which typically includes sending harassing messages (via text or the Internet), posting disparaging comments on a social networking site, posting humiliating pictures, or threatening/intimidating someone electronically, has become an international public health concern among adolescents. Considerable evidence has shown that the experience of cyberbullying has a negative impact on mental health including feelings of depression and suicidal ideation (Hinduja and Patchin 2010; Kowalski et al. 2014; Nixon 2014; Smith et al. 2008). In addition, data from the Global Mind Project shows that the impact of cyberbullying on mental health is almost as significant as sexual abuse (Sapien Labs 2023a). This association of a higher likelihood of cyberbullying with a younger age of first smartphone is also in line with other studies that shows that early social media initiation (e.g. Snapchat or Instagram) before age 10 is significantly associated with more

unsympathetic online behaviors, and greater likelihood of online harassment and sexual harassment victimization (Charmaraman et al. 2022; Young 2024). While the incidence of cyberbullying appears to be broadly similar in males and females (WHO 2024), here we show that the association between age of smartphone ownership and the experience of cyberbullying is most apparent in females.

The association of earlier smartphone ownership during childhood sexual abuse or assault by ages 18–24, among females in North America likely has different causes from cyberbullying which may be more peer-to-peer. It is known that social media platforms can allow predators to exploit vulnerable individuals through social media platforms, messaging apps, and online games, often under the guise of anonymity or false identities. Younger girls are likely particularly vulnerable as they do not have the worldly experience to understand and interpret overtures. In addition, social media also exposes children to sexually explicit material, which can normalize inappropriate behaviors and desensitize them to healthy sexual boundaries (Braun-Courville and Rojas 2009; Owens et al. 2012; Peter and Valkenburg 2006). For example, a recent report from Common Sense Media found that 15% of teen respondents aged 13 to 17 in the US said they first saw online pornography at age 10 or younger, with the average age being 12 (Common Sense Media 2022). Owning a smartphone at an early age increases the risk of children being exposed to this type of information at a younger age and may be less equipped to recognize and handle such predatory behavior online, making them more vulnerable to exploitation. However, evidence also suggests a potentially bi-directional relationship with those who have experienced adverse childhood experiences (e.g. abuse neglect), being more likely to be problematic smartphone users (Geng et al. 2022; Zheng et al. 2024). As females are typically more heavy social media users, this may, in part explain the gender differences. However, regional differences also emerged with, females in the Middle East reporting lower levels of sexual abuse/assault, possibly due to stricter digital boundaries within cultural norms compared to countries such as the US.

Ultra-processed food

Numerous studies have demonstrated the negative impact of frequent UPF consumption on both physical and mental health with estimates suggesting that UPF consumption may account for up to one third of the mental health challenges faced by young people today (Bala et al. 2025; Lane et al. 2024; Sapien Labs 2023c). In addition, estimates of ultra-processed food consumption in the US indicate that adolescents obtain approximately 60% of their calories from UPF, while adolescent consumption of UPF consumption is currently between 20-30% in Latin America and on the rise (Matos, Adams, and Sabaté 2021), consumption is higher in those with a higher socioeconomic status, who will also be those who are reflected in the internet-enabled sample of the Global Mind Project (Louzada et al. 2023). Thus, the effect of age of smartphone ownership on UPF consumption is very small, possibly because the majority of the sample are likely high consumers of UPF independent of smartphones. That said, there are multiple possible routes through which smartphone ownership can impact UPF consumption. For example, smartphone use during meals is associated with higher caloric intake, potentially due to a diminished awareness of satiety signals or reduced mindfulness around what one is eating and may impair 'meal memory', leading to overeating and decreased dietary satisfaction (Gonçalves et al. 2019; La Marra et al. 2020). Furthermore, prolonged smartphone use, is linked with unhealthy dietary patterns such as frequent consumption of instant noodles, sugary beverages, and fast food, coupled with lower intakes of fruits and vegetables (Ryu et al. 2022). Moreover directly, food delivery applications, made more easily accessible through smartphone apps, has been implicated in promoting UPF consumption, snacking, and irregular meal patterns (Stephens, Miller, and Militello 2020).

Physical acitivty

Evidence has previously linked smartphone ownership with levels of physical activity and/or sedentary behavior (Fennell et al. 2019; Grimaldi-Puyana et al. 2020; Jeong et al. 2023; Xiang et al. 2019). However, here we found no significant link between the age of first smartphone ownership in childhood and the frequency of regular exercise in young

adulthood for either males or females. One possibility is the specific wording of the question and the suggestion that smartphone use may lead to increased sedentary behavior or hours of sitting, independent of levels physical activity (Fennell et al. 2019). However, as levels of physical activity is currently only probed with a single question, it was not possible to explore this association further in this analysis. However, given that levels of physical activity in children and adolescents is an issue of growing concern (Guthold et al. 2020), further research is warranted in this area.

Overall conclusions from Sections 1 and 2

In conclusion, these findings indicate that earlier smartphone ownership in childhood is associated with significant and cumulative effects on mind health, particularly in females. In light of a recent study that younger age of smartphone ownership is associated with more pervasive smartphone use and different approaches to social media as those children grow up (Gerosa et al. 2024), also highlights how habits and behaviors, shaped by early smartphone ownership and use during critical periods of development, can persist and evolve over time. However, we also note that these associations may be influenced by smartphone use itself, rather than—or in addition to—the age at which a smartphone was first owned.

Altogether, we highlight the complex interplay of factors that meditate the relationship between smartphone ownership and mind health outcomes in young adulthood. Frequent consumption of ultra-processed foods (UPFs), insufficient sleep, weaker social relationships, and experience of interpersonal traumas, such as cyberbullying and sexual abuse/assault, which are all shaped by smartphone and social media use, emerged as key contributors to this association. Regression analyses further underscored the pivotal role of the age of initiation to social media, explaining up to 40% of the association globally, with contributions as high as 70% in North America. These findings suggest that early smartphone access and particularly social media use, shapes lifestyle habits, social

dynamics, and digital behaviors, and, in turn, mind health trajectories from adolescence to young adulthood.

These outcomes highlight the need for comprehensive policies that promote responsible smartphone use, support digital literacy, and mitigate risks associated with early exposure. Interventions could include delaying smartphone acquisition, fostering offline social interactions, and implementing safeguards to reduce exposure to harmful online content. As the age of first smartphone ownership continues to get younger, understanding and addressing its long-term implications will be critical to ensuring the mental wellbeing of future generations. Further research is needed to explore these trends with greater resolution and to develop evidence-based strategies for intervention and prevention.

These outcomes emphasize the urgent need for holistic policies that prioritize responsible digital integration and safeguard young people from the risks associated with early smartphone exposure. Policymakers should consider strategies such as delaying the age of smartphone acquisition, promoting digital literacy programs, providing opportunities for offline social interactions at a community level, and enforcing stricter protections against harmful online content. As global trends show increasingly younger ages of first smartphone ownership, addressing these issues through continued research and international collaboration will be vital for safeguarding the mind health and social development of future generations in an increasingly digital world.

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