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

2 **adulthood**

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Abstract

As digital technologies become increasingly embedded in childhood, understanding their long-term effects on mental functioning is of critical importance. This working paper draws on data from over 130,000 individuals aged 18 to 24 across 59 countries, as part of the Global Mind Project, to explore the association between age of first smartphone ownership and mind health in early adulthood. Using the Mind Health Quotient (MHQ), a multidimensional and functionally grounded assessment of mind health and wellbeing, the study finds that younger age of smartphone acquisition is strongly associated with diminished capacities and increased psychological distress in early adulthood. Individuals who received smartphones each year before the age of 13 show higher levels of suicidal thoughts, aggression, and hallucinations, along with reduced emotional resilience and self-image resulting in an increase of 10% who are clinically distressed or struggling between those who got a phone below age 10 vs above age 13. These effects are more pronounced among females and are consistent across global regions. The analysis also examines lifestyle and interpersonal factors that may mediate this relationship, including age of first social media use, sleep sufficiency, diet, family closeness, friendships, and exposure to trauma. Regression models suggest that these factors together explain approximately 56% of the observed association, with age of social media account, sleep, and family relationships contributing most significantly. The findings point to a cumulative developmental impact of early smartphone exposure on mental functioning and highlight the need for early interventions, including policy measures to delay smartphone and social media access.

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.

87   *Terminology: Mental wellbeing and mind health*

88   While the terms 'mind health', 'mental health' and 'mental wellbeing' are often used

89   interchangeably, they have different associations and connotations in people's minds. The

90   World Health Organization (WHO) defines mental health and wellbeing as follows:

91   *'Mental health is a state of mental wellbeing that enables people to cope with the*

92   *stresses of life, realize their abilities, learn well and work well, and contribute to*

93   *their community.'*

94   However, many people tend to conflate the term 'mental wellbeing' with their mood or

95   happiness, while this is just one facet of our mental wellbeing. In addition, the term is often

96   used in academic circles to predominantly reflect the positive psychology aspects of

97   wellbeing (e.g. life meaning, purpose), and does not fully capture the full spectrum of

98   mental functioning. Conversely, 'mental health' as a term is typically used to reflect

99   mental challenges or clinical disorders such as depression and anxiety. In contrast, 'mind

100 health' refers to the overall health of our mental processes, emotions, and cognitive

101 abilities and therefore has a more functional association in people's mind. It spans the full

102 range from what would be considered mental illness, includes feelings of happiness and,

103 in the aggregate, encompasses the capacity to navigate life's challenges and function

104 effectively in daily life. The term mind health is thus better aligned with the outcomes of the

105 MHQ assessment that we report here, which encompasses 47 aspects of mental function

106 assessed on a life impact scale that span the dimensions of Mood & Outlook, the Social

107 Self (or relational aspects), Adaptability & Resilience, Drive & Motivation, Cognition and

108 Mind-Body Connection (or physical aspects).

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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).
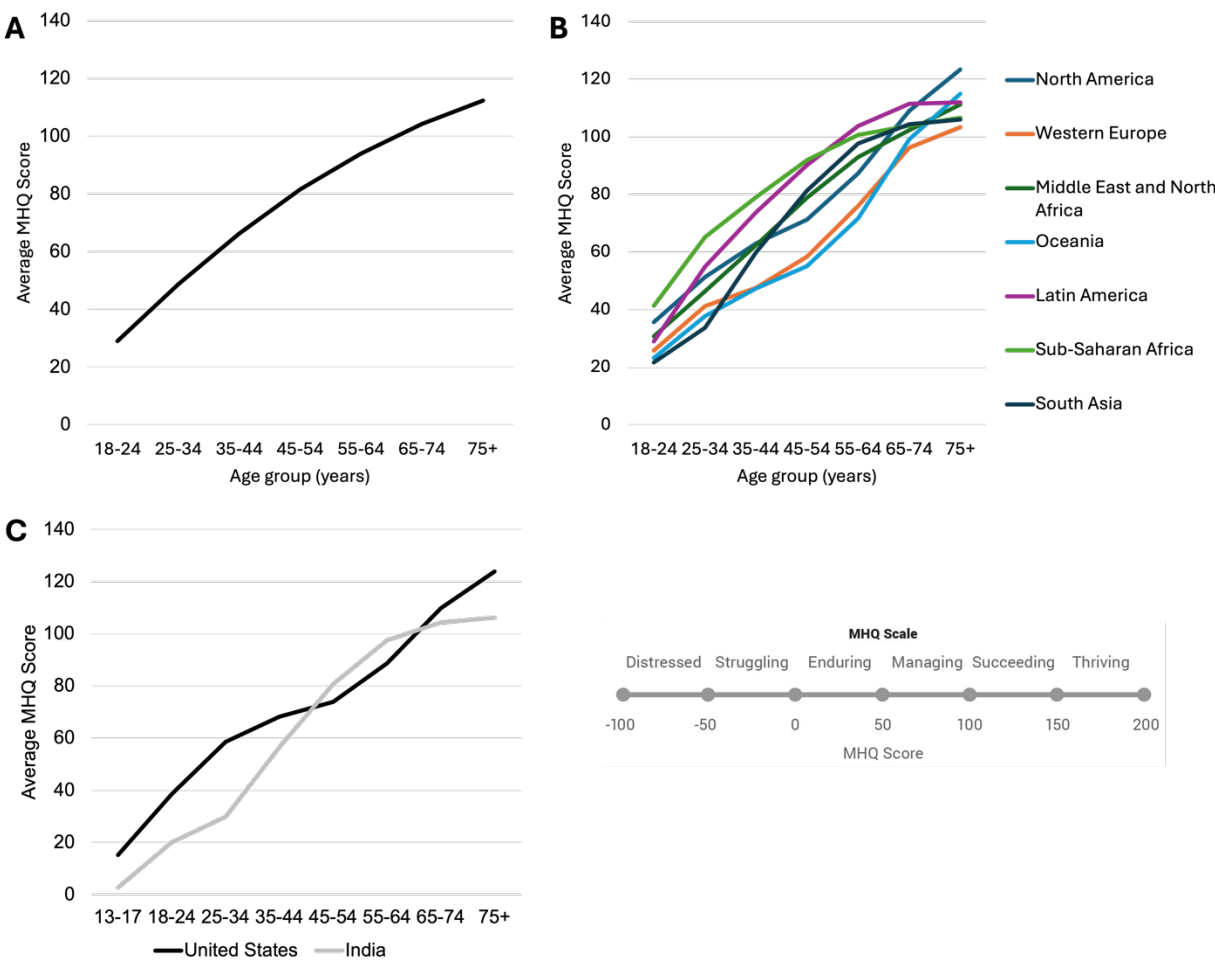
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142 **Figure 1:** *Trend of lower mind health in younger generations compared to older*

143 *generations. Numbers from graphs shown in Supplementary Table 1. (A) Global trend in*

144 *average MHQ scores in adults aged 18-24 through to 75+ (N = 761,462; 2024). (B)*

145 *Comparison of average MHQ scores for younger (age 18-24) and older ages (age 55-64)*

146 *across different regions of the globe. See Figure 2 for the countries included in each region*

147 *(N = 761,462; 2024). Percentage Distressed/Struggling for each age and region group*

148 *shown in Table 1. (C) Average MHQ scores in the US (black) and India (grey), showing the*

149 *trends down to age 13-17 (India: N = 19,847; US: N = 4,423). Note: The MHQ scale from -*

150 *100 to +200 showing the different score categories from Distressed to Thriving.*

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152   **Table 1:** Percentage Distressed/Struggling for each age group, overall and for each region

153   in younger generations compared to older generations. Data also shown for US and India

154   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%

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156   *What has changed to cause this global decline?*

157   One factor that corresponds to this time period is the rapid proliferation of technology and

158   the ubiquity of smartphones and social media, especially amongst youth (Common Sense

159   Media 2021; Data Reportal 2024; Our World in Data 2024; Pew Foundation 2022; Poushter

160   2016; Silver 2019). For example, according to the Global System for Mobile

161   Communications Association's (GSMA) annual State of Mobile Internet Connectivity

162   Report 2024, over half (57%) of the global population (4.6 billion people) now owns a

163   smartphone (GSMA 2024) with the typical internet user spending 6 hours and 40 minutes

164   online each day (Data Reportal 2024). Estimates from the US suggest 48% of 18–29-year-

165   olds are online 'almost constantly' (Pew Foundation, 2022) with teens aged 13-18

166   spending on average 8.4 hours a day on entertainment screen use, while 8–12-year-olds

167   spend an average of 5.3 hours (Common Sense Media, 2021). These statistics, together

168   with the trends of declining mental health in youth has generated significant debate

169   regarding the impact of technology on mental health and wellbeing. For example,

170   numerous studies have examined the impact of screen time and social media on mental

171   health and wellbeing with often varied and opposing findings and opinions (Odgers 2018;

172   Orben et al. 2022; Orben and Przybylski 2019; Twenge 2020; Twenge, Martin, and Campbell

173   2018). In general, smaller effects are reported when males and females are combined

174   (Orben and Przybylski 2019) whereas larger effects are observed when females are

175   analyzed separately or when analysis is limited to social media rather than all digital media

176   (Twenge et al. 2020).

177

178   The age at which one gets their first smartphone is one of the biggest difference across

179   generations suggesting the possibility of developmental effects. GenZ, today's

180   adolescents and young adults, are the first generation raised as digital natives. Grass roots

181   campaigns such as Wait Until 8th in the US and Smartphone Free Childhood in the United

182   Kingdom (UK) have been campaigning for parents to delay giving their child a smartphone

183   because of the potential harms, but there is still only limited evidence on the impacts of

184   giving a child a smartphone earlier in childhood. Studies to date are small scale, often

185   county specific and have shown conflicting results (Dempsey, Lyons, and McCoy 2019,

186   2020; Gerosa and Gui 2023; Gerosa, Losi, and Gui 2024; Jaalouk and Boumosleh 2018; Sun

187   et al. 2023). For example, one study investigating the impact of smartphone ownership on

188   sadness and sleep outcomes in 263 children from 2012 to 2017 found no statistically

189   significant associations (Sun et al. 2023) while another study found a statistically

190   significant and negative relationship between early mobile phone ownership and academic

191   outcomes and mental wellbeing (Dempsey et al. 2019). There is therefore a need to better

192   understand the relationship between the age at which children first own a smartphone and

193   their mind health outcomes using large-scale, global data that can capture a

194   multidimensional picture of both mind health, and broader life context including age of

195   smartphone ownership.

196

197   *The Global Mind Project*

198   The Global Mind Project is a unique initiative that acquires data from the literate Internet-

199   enabled world to systematically examine the evolving landscape of mind health in the

200   context of multidimensional determinants that reflect the social, cultural, technological

201   and environmental world in which we live and work. This project adopts a global

202   perspective, with outreach conducted across over 70 countries in 17 languages to capture

203   variations in mind health across different demographic and sociocultural contexts. It

204   utilizes an online, self-report tool called the Mind Health Quotient (MHQ) to capture 47

205   different aspects of mind health and generates a single composite metric, the MHQ score,

206   as well as sub-scores across six dimensions of mind health: Mood and Outlook, Social

207   Self, Mind-Body Connection, Drive and Motivation, Cognition, and Adaptability and

208   Resilience (Newson, Hunter, and Thiagarajan 2020; Newson, Pastukh, and Thiagarajan

209   2022; Newson, Sukhoi, and Thiagarajan 2024; Newson and Thiagarajan 2020). The Global

210   Mind project therefore provides an opportunity to explore the association between mind

211   health and technology habits at larger scale, in particular the age at which someone gets

212   their smartphone during childhood, across a large-global sample, whilst also considering

213   the impacts from a multidimensional perspective, and taking into account the wider

214   ecosystem of lifestyle and life experience factors. In this first section, we focus on 18-24-

215   years-olds and how the age at which they first owned their smartphone in childhood

216   impacts their mind health.

217

218   **Methods**

219   **Data acquisition**

220   Data used in section 1 of this working paper are taken from the Global Mind Project. Data

221   were obtained between January 2023 to October 2024 from 131,037 internet-enabled 18–

222   24-year-olds (63% females, 37% males) who were predominantly from 59 countries across

223   North America, Western Europe, Latin America and the Caribbean, Oceania, South Asia,

224   Middle East, North Africa and Sub-Saharan Africa (Figure 2). Participants were recruited as

225   part of the ongoing Global Mind Project through online advertisements placed on

226 Facebook and Google that targeted age-sex groups (18-85+) and geographical regions

227 across broad based interests and key words (Taylor et al. 2023). Participants were directed

228 to the MHQ website (https://sapienlabs.org/mhq/) and completed the anonymous self-

229 report MHQ assessment for the purpose of getting their mind health scores and

230 personalized report.
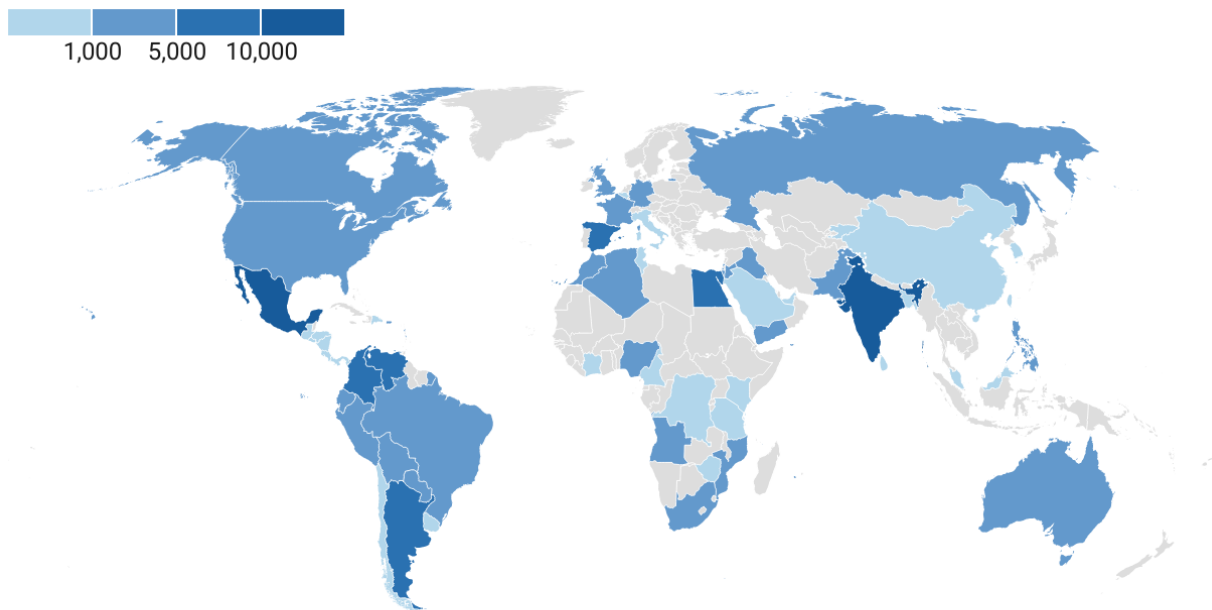
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232 **Figure 2:** *Illustration of the countries and sample sizes included in this analysis. Values*

233 *and regional groupings shown in Supplementary Table 2.*

234

235 Presently, 1,000-2,000 people complete the assessment each day and are added to a

236 dynamic database. In addition to the scored questions on mental feeling and function,

237 respondents answer various demographic, lifestyle, and life experience questions

238 including age of smartphone ownership: '*At what age did you get your own smartphone*

239 *with Internet access that you could carry with you?*'.

240

241 The Global Mind Project is a public interest project that has ethics approval from the

242 Health Media Lab Institutional Review Board (HML IRB), an independent IRB that provides

243 assurance for the protection of human subjects in international social and behavioral

244   research (OHRP Institutional Review Board #00001211, Federal Wide Assurance

245   #00001102, IORG #0000850).

246

247   **The MHQ**

248   The MHQ captures 47 aspects of mind health including symptoms across 10 major mental

249   health disorders as well as items derived from Research Domain Criteria (RDoC) (Newson

250   and Thiagarajan 2020). Items were determined based on a comprehensive coding of

251   mental health symptoms assessed in questions across 126 different mental health

252   questionnaires and interviews. Within the MHQ, each of these 47 items are rated by

253   respondents using a 1-9 life impact scale (i.e. a Likert scale with 9 positions) reflecting the

254   impact on one's ability to function. For the items on a spectrum from positive to negative

255   (spectrum items such as self-image), the rating scale is defined as follows: a 1 rating on

256   the 9-point scale refers to *Is a real challenge and impacts my ability to function*, the 9 rating

257   refers to *It is a real asset to my life and my performance,* and the 5 rating refers to

258   *Sometimes I wish it was better, but it's ok*. For the items with varying degrees of problem

259   severity (problem items such as suicidal thoughts): the 1 rating on the 9-point scale refers

260   to *Never causes me any problems*, the 9 rating refers to *Has a constant and severe impact*

261   *on my ability to function,* and the 5 rating refers to *Sometimes causes me difficulties or*

262   *distress but I can manage*. Respondents rate these elements based on their current

263   perception of themselves.

264

265   Ratings from these 47 items are aggregated into a score (the MHQ score) that positions

266   individuals in six categories from *Distressed* to *Thriving* (Newson et al. 2024). The score is

267   based on an algorithm that thresholds ratings as negative and positive based on the

268   impact to function and applies a nonlinear transformation of the scale such that increasing

269   negative impact to function is amplified. The resulting MHQ scores fall on a positive-

270   negative continuum. The MHQ score has been shown to have strong sample-to-sample

271   consistency as well as criterion validity using data from 179,298 people across eight

272   English-speaking countries. This includes demonstration that, in the aggregate, average

273   number of clinical symptoms and clinical diagnoses increase systematically as MHQ

274   scores decrease, and that MHQ scores are linearly related to work productivity, including

275   absenteeism and presenteeism (Newson et al. 2022, 2024).

276

277   Dimensional scores are aggregate scores constructed from subsets of the 47 items in the

278   assessment using the same scale as the MHQ and similar principles. For instance: Social

279   Self includes ratings of elements such as *Self-image*, *Self-worth & confidence*,

280   *Relationships with others*, and *Social interaction & cooperation* as well as problems such

281   as *Feeling of aggression towards others* and *Suicidal thoughts & intentions*. Mood &

282   Outlook includes ratings of asset items such as *Stability & calmness*, *Emotional control,*

283   and *Outlook & optimism* as well as problem items such as *Fear & Anxiety*, *Feelings of*

284   *sadness, distress or hopelessness* and *Mood Swings*. Adaptability & Resilience includes

285   ratings of items such as *Adaptability to change*, *Emotional resilience*, *Creativity & problem*

286   *solving,* and *Ability to learn*.

287

288   **Data exclusion criteria**

289   Only those respondents who stated that they found the MHQ easy to understand were

290   included in this analysis. This exclusion criterion was applied by only selecting

291   respondents who answered "Yes" to the final question in the MHQ which asks them "Did

292   you find this assessment easy to understand?". Also excluded were those assessments

293   completed in under 7 minutes (the minimum time needed to read and respond to the

294   MHQ), and those where response ratings had a standard deviation of less than 0.2,

295   indicating that the same rating value was selected across all 47 rating items.

296

297   **Data analysis and statistics**

298   Average MHQ scores, dimensional scores, and average ratings for each of the 47 problems

299   and mental capabilities assessed, were calculated separately for females and males for

300   each age of smartphone ownership for the global data in its entirety (131,037 18-24-year-

301   olds, 63% females, 37% males). These same averages were also calculated for seven

302 geographical groupings: North America (*N* = 6,192; 3,756/61% females, 2,436/39% males),

303 Western Europe (*N* = 15,357; 10,036/65% females, 5321/35% males), Latin America (*N* =

304 49,560; 30,197/61% females, 19,363/39% males), South Asia (*N*= 23,788; 15,135/64%

305 females, 8,653/36% males), Sub-Saharan Africa (*N*= 11,246; 7,120/63% females,

306 4,126/37% males), Middle East and North Africa (*N*= 18,304; 11,545/63% females,

307 6,759/37% males) and Oceania (*N*= 1,904; 1,208/63% females, 696/37% males).

308

309 **Results**

310 ***Relationship between age of smartphone ownership and mind health***

311 For young adults aged 18-24, and aggregated across all regions, owning a smartphone

312 before age 13 was associated with significantly lower MHQ scores and higher probability of

313 scores in the lowest *Distressed* or *Struggling* ranges (MHQ scores<0), compared to first

314 owning a smartphone after age 13 (p<0.001: age of smartphone <10: 55%

315 distressed/struggling vs age 14+: 45%; Figure 3A and 3B; Supplementary Table 3). In

316 particular, those who reported owning their first smartphone at ages 5 or 6 had sharply

317 lower MHQ scores with almost 70% of females and 50% of males having MHQ scores in

318 the *Distressed* or *Struggling* range compared to 51% (females) and 38% (males) of those

319 who reported owning their phone at age 13 [males: p<0.001 (age of smartphone <10: 43%

320 distressed/struggling vs age 14+: 38%); females: p<0.001 (<10: 61% distressed/struggling

321 vs 14+: 50%)]18-24-year-olds who reported owning their first smartphone from age 13

322 onwards did not show significantly different MHQ scores, although approximately 50% of

323 females and 40% of males still had MHQ scores in the *Struggling* or *Distressed* range.

324 Notably, the *Social Self* dimension of mind health, which encompasses how we see

325 ourselves and our capacity to relate to others, showed the most pronounced decline with

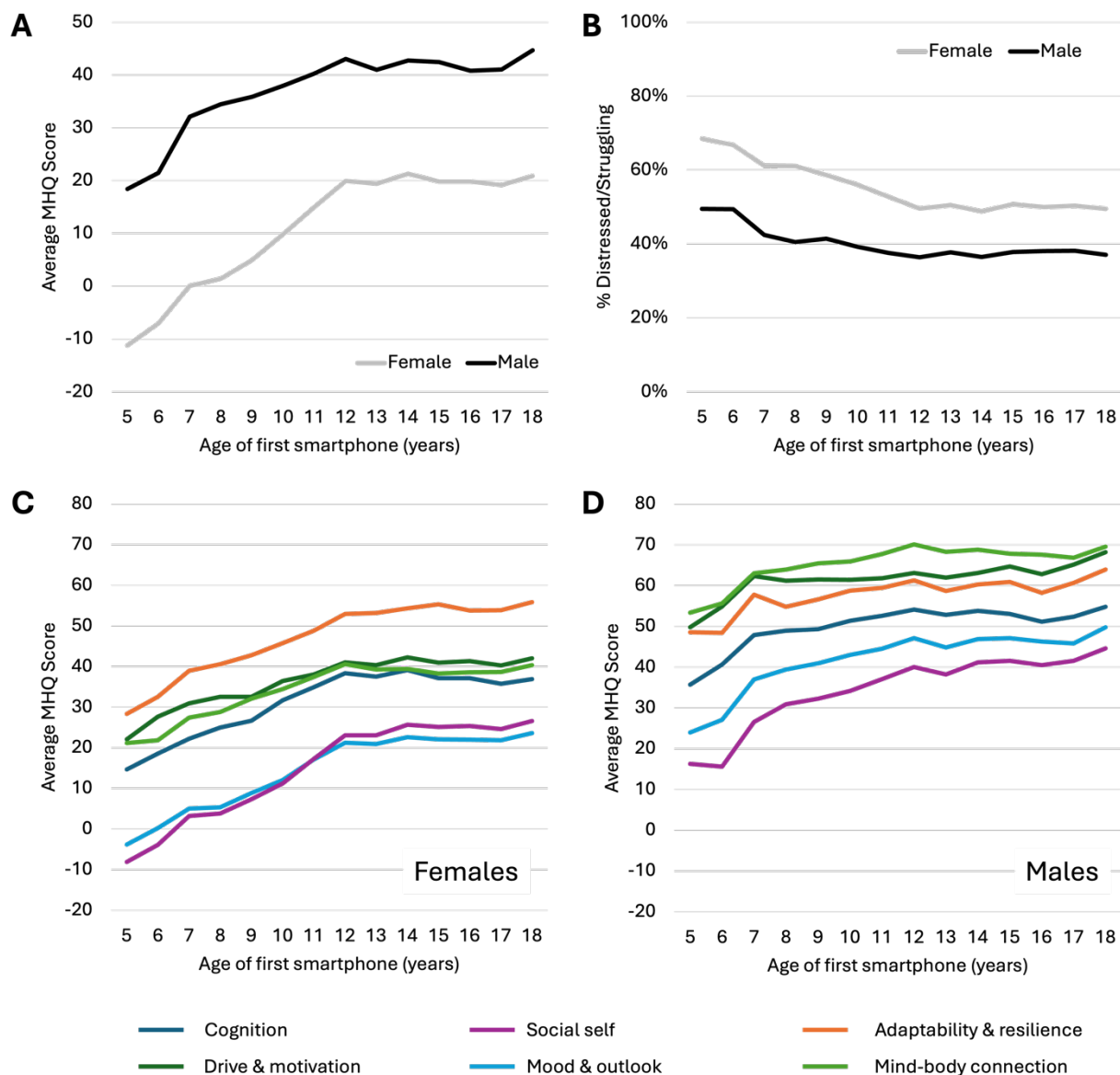326 younger age of smartphone ownership (Figure 3C, 3D).

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328

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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*

15

340 *dimensions in male 18–24-year-olds and age of smartphone ownership during childhood*

341 *(aggregated across regions).*

342

343 This trend was evident across Internet-enabled populations globally and was consistent

344 across all regions of the world (Trend in females shown in Figures 4A & 4B. Males shown in

345 Supplementary Table 4). In addition, the trend was observable in both males and females,

346 though it was markedly more pronounced among females [p<0.001 between males &

347 females at age <10 (M: 42% vs F: 61%), and p<0.001 at ages 14+(M: 37% vs F: 51%)].

348 Females not only demonstrated a steeper decline in MHQ scores with earlier age of

349 smartphone ownership but also consistently exhibited lower MHQ scores relative to their

350 male counterparts overall. In addition, while shown here for the entire 18-24 cohort, the

351 same pattern persists for each individual age with steeper effects for those aged 18-20

352 versus 21-24, which may relate to their age during the COVID pandemic (see
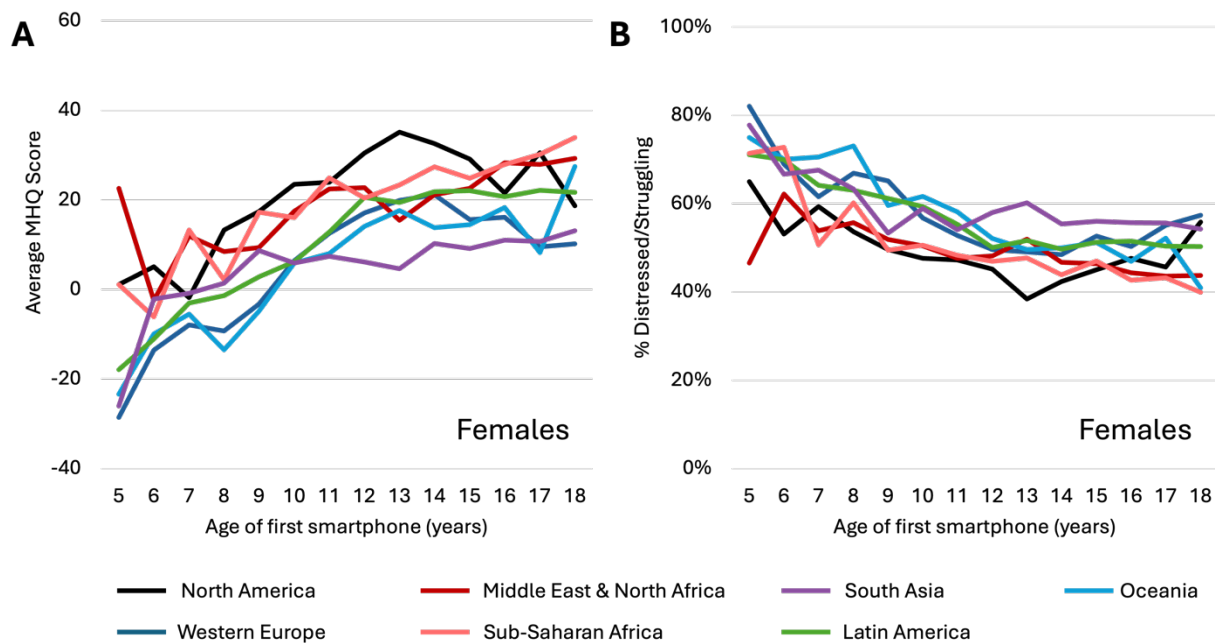
353 supplementary data).

354

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356

357 **Figure 4:** *Regional relationship between age of smartphone ownership during childhood*

358 *and mind health at age 18-24. Values shown in Supplementary Table 4. (A) Relationship*

359 *between average MHQ scores in females aged 18–24-year-olds and age of smartphone*

360 *ownership during childhood across the 7 different regions. (B) Relationship between the %*

361 *Distressed/Struggling (MHQ scores<0) in females 18–24-year-olds and age of smartphone*

362 *ownership during childhood across the 6 regions. Trends for males shown in*

363 *Supplementary Table 4.*

364

365 **Relationship between age of smartphone ownership and individual MHQ items**

366 Of the 47 aspects of mind health captured by the MHQ, 30 were significantly associated with

367 age of first smartphone ownership in females and 15 were significantly associated with age

368 of first smartphone ownership in males ($p<0.001$; Supplementary Table 5). For females aged

369 18-24, the capacities of positive self-image, self-worth and confidence, sleep quality,

370 emotional resilience, and emotional control declined with a younger age of first smartphone

371 (Figure 5A; Supplementary Table 6). Correspondingly, problems with suicidal thoughts were

372 most steeply and significantly higher in females aged 18-24 who reported getting their first

373 smartphone at a younger age, followed by problems with aggression towards others, a sense

374 of being detached from reality, repetitive & compulsive actions, and hallucinations (Figure

375 5B).

376

377 In males aged 18-24, the ranking of capacities and problems most impacted by age of

378 smartphone ownership was slightly different. In particular, males who reported getting their

379 smartphone at a younger age had diminished capabilities of relationships with others,

380 outlook & optimism, stability & calmness, self-worth & confidence, and empathy (Figure

381 5C). In addition, young adult males who had got their first smartphone at a younger age had

382 increased problems with suicidal thoughts, feelings of sadness, distress & hopelessness,

383 guilt & blame, restlessness & hyperactivity, and hallucinations (Figure 5D).

384

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.
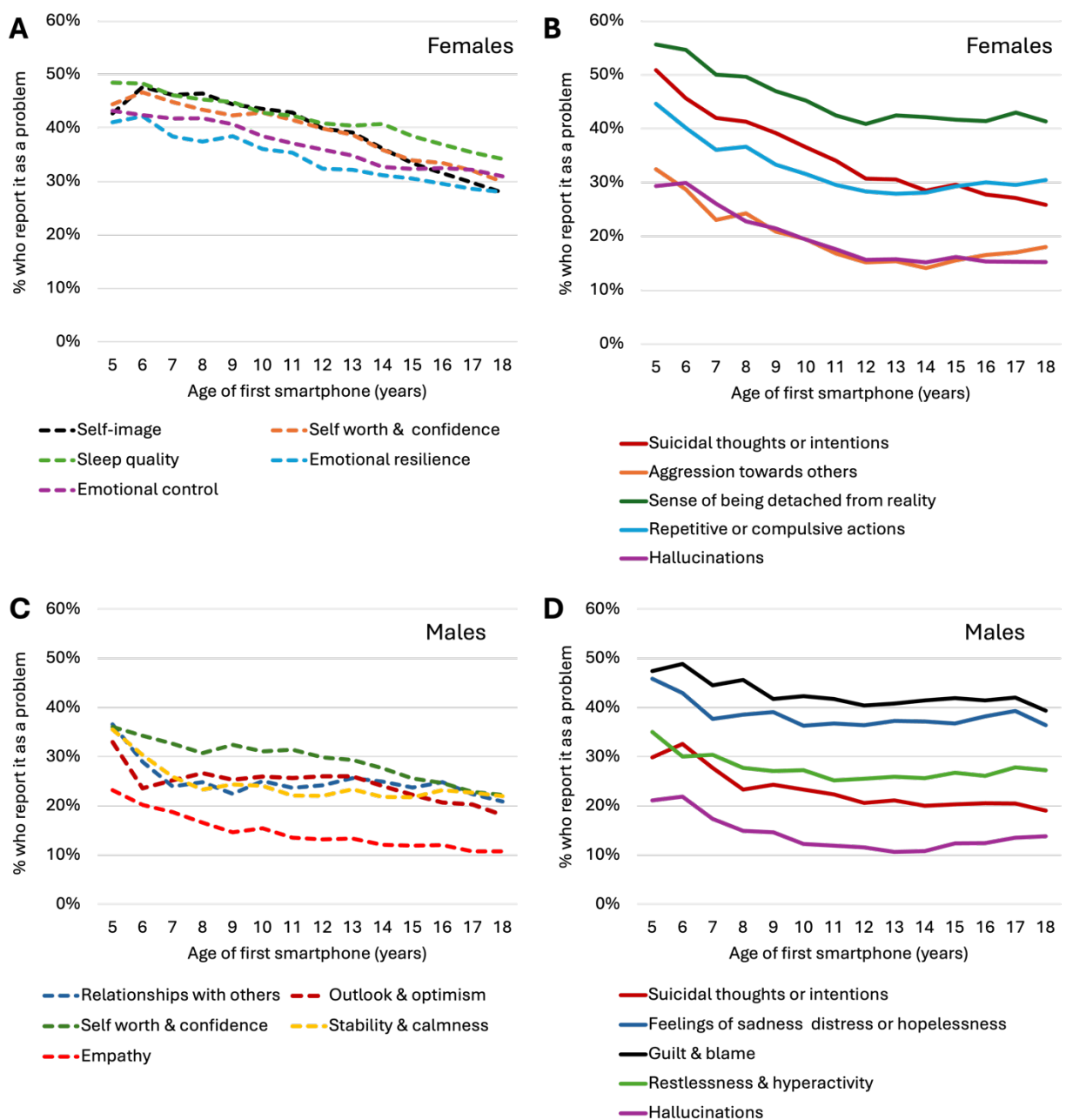
393

394 ***Figure 5:*** *MHQ items showing the biggest difference between younger vs older age of first*

395 *smartphone ownership for females (A, B) and males (C,D). Top 5 Spectrum items are*

396 *shown in (A) and (C). Top 5 problem items are shown in (B) and (D). Values shown in*

397 *Supplementary Table 6.*

398

399

400 ***Smartphone ownership trends***

401 Estimates of smartphone ownership trends by country will be influenced by internet

402 penetration rates which vary widely across the globe (World Bank 2024). In this data,

403 globally (which represents only those who have a smartphone), the average age of first

404 smartphone ownership among 18–24-year-olds was 13. Notably in the US it was 12.6 for

405 18–24-year-olds and 11.7 for 13–17-year-olds, while in India it was 15.9 for 18–24-year-olds

406 but 13.2 for 13-17 olds, a full 2.5 years younger (see Supplementary Table 7 for the average

407 age of smartphone ownership for each country, together with the internet penetration

408 percentages). In addition, it is also notable that the age of first smartphone is rapidly

409 getting younger (Common Sense Media 2021; Ofcom 2024), reflecting the penetration of

410 both broadband, and greater affordability of data and smartphones (Table 2).

411

412 **Table 2:** Comparison of average age of smartphone ownership in males and females aged

413 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

414

415

416 **Discussion**

417 The findings of this study highlight a significant relationship between the age of first

418 smartphone ownership in childhood and mind health outcomes in early adulthood, as

419 measured by the MHQ. This association between age of smartphone ownership and mind

420 health indicates a cumulative impact of smartphone ownership and usage that is in line

421 with other evidence that suggests that owning a smartphone from a younger age results in

422 more problematic and pervasive smartphone use as individuals grow older (Gerosa et al.

423 2024).

424

425 Altogether, across the globe, a younger age of smartphone ownership in childhood is

426 associated with a progressive erosion of various important capacities from self-worth,

427 optimism, emotional resilience, emotional control and empathy and a corresponding

428 progressive rise in suicidal thoughts, aggression, hallucinations, and a sense of being

429 detached from reality. It is of substantial importance that these factors are not the

430 commonly observed or measured symptoms of sadness or anxiety. Rather they represent

431 a new pattern of symptom profiles that seem to be unique to our technology-driven world,

432 with serious implications for society, particularly with respect to a diminished capacity for

433 cooperative social endeavours, and an increased potential for violence. In the US for

434 example, the Centers for Disease Control and Prevention (CDC) has reported rising rates

435 of suicide and violence among adolescents (CDC 2023b, 2023a). In addition, at a country

436 level, Social Self scores (the dimension that diminishes most steeply with younger age of

437 smartphone ownership) is negatively correlated with country reported rates of violent

438 assault (Sapien Labs 2022).

439 Differences in biological sex in the observed trends warrant particular attention. Females

440 appear more vulnerable to the negative effects of early smartphone use, possibly due to

441 differences in how digital technology is utilized (Leonhardt and Overå 2021; Svensson,

442 Johnson, and Olsson 2022; Twenge and Martin 2020). For example, while boys may engage

443 more in gaming, girls are more likely to use social media, which has been associated with

444 higher rates of appearance-related anxiety, social comparison, and relational conflict

445 (Caner, Efe, and Başdaş 2022; Steinsbekk et al. 2021). These sex-specific patterns,

446 together with differences in developmental sensitivity (Orben et al. 2022), underscore the

447   need for targeted interventions to address the unique risks faced by different demographic

448   groups.

449   The declining age of smartphone ownership is also a global trend, with children in Western

450   Europe and Latin America acquiring devices earlier than those in regions such as South

451   Asia, Sub-Saharan Africa, and the Middle East. What's more, the generational shift is clear:

452   today's adolescents receive smartphones at younger ages than their slightly older peers,

453   reflecting the increasing penetration and ubiquity of digital technology. While this trend

454   underscores the potential for digital inclusion, it also amplifies the urgency of addressing

455   its implications during critical developmental periods. As noted by Gerosa et al, '*Early*

456   *smartphone receipt does not appear to confer a technology advantage; rather, the*

457   *portability of smartphones and their constant supply of audiovisual stimuli may encourage*

458   *their exclusive and pervasive use, especially if this begins earlier in life' (Gerosa et al.*

459   *2024).*

460

461   *What causes the impacts of younger age of first smartphone?*

462   The cumulative negative effects of earlier smartphone ownership can potentially be

463   attributed to several mechanisms. For example, smartphone ownership at a young age

464   often coincides with critical developmental milestones, during which excessive digital

465   engagement may displace opportunities for face-to-face social interaction and skill-

466   building. Social behavior requires the mastery of nuanced cues such as facial expressions,

467   tone of voice, and body language, which are often absent or distorted in virtual

468   communication. As children spend increasing amounts of time in digital environments

469   they may miss out on the "field practice" necessary for developing and sustaining social

470   bonds. This displacement effect may lead to diminished social confidence, poorer self-

471   image, and weaker interpersonal relationships, contributing to the observed decline in the

472   Social Self dimension.

473   However, early smartphone ownership potentially also increases exposure to risks such as

474   cyberbullying, online harassment, and inappropriate content (Charmaraman et al. 2022;

475   Common Sense Media 2022; Ybarra, Mitchell, and Oppenheim 2022; Young 2024). These

476   experiences are disproportionately reported by females, particularly in Western countries,

477   and are strongly linked to long-term psychological harm, including heightened feelings of

478   aggression, suicidal ideation, and emotional instability. The disruption of sleep, a well-

479   documented consequence of smartphone use, exacerbates these challenges by impairing

480   emotional regulation and cognitive functioning, further contributing to poorer mental

481   health outcomes (Amez et al. 2020; Burnell et al. 2024; Dibben et al. 2023; Maurya et al.

482   2022; McCaffrey et al. 2024; Sá et al. 2023). In Section 2 we explore what could be behind

483   the relationships between poorer mind health at age 18-24 and earlier age of smartphone

484   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).

514   This section therefore explores how the age of first smartphone ownership intersects with

515   multiple key lifestyle and interpersonal factors that are critical for mind health: physical

516   exercise, sleep sufficiency, and consumption of ultra-processed or "junk" food, as well as

517   age of opening a social media account, closeness to the family, friendship quality, and

518   experiences of two interpersonal traumas; cyberbullying and sexual abuse/assault. We

519   look at the associations between various lifestyle and interpersonal factors by age of first

520   smartphone in 18–24-year-olds and determine through regression models which of these

521   may offer causal explanation.

522

523   **Methods**

524   Data used in Section 2 of this working paper is the same as that used in Section 1. All other

525   details relating to data acquisition and exclusion criteria were the same as in Section 1. In

526   order to explore other factors associated with the relationship between age of smartphone

527   ownership and mind health outcomes, we utilized data relating to other lifestyle and

528   interpersonal factors. These data were obtained from the following questions in the MHQ:

529

530   *Lifestyle factors:*

531   Ultra-processed food (UPF) consumption: *'How often do you eat processed, packaged, or*

532   *fast food that is not made from fresh ingredients? e.g. McDonalds, Dominos, microwave*

533   *meals, processed canned food, deli meats/cold cuts, noodles in a cup, packaged*

534   *crisps/chips, sweets/candies, sodas/fizzy drinks'*. Answer options included: *Several times*

535   *a day; Once a day; A few times a week; A few times a month; Rarely/never*

536

537   Sleep sufficiency: *'In general, I get as much sleep as I need:'* with answer options of: *All of*

538   *the time; Most of the time; Some of the time; Hardly ever*.

539

540   Physical exercise: *'How regularly do you engage in physical exercise (30 minutes or*

541   *more)?'*. Answer options included: *Every day*; *Few days a week*; *Once a week*; *Less than*

542   *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;

571   *Displacement from your home due to political, environmental or economic reasons;*

572   *Serious injury, harm, or death you caused to someone else;*

573   *Suffered a loss in a major fire, flood, earthquake, or natural disaster;*

574   *Threatening, coercive or controlling behavior by another person;*

575   *Forced family control over major life decisions (e.g. marriage);*

576   *Caring for a parent or sibling with a major chronic disability or illness;*

577   *Parent/ Caregiver/Sibling with mental illness or who committed suicide;*

578   *Parent/Caregiver/Sibling went to prison;*

579   *I did not experience any of the above during my childhood;*

580   *Prefer not to say.*

581

582   For the purpose of this study, we examined 2 specific interpersonal traumas including:

583   *Cyberbullying or online abuse; Prolonged sexual abuse, or severe sexual assault*

584

585   ***Regression Analysis***

586   A regression analysis was conducted on a subset of the Global Mind data collected

587   between July 1, 2023 to November 30, 2024, from 64,779 18–24-year-olds (63% females,

588   35% males,2% preferred not to say) (Figure 2) and excluded individuals who were 18 or

589   older when they first acquired smartphones and/or first acquired a social media account.

590

591   We ran a linear regression model where the outcome was the MHQ score and the primary

592   coefficient of interest was the slope of the age at first smartphone ownership variable. This

593   slope (or beta co-efficient) would be expected to change with the addition of other factors

594   (variables) on the causal pathway between age at first smartphone ownership and MHQ.

595   The other factors added to the model included: (i) age at first social media account, (ii)

596   closeness to family (iii) Having close friends who help out, (iv) *Cyberbullying or online*

597   *abuse,* (v) Prolonged sexual abuse or severe sexual assault*;* and (vi) sleep sufficiency and

598   (vii) UPF consumption.

599

600   Since we wanted to gauge the relative importance of each factor in both explaining the age

601   at smartphone-MHQ relationship, as well as to determine the importance of each factor to

602   the R^2, we used two variants of a linear regression model. In the first approach, we

603   included each factor first- i.e., right after the inclusion of the age of smartphone variable.

604   This specification will in general provide an upper bound on the relative importance of the

605   particular factor. In the second approach, we included the factor after the inclusion of

606   every other factor. This specification should provide the "residual" importance of a

607   specific factor after every other factor has been accounted for, i.e. accounting for all o the

608   multi-collinearity in among the variables.

609

610   **Approach 1: First addition**

611
$$MHQ = \beta_{01} + \beta_{1,sph}Age\_sph + u_a \qquad (1)$$
$$MHQ = \beta_{02} + \beta_{2,sph}Age\_sph + \beta_{agesoc}Agesocialmed + u_b \qquad (2)$$
$$MHQ = \beta_{03} + \beta_{3,sph}Age\_sph + \beta_{famrel}Famrel + u_c \qquad (3)$$
$$MHQ = \beta_{04} + \beta_{4,sph}Age\_sph + \beta_{friendhlp}Friendhlp + u_d \qquad (4)$$
$$MHQ = \beta_{05} + \beta_{5,sph}Age\_sph + \beta_{cyber}Cyberbully + u_e \qquad (5)$$
$$MHQ = \beta_{06} + \beta_{6,sph}Age\_sph + \beta_{sexab}Sexabuse + u_f \qquad (6)$$
$$MHQ = \beta_{07} + \beta_{7,sph}Age\_sph + \beta_{upf}UPF + u_g \qquad (7)$$
$$MHQ = \beta_{08} + \beta_{8,sph}Age\_sph + \beta_{sleep}Sleep + u_h \qquad (8)$$

612    $\beta_{1,sph}$ represents the slope of the age at smartphone ownership (Age_sph) and MHQ

613   relationship. For variant 1 in our model we add, separately, each additional factor as

614   shown above. There are two statistics we compute to gauge the importance of a factor.

615   First, the percent change in Beta after adding (in equation 2) the age at first social media

616   posting ($Agesocialmed$) is given by: $\left(\left(\beta_{1,sph} - \beta_{2,sph}\right) \times 100 / \beta_{1,sph}\right)$. Second, we estimate the

617   change in R^2 between the two models (for example, equation 1 and equation 2, equation 1

618   and equation 3, and so on).

619

620   Our **second approach** is similar to the first, except that we add each factor last—i.e., after

621   the addition of all other factors.

622　For example, with the age at social media variable, Equation 9 when every factor except

623　social media is included, and equation 9' where we also include social media.

$$MHQ = \beta_{02} + \beta_{2,sph} Age\_sph + \beta'_X X_{-agesocmed} + u_b \qquad (9)$$

624　$$MHQ = \beta_{02} + \beta_{2,sph} Age\_sph + \beta'_X X_{-agesocmed} + \beta_{agesoc} Agesocialmed + u_b \qquad (9')$$

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

626　social media posting.

627　The statistics calculated are otherwise similar to approach 1 above.

628

629　The analysis computed two statistics obtained from the regression when adding each

630　successive group of variables as follows:

631　　1) the percent change in (β) that represents the slope of the relationship between the

632　　　age at smartphone ownership and mind health.

633　　2) The change in R^2 from the regression.

634

635　**Results**

636　***Lifestyle factors***

637　*Ultra-processed food consumption (UPF)*

638　Here we show the association between the age of first smartphone ownership during

639　childhood and the frequency of UPF consumption in young adults aged 18–24 years. Young

640　adults who owned a smartphone at an earlier age during childhood were more likely to

641　report they consumed UPF 'Several times a day' or 'Once a day' compared to those who

642　owned their smartphone from a later age during childhood (Figure 6A, 6B). This trend was

643　present across both males and females. Furthermore, the pattern was observed across all

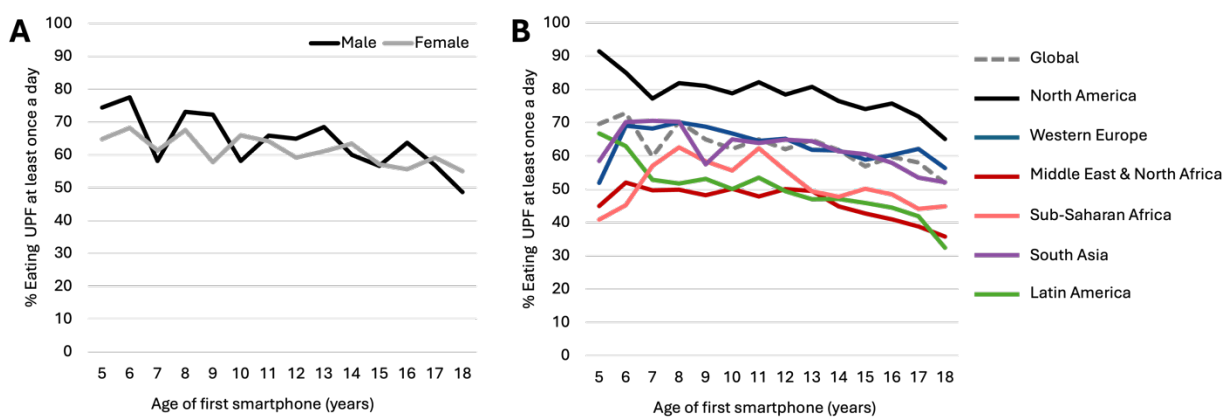644　Internet-enabled regions, with particularly pronounced effects in North America and Latin

645　America.

646

647
648 **Figure 6:** *Relationship between age of smartphone during childhood and UPF consumption*

649 *frequency at age 18-24. (A) Global trend in males (black) and females (grey) at age 18-24.*

650 *(B) Regional trend (males and females combined). Values shown in Supplementary Table*

651 *8.*

652

653 *Sleep Sufficiency*

654 Here we show the association between the age of first smartphone ownership during

655 childhood and the reported frequency of good sleep among 18–24-year-olds. We found

656 that females, aged 18-24 who owned a smartphone at a younger age during childhood

657 were more likely to experience poor or insufficient sleep as shown by the percentage who

658 indicated that that they slept well either 'All of the time' or 'Most of the time' (Figure 7A).

659 This trend was not observed in males, highlighting a biological sex disparity in the impact of

660 early smartphone use on sleep patterns (Figure 7A; see Supplementary Table 9) in line with

661 other studies (Amez et al. 2020). This trend in females was present in most regions and

662 particularly pronounced in Western Europe and Sub-Saharan Africa (Figure 7B).

29

663
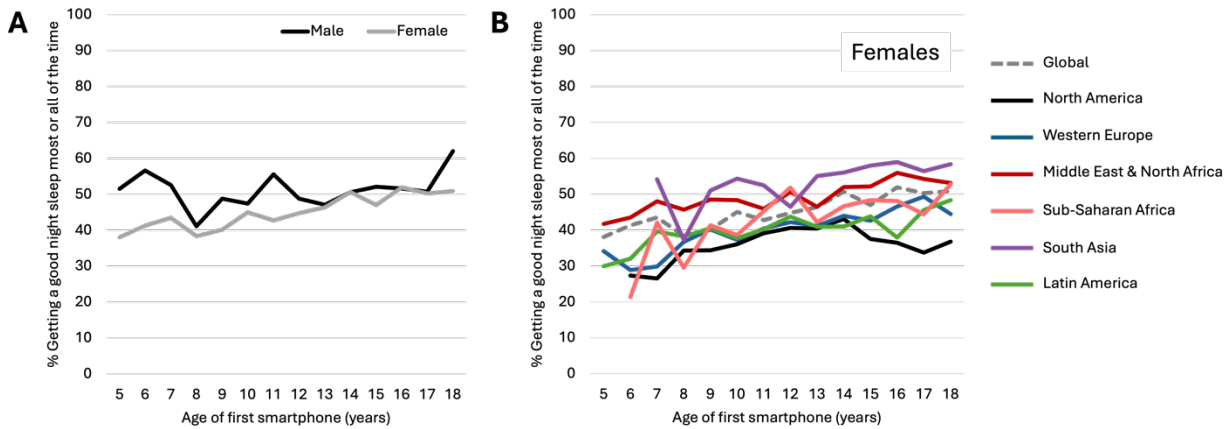
Figure 7: *Relationships between age of smartphone ownership in childhood and sleep*

sufficiency at age 18-24. (A) Global trend in males (black) and females (grey) at age 18-24.

(B) Regional trend in females aged 18-24. Values for males and females shown in

Supplementary Table 9.

Physical exercise

Here we show the association between age of first smartphone in childhood and the

exercise frequency of 18–24-year-olds. There was no significant association between the

age of first smartphone ownership and the percentage who reported exercising regularly

(Every day or a Few days a week) in young adulthood in either males or females (Figure 8A,

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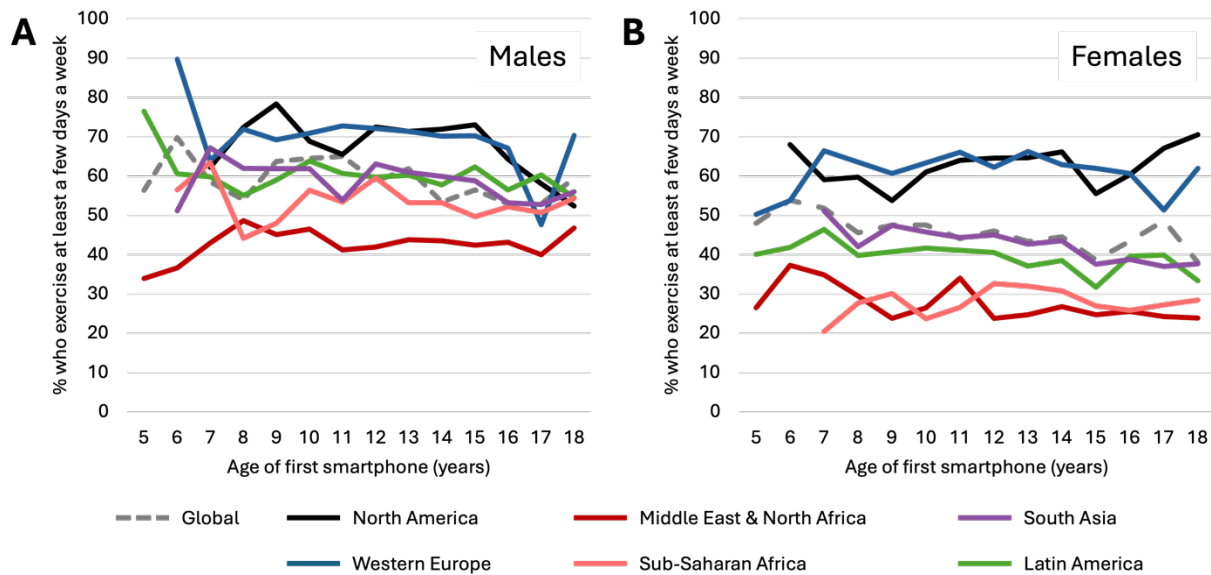
Figure 8: *Relationships between age of smartphone ownership in childhood and frequency of physical exercise at age 18-24. (A) Global and regional trend in males at age 18-24 (B) Global and regional trend in females at age 18-24. Values shown in Supplementary Table 10.*

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.
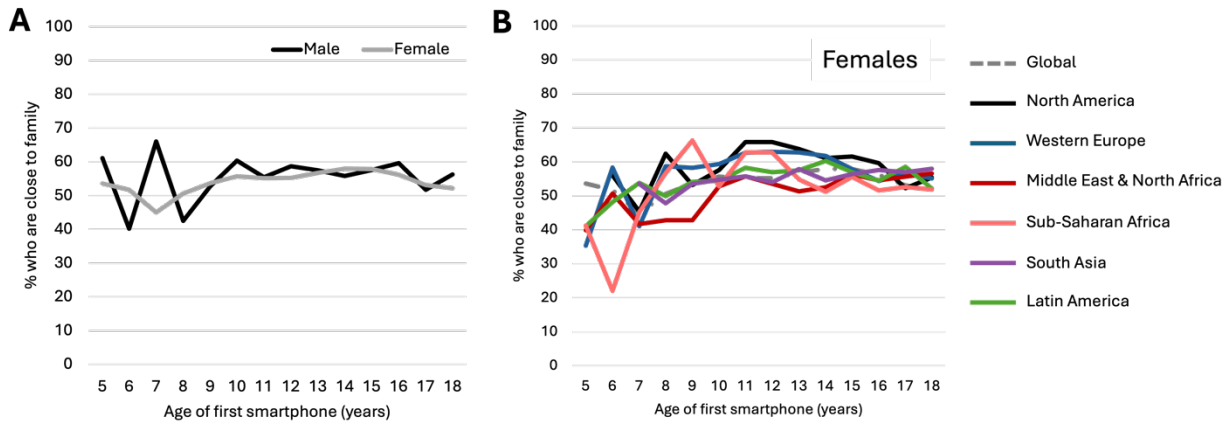
693

694 **Figure 9:** *(A) Relationship between age of smartphone ownership in childhood and family*

695 *closeness at age 18-24 for males (black) and females (grey) globally. (B) Relationship*

696 *between age of smartphone ownership in childhood and family closeness for females aged*

697 *18-24 globally and across regions. Values shown in Supplementary Table 11.*

698

699 *Friendships*

700 Here we show the relationship between the age of first smartphone ownership during

701 childhood and the likelihood of having close friends who would help one out at age 18–24.

702 Globally, young adults, and females in particular, were more likely to report having friends

703 who would help them out if they received their first smartphone at an older age (Figure 10;

704 Supplementary Table 12). This increasing trend was most prominent among females in the

705 Middle East (Figure 10B). In contrast, an inverted U-shaped pattern was observed in

706 Western Europe and North America where females who received smartphones after age 13

707 reported a lower likelihood of having close friends who would help them out while there

708 was no relationship in South Asia. These findings again suggest that the timing of

709 smartphone ownership interacts with cultural and social factors to influence the quality

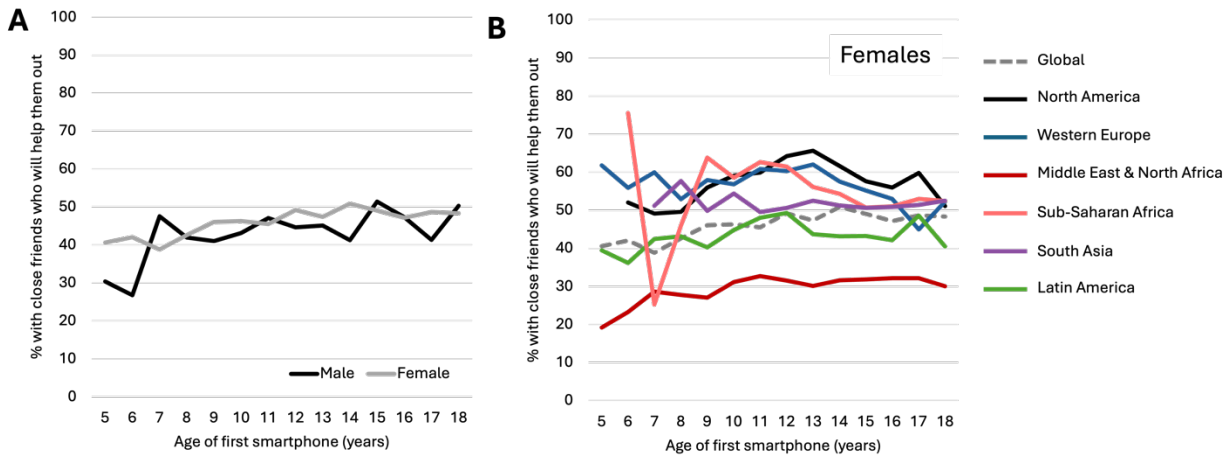710 and accessibility of close friendships.

711

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
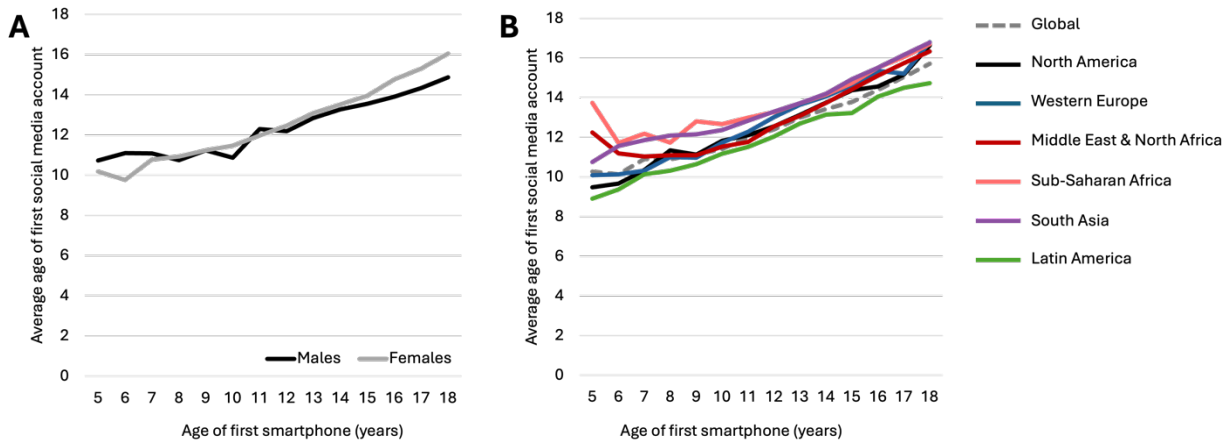media accounts as early as age 10 on average.

727

728 **Figure 11:** *Relationship between age of smartphone ownership and age of first social*

729 *media account. (A) Global trend in males (black) and females (grey) at age 18-24). (B)*

730 *Regional trend (males and females combined). Values shown in Supplementary Table 13.*

731

732 *Cyberbullying:*

733 Here we show the association between the percentage of 18–24-year-olds who reported

734 having experienced cyberbullying and the age at which their owned their smartphone

735 during childhood. In many regions, earlier age of smartphone ownership was associated

736 with a greater likelihood of having experienced cyberbullying by age 18-24 (Figure 12;

737 Supplementary Table 14). This trend was particularly pronounced in North America and
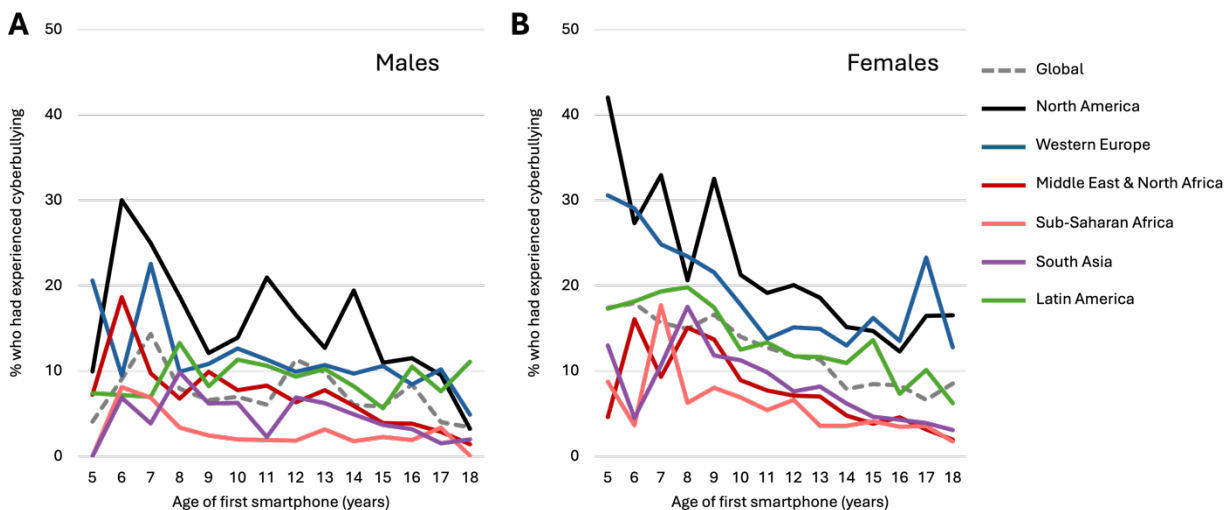
738 Western Europe and was stronger in females than males.

739

740

741   **_Figure 12:_** _Relationship between age of smartphone ownership in childhood and the_

742   _likelihood of having experienced cyberbullying by age 18-24 in males (A) and females (B)_

743   _globally and across the different regions. Values shown in Supplementary Table 14._

744

745   _Sexual abuse & assault_

746   Here we show the association between the percentage of 18–24-year-olds who reported

747   having experienced sexual abuse or assault and the age at which their owned their

748   smartphone during childhood. In females in North America in particular, an earlier age of

749   smartphone ownership was associated with a greater likelihood of having experienced

750   sexual abuse or assault by age 18-24 (Figure 13; Supplementary Table 15). This trend was

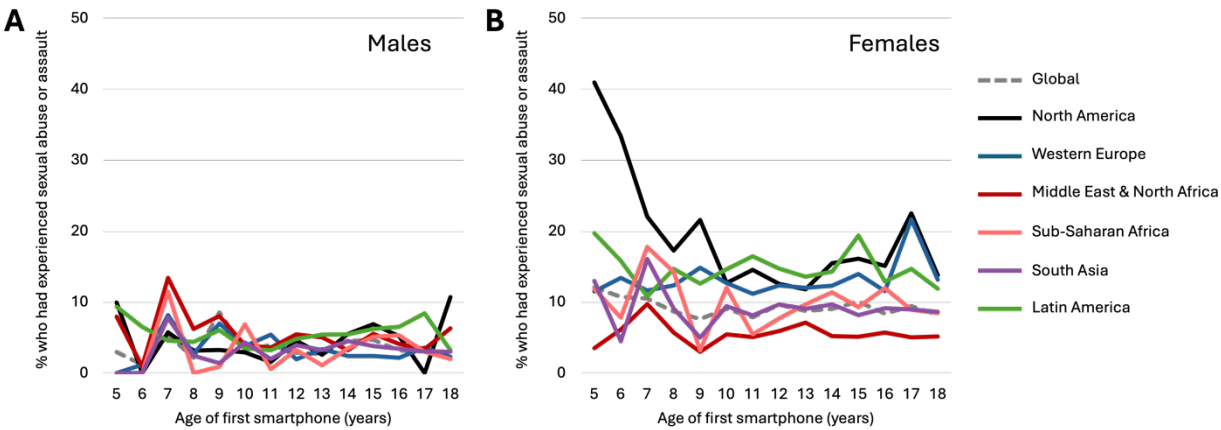751   not present in other regions, or in males.

752

753

754

755   **_Figure 13:_** _Relationship between age of smartphone ownership in childhood and the_

756   _likelihood of having experienced sexual abuse/assault by age 18-24 in males (A) and_

757   _females (B) globally and across the different regions. Values shown in Supplementary_

758   _Table 15._

759

760   **Overall contribution of lifestyle and interpersonal factors**

761   We next looked at how much these factors contribute to the overall trend of diminished

762   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.

792 When looking at the change in R^2, we find that family relationships and sleep contribute the

793 most to mind health or MHQ scores over and above the impact associated with age of first

794 smartphone, as indicated by the largest change in R^2 ranging from about 0.07 to 0.15 for

795 family relationships and 0.05 to 0.11 for sleep. On the other hand, the age at social media

796 posting that explained a substantial part of the age of smartphone effect, explains almost a

797 minimal portion of the overall MHQ over and above age of first smartphone. In Table 4,

798 where the factors are added last, the results are qualitatively similar, even when

799 accounting for all other factors. Thus, while sleep and family relationships explain some of

800 the effects of the effects of age of first smartphone on mind health, they also have

801 independent effects. The limited effect of UPF suggests that the effects of UPF on mind

802 health (Bala et al. 2025) are not related to age of first smartphone per se, though an

803 association with patterns of smartphone use cannot be ruled out.

804

805 **Table 3:** Percentage change in the beta coefficient for the age of first smartphone variable

806 and R^2 for the overall population and for each region separately in regression models where

807 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

	Statistic							
	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

808

809 **Table 4:** Percentage change in the beta coefficient for the age of first smartphone variable

810 and R^2 for the overall population and for each region separately in regression models where

811 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

812

813

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

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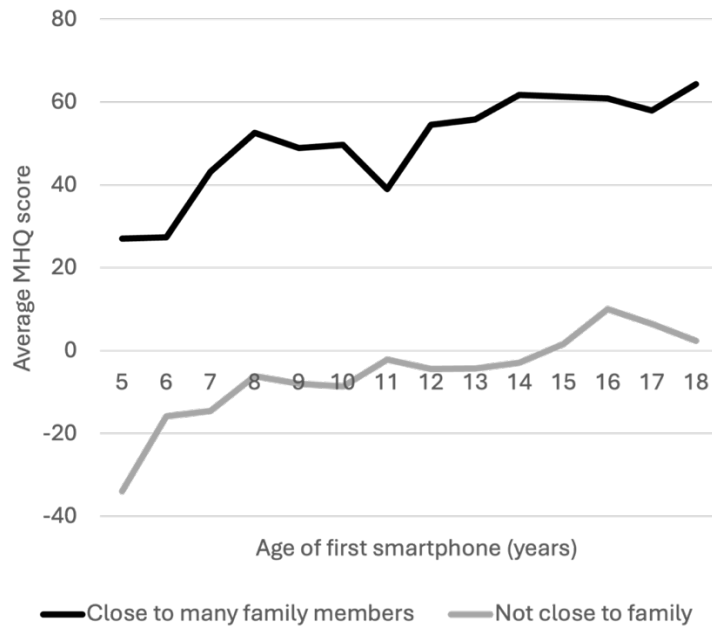
829   children smartphones at a younger age.

830

831

832   ***Figure 14:*** *Relationship between MHQ Score at age 18-24 and age of smartphone*

833   *ownership in childhood for respondents who reported they were close to many family*

834   *members (black) and those who reported they were not close to family (grey) (global).*

835   *Values shown in Supplementary Table 16.*

836

837   **Discussion**

838   Altogether we show that the timing of smartphone ownership during childhood interacts

839   with multiple dimensions of lifestyle and interpersonal experience, which collectively

840   influence mind health trajectories in 18–24-year-olds. Particularly, age of first social media

841   account explained 25% to 70% of the age at smartphone ownership effect overall (based

842   on effect when added first in the regression), with the biggest contribution in the

843   Anglosphere and smallest effect in South Asia. This was followed by family relationships

844   (11 to 20%) and sleep, which contributed 12% globally with the biggest contribution in

845   South Asia (35%). Cyber-bullying contributed 10% globally, with substantially higher

846   contribution in North America (37%). It is important to clarify that these number only

847   represent how much these factors are likely contributing on account of early age of

848   smartphone during childhood, and not their contribution arising from patterns of

849   smartphone use in adulthood or their total contribution to mind health which will be

850   higher. Overall, these results suggest that the age of social media account lies on the

851   causal pathway of the association between age at smartphone and mind health. However,

852   it is the variation in social factors (i.e., relationship with family and friends) that explains

853   the greatest share of the variation in mind health. While the impact of a younger age of

854   smartphone on MHQ scores in adulthood are partly mediated through a decrease in family

855   closeness, the converse is not true. That is, those with families that were not close were

856   not more likely to give their children smartphones at a younger age. Therefore, while

857   restrictions on age at social media use, such as those recently implemented in Australia,

858   may cushion the deleterious effects of an early age of smartphone ownership on mind

859   health, better relationships between young adults (18-24) and their family and sleep are

860   extremely important for improving overall mind health and points to a large cultural

861   component, and possibly time spent online by parents at the exclusion of engagement

862   with their children. Below we provide a perspective on why and how each of the

863   contributing factors that impact mind health may be influenced by the age of first

864   smartphone.

865

866   *Age of social media account*

867   Girls are often considered to be heavier users of social media platforms and more

868   susceptive to its impact on mind health (Twenge and Martin 2020), while other evidence

869   suggests that the age of first smartphone ownership can influence the way adolescents

870   approach social media (Gerosa et al. 2024). Here we showed that the age of social media

871   had the biggest explanatory power of the effects of age of first smartphone on mind health

872   in adulthood. As well as the interpersonal risks discussed below , evidence also suggests

873   that social media, especially when it is problematic or other focused, is associated with

874   lower self-esteem in some adolescents, especially in females and those with smaller

875   social networks (Lim, Lau, and Li 2021; Steinsbekk et al. 2021; Tibber, Zhao, and Butler

876   2020). Given the association between age of smartphone ownership and age of social

877   media account, this may also contribute to why age of smartphone ownership has the

878   most profound impact on the dimension of Social self (as shown in Section 1). In addition,

879   the minimum age for a child to create a social media account varies by platform, but most

880   set the age at 13 years old in compliance with regulations such as the Children's Online

881   Privacy Protection Act (COPPA) in the United States (Federal Trade Commission 1998).

882   However, despite these guidelines, many younger children access social media with or

883   without parental consent. For example, in the UK, 80% of children age 12 have a social

884   media account (OFCOM 2023) while in the US 38% of 8-12-year-olds have used social

885   media and nearly one in five (18%) now say they use social media "every day"(Common

886   Sense Media 2021). Here we found that children who receive smartphones at a younger

887   age tend to create social media accounts earlier, often before the minimum age of 13, with

888   some starting as young as 10, a trend observed across genders and regions.

889

890   *Sleep*

891   The relationship between poor mind health and disrupted sleep is well established. In

892   addition, smartphone use has been widely implicated in disrupted sleep patterns through

893   a number of routes (Amez et al. 2020; Brautsch et al. 2023; Burnell et al. 2024; Dibben et

894   al. 2023; Lemola et al. 2015; Maurya et al. 2022; McCaffrey et al. 2024; Sá et al. 2023). For

895   example, excessive smartphone use, especially during the evening and night-time hours,

896   and checking or using smartphones during the night are associated with displacement of

897   sleep time, delayed bedtimes, fragmented sleep, reduced sleep duration, and can lead to

898   re-entrainment of the body's natural circadian rhythm. Importantly, the cumulative effects

899   of poor sleep hygiene can contribute to a significant sleep debt, or 'social jet lag' over time

900   (Touitou 2013). The effect of early age of smartphones on poor sleep in adulthood in

901   females but not males is consistent with other studies (Amez et al. 2020). This suggests

902   that, similar to with UPF consumption, unhealthy sleep habits established by girls during

903   adolescence, shaped by early smartphone ownership, may persist into young adulthood,

904   contributing to a cumulative sleep debt and ongoing impacts on mind health at ages 18-24.

905   *Family Closeness and Friendships*

906   There has been considerable debate about the impact of smartphone usage on family and

907   friendship dynamics. The ubiquity of smartphones by today's adolescents has

908   fundamentally reshaped how friendships develop and operate compared to previous

909   generations, with social media and messaging platforms playing a central role in

910   communication and connection. However, although this has created new opportunities for

911   social interaction, it has also raised concerns about the consequence on the development

912   of social skills such as empathy, conflict resolution, and emotional regulation which need

913   to be practiced and developed in the real world. For example, a recent report found that 13

914   year old girls report greater levels of aggression and anger compared to 17 year olds, a

915   trend that can in part be attributed to earlier age of smartphone ownership (Sapien Labs

916   2025). Similarly, in family settings, smartphones have introduced new sources of conflict,

917   such as disputes over screen time, privacy, and parental restrictions (Kim et al. 2019;

918   Merkaš et al. 2024), although it is important to note that both parents and child practices

919   are relevant in a family setting. For example, Practices like 'phubbing' - ignoring family

920   members in favor of smartphone use - have been linked to feelings of neglect and

921   disconnection within households (Solecki 2022). On the other hand, smartphones also

922   offer opportunities for families to stay connected across distances, highlighting their dual

923   role as both a unifying and divisive tool. Here, and in line with this complexity, we show a

924   nuanced interplay between the timing of smartphone ownership, cultural context, and

925   social relationships. In particular, we find that, globally, young adults, and particularly

926   females, were more likely to report being close to their families and having friends who

927   would help them if they received their first smartphone at an older age. However, these

928   patterns varied regionally, with cultural and social factors influencing outcomes. For

929   instance, while older smartphone ownership was linked to greater family closeness in

930   regions like Latin America, North America displayed an inverted U-shaped trend, with

931   family closeness decreasing when smartphones were first owned after age 13. Similarly,

932   while older smartphone ownership correlated with stronger friendships globally, regions

933   like Western Europe and North America showed a decline in close friendships for those

934   receiving smartphones after age 13. This may arise due to greater conflict between child

935   and parents for withholding a smartphone when all of their peers and being excluded from

936   online social interactions of their peers.

937

938   *Cyberbullying & sexual abuse/assault*

939   Previous research has shown that adolescent encounter multiple different types of threats

940   on social media such as cyberbullying, sexual harassment, racism, unauthorized

941   distribution of sensitive material, phishing attempts, misinformation, the sale or

942   distribution of drugs, and harmful or dangerous social media challenges (Lahti et al. 2024).

943   Early adoption of smartphones among children and adolescents therefore introduces

944   substantial interpersonal risks from a young age. For example, it's well known that the

945   internet can expose children to content that is unregulated or inappropriate (Common

946   Sense Media 2022) and offers a substantial departure from the family- and community-

947   centric experiences of the past Here we examined two specific forms of interpersonal

948   trauma, cyberbullying and sexual abuse/assault, both of which are often associated with

949   smartphone use, particularly through social media platforms and which have a negative

950   impact on mind health (Sapien Labs 2023a).

951

952   Cyberbullying, which typically includes sending harassing messages (via text or the

953   Internet), posting disparaging comments on a social networking site, posting humiliating

954   pictures, or threatening/intimidating someone electronically, has become an international

955   public health concern among adolescents. Considerable evidence has shown that the

956   experience of cyberbullying has a negative impact on mental health including feelings of

957   depression and suicidal ideation (Hinduja and Patchin 2010; Kowalski et al. 2014; Nixon

958   2014; Smith et al. 2008). In addition, data from the Global Mind Project shows that the

959   impact of cyberbullying on mental health is almost as significant as sexual abuse (Sapien

960   Labs 2023a). This association of a higher likelihood of cyberbullying with a younger age of

961   first smartphone is also in line with other studies that shows that early social media

962   initiation (e.g. Snapchat or Instagram) before age 10 is significantly associated with more

963   unsympathetic online behaviors, and greater likelihood of online harassment and sexual

964   harassment victimization (Charmaraman et al. 2022; Young 2024). While the incidence of

965   cyberbullying appears to be broadly similar in males and females (WHO 2024), here we

966   show that the association between age of smartphone ownership and the experience of

967   cyberbullying is most apparent in females.

968

969   The association of earlier smartphone ownership during childhood sexual abuse or assault

970   by ages 18–24, among females in North America likely has different causes from

971   cyberbullying which may be more peer-to-peer. It is known that social media platforms can

972   allow predators to exploit vulnerable individuals through social media platforms,

973   messaging apps, and online games, often under the guise of anonymity or false identities.

974   Younger girls are likely particularly vulnerable as they do not have the worldly experience to

975   understand and interpret overtures. In addition, social media also exposes children to

976   sexually explicit material, which can normalize inappropriate behaviors and desensitize

977   them to healthy sexual boundaries (Braun-Courville and Rojas 2009; Owens et al. 2012;

978   Peter and Valkenburg 2006). For example, a recent report from Common Sense Media

979   found that 15% of teen respondents aged 13 to 17 in the US said they first saw online

980   pornography at age 10 or younger, with the average age being 12 (Common Sense Media

981   2022). Owning a smartphone at an early age increases the risk of children being exposed to

982   this type of information at a younger age and may be less equipped to recognize and

983   handle such predatory behavior online, making them more vulnerable to exploitation.

984   However, evidence also suggests a potentially bi-directional relationship with those who

985   have experienced adverse childhood experiences (e.g. abuse neglect), being more likely to

986   be problematic smartphone users (Geng et al. 2022; Zheng et al. 2024). As females are

987   typically more heavy social media users, this may, in part explain the gender differences.

988   However, regional differences also emerged with, females in the Middle East reporting

989   lower levels of sexual abuse/assault, possibly due to stricter digital boundaries within

990   cultural norms compared to countries such as the US.

991

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

1021   adulthood for either males or females. One possibility is the specific wording of the

1022   question and the suggestion that smartphone use may lead to increased sedentary

1023   behavior or hours of sitting, independent of levels physical activity (Fennell et al. 2019).

1024   However, as levels of physical activity is currently only probed with a single question, it

1025   was not possible to explore this association further in this analysis. However, given that

1026   levels of physical activity in children and adolescents is an issue of growing concern

1027   (Guthold et al. 2020), further research is warranted in this area.

1028

1029   ***Overall conclusions from Sections 1 and 2***

1030   In conclusion, these findings indicate that earlier smartphone ownership in childhood is

1031   associated with significant and cumulative effects on mind health, particularly in females.

1032   In light of a recent study that younger age of smartphone ownership is associated with

1033   more pervasive smartphone use and different approaches to social media as those

1034   children grow up (Gerosa et al. 2024), also highlights how habits and behaviors, shaped by

1035   early smartphone ownership and use during critical periods of development, can persist

1036   and evolve over time. However, we also note that these associations may be influenced by

1037   smartphone use itself, rather than—or in addition to—the age at which a smartphone was

1038   first owned.

1039

1040   Altogether, we highlight the complex interplay of factors that meditate the relationship

1041   between smartphone ownership and mind health outcomes in young adulthood. Frequent

1042   consumption of ultra-processed foods (UPFs), insufficient sleep, weaker social

1043   relationships, and experience of interpersonal traumas, such as cyberbullying and sexual

1044   abuse/assault, which are all shaped by smartphone and social media use, emerged as key

1045   contributors to this association. Regression analyses further underscored the pivotal role

1046   of the age of initiation to social media, explaining up to 40% of the association globally,

1047   with contributions as high as 70% in North America. These findings suggest that early

1048   smartphone access and particularly social media use, shapes lifestyle habits, social

1049   dynamics, and digital behaviors, and, in turn, mind health trajectories from adolescence to

1050   young adulthood.

1051

1052   These outcomes highlight the need for comprehensive policies that promote responsible

1053   smartphone use, support digital literacy, and mitigate risks associated with early

1054   exposure. Interventions could include delaying smartphone acquisition, fostering offline

1055   social interactions, and implementing safeguards to reduce exposure to harmful online

1056   content. As the age of first smartphone ownership continues to get younger, understanding

1057   and addressing its long-term implications will be critical to ensuring the mental wellbeing

1058   of future generations. Further research is needed to explore these trends with greater

1059   resolution and to develop evidence-based strategies for intervention and prevention.

1060

1061   These outcomes emphasize the urgent need for holistic policies that prioritize responsible

1062   digital integration and safeguard young people from the risks associated with early

1063   smartphone exposure. Policymakers should consider strategies such as delaying the age

1064   of smartphone acquisition, promoting digital literacy programs, providing opportunities for

1065   offline social interactions at a community level, and enforcing stricter protections against

1066   harmful online content. As global trends show increasingly younger ages of first

1067   smartphone ownership, addressing these issues through continued research and

1068   international collaboration will be vital for safeguarding the mind health and social

1069   development of future generations in an increasingly digital world.

1070

1071   **References**

1072   Amez, Simon, Sunčica Vujić, Pieter Soffers, and Stijn Baert. 2020. "Yawning While

1073   Scrolling? Examining Gender Differences in the Association between Smartphone

1074   Use and Sleep Quality." *Journal of Sleep Research* 29(6):e12971. doi:

1075   10.1111/jsr.12971.

1076   Askari, Melanie S., Daniel W. Belsky, Mark Olfson, Joshua Breslau, Ramin Mojtabai,

1077   Sandhya Kajeepeta, Emilie Bruzelius, and Katherine M. Keyes. 2023. "An Integrative

1078   Literature Review of Birth Cohort and Time Period Trends in Adolescent Depression

1079   in the United States." *Social Psychiatry and Psychiatric Epidemiology*. doi:

1080   10.1007/s00127-023-02527-8.

1081 Bala, Jerzy, Oleksii Sukhoi, Jennifer Newson, and Tara Thiagarajan. 2025. "Estimation of

1082   the Nature and Magnitude of Mental Distress in the Population Associated with

1083   Ultra-Processed Food (UPF) Consumption." *In Review*.

1084 Balhara, Maria. 2022. "Examining Smartphone Use During Mealtime and Its Association

1085   With Eating Disorders Among Adolescents." in *Endocrine Abstracts*. Vol. 86.

1086   Bioscientifica.

1087 Barros, Anna Karolina Cerqueira, Gilmar Mercês de Jesus, Graciete Oliveira Vieira, and

1088   Lizziane Andrade Dias. 2023. "Use of Screens and Intake of Unhealthy Food among

1089   Children and Adolescents: Association with Physical Activity in a Cross-Sectional

1090   Study." *BMC Nutrition* 9:104. doi: 10.1186/s40795-023-00763-4.

1091 Blanchflower, David. 2023. "The Global Loss of the U-Shaped Curve of Happiness."

1092   Retrieved June 21, 2024 (https://www.afterbabel.com/p/youth-health-declines-82-

1093   countries).

1094 Blanchflower, David G. 2021. "Is Happiness U-Shaped Everywhere? Age and Subjective

1095   Well-Being in 145 Countries." *Journal of Population Economics* 34(2):575–624. doi:

1096   10.1007/s00148-020-00797-z.

1097 Braun-Courville, Debra K., and Mary Rojas. 2009. "Exposure to Sexually Explicit Web Sites

1098   and Adolescent Sexual Attitudes and Behaviors." *Journal of Adolescent Health*

1099   45(2):156–62. doi: 10.1016/j.jadohealth.2008.12.004.

1100 Brautsch, Louise As., Lisbeth Lund, Martin M. Andersen, Poul J. Jennum, Anna P. Folker,

1101   and Susan Andersen. 2023. "Digital Media Use and Sleep in Late Adolescence and

1102   Young Adulthood: A Systematic Review." *Sleep Medicine Reviews* 68:101742. doi:

1103   10.1016/j.smrv.2022.101742.

1104 Burnell, Kaitlyn, Shedrick L. Garrett, Benjamin W. Nelson, Mitchell J. Prinstein, and Eva H.

1105   Telzer. 2024. "Daily Links between Objective Smartphone Use and Sleep among

1106   Adolescents." *Journal of Adolescence* 96(6):1171–81. doi: 10.1002/jad.12326.

Butterworth, Peter, Stefanie Schurer, Trong-Anh Trinh, Esperanza Vera-Toscano, and Mark Wooden. 2022. "Effect of Lockdown on Mental Health in Australia: Evidence from a Natural Experiment Analysing a Longitudinal Probability Sample Survey." *The Lancet Public Health* 7(5):e427–36. doi: 10.1016/S2468-2667(22)00082-2.

Caner, Nuray, Yağmur Sezer Efe, and Öznur Başdaş. 2022. "The Contribution of Social Media Addiction to Adolescent LIFE: Social Appearance Anxiety." *Current Psychology (New Brunswick, N.j.)* 41(12):8424–33. doi: 10.1007/s12144-022-03280-y.

CDC. 2020. "Youth Risk Behavior Survey Data Summary & Trends Report: 2009-2019."

CDC. 2023a. *Suicide and Homicide Death Rates Among Youth and Young Adults Aged 10–24: United States, 2001–2021*.

CDC. 2023b. *Youth Risk Behavior Survey: Data Summary & Trends Report*.

Charmaraman, Linda, Alicia Doyle Lynch, Amanda M. Richer, and Jennifer M. Grossman. 2022. "Associations of Early Social Media Initiation on Digital Behaviors and the Moderating Role of Limiting Use." *Computers in Human Behavior* 127:107053. doi: 10.1016/j.chb.2021.107053.

Common Sense Media. 2021. *The Common Sense Census: Media Use by Tweens and Teens*.

Common Sense Media. 2022. *2022 Teens and Pornography*.

Data Reportal. 2024. "Digital 2024: Global Overview Report." Retrieved December 10, 2024 (https://datareportal.com/reports/digital-2024-global-overview-report).

Dempsey, Seraphim, Seán Lyons, and Selina McCoy. 2019. "Later Is Better: Mobile Phone Ownership and Child Academic Development, Evidence from a Longitudinal Study." *Economics of Innovation and New Technology* 28(8):798–815. doi: 10.1080/10438599.2018.1559786.

Dempsey, Seraphim, Seán Lyons, and Selina McCoy. 2020. "Early Mobile Phone Ownership: Influencing the Wellbeing of Girls and Boys in Ireland?" *Journal of Children and Media* 14(4):492–509. doi: 10.1080/17482798.2020.1725902.

Dibben, Grace O., Anne Martin, Colin B. Shore, Avril Johnstone, Christina McMellon, Victoria Palmer, Juliana Pugmire, Julie Riddell, Kathryn Skivington, Valerie Wells, Lisa McDaid, and Sharon A. Simpson. 2023. "Adolescents' Interactive Electronic Device Use, Sleep and Mental Health: A Systematic Review of Prospective Studies." *Journal of Sleep Research* 32(5):e13899. doi: 10.1111/jsr.13899.

Federal Trade Commission. 1998. "Children's Online Privacy Protection Rule ('COPPA')." Retrieved January 13, 2025 (https://www.ftc.gov/legal-library/browse/rules/childrens-online-privacy-protection-rule-coppa).

Fennell, Curtis, Jacob E. Barkley, and Andrew Lepp. 2019. "The Relationship between Cell Phone Use, Physical Activity, and Sedentary Behavior in Adults Aged 18–80." *Computers in Human Behavior* 90:53–59. doi: 10.1016/j.chb.2018.08.044.

Geng, Jingyu, Ling Bao, Hongxia Wang, Jue Wang, Ting Gao, and Li Lei. 2022. "Does Childhood Maltreatment Increase the Subsequent Risk of Problematic Smartphone Use among Adolescents? A Two-Wave Longitudinal Study." *Addictive Behaviors* 129:107250. doi: 10.1016/j.addbeh.2022.107250.

Gerosa, Tiziano, and Marco Gui. 2023. "Earlier Smartphone Acquisition Negatively Impacts Language Proficiency, but Only for Heavy Media Users. Results from a Longitudinal Quasi-Experimental Study." *Social Science Research* 114:102915. doi: 10.1016/j.ssresearch.2023.102915.

Gerosa, Tiziano, Lucilla Losi, and Marco Gui. 2024. "The Age of the Smartphone: An Analysis of Social Predictors of Children's Age of Access and Potential Consequences Over Time." *Youth & Society* 56(6):1117–43. doi: 10.1177/0044118X231223218.

Gonçalves, Renata Fiche da Mata, Danyela de Almeida Barreto, Pâmela Ione Monteiro, Márcio Gilberto Zangeronimo, Paula Midori Castelo, Andries van der Bilt, and Luciano José Pereira. 2019. "Smartphone Use While Eating Increases Caloric Ingestion." *Physiology & Behavior* 204:93–99. doi: 10.1016/j.physbeh.2019.02.021.

Grimaldi-Puyana, Moisés, José María Fernández-Batanero, Curtis Fennell, and Borja Sañudo. 2020. "Associations of Objectively-Assessed Smartphone Use with

Physical Activity, Sedentary Behavior, Mood, and Sleep Quality in Young Adults: A Cross-Sectional Study." *International Journal of Environmental Research and Public Health* 17(10):3499. doi: 10.3390/ijerph17103499.

GSMA. 2024. "GSMA | The State of Mobile Internet Connectivity Report 2024 - Mobile for Development." Retrieved December 10, 2024 (https://www.gsma.com/r/somic/).

Guthold, Regina, Gretchen A. Stevens, Leanne M. Riley, and Fiona C. Bull. 2020. "Global Trends in Insufficient Physical Activity among Adolescents: A Pooled Analysis of 298 Population-Based Surveys with 1·6 Million Participants." *The Lancet Child & Adolescent Health* 4(1):23–35. doi: 10.1016/S2352-4642(19)30323-2.

Hinduja, Sameer, and Justin W. Patchin. 2010. "Bullying, Cyberbullying, and Suicide." *Archives of Suicide Research: Official Journal of the International Academy for Suicide Research* 14(3):206–21. doi: 10.1080/13811118.2010.494133.

Jaalouk, Doris, and Jocelyne Boumosleh. 2018. "Is Smartphone Addiction Associated with a Younger Age at First Use in University Students?" *Global Journal of Health Science* 10(2):p134. doi: 10.5539/gjhs.v10n2p134.

Jeong, Ahnhyun, Soorak Ryu, Solji Kim, Hoon-Ki Park, Hwan-Sik Hwang, and Kye-Yeung Park. 2023. "Association between Problematic Smartphone Use and Physical Activity among Adolescents: A Path Analysis Based on the 2020 Korea Youth Risk Behavior Web-Based Survey." *Korean Journal of Family Medicine* 44(5):268–73. doi: 10.4082/kjfm.22.0154.

Keyes, Katherine M., Dahsan Gary, Patrick M. O'Malley, Ava Hamilton, and John Schulenberg. 2019. "Recent Increases in Depressive Symptoms among US Adolescents: Trends from 1991 to 2018." *Social Psychiatry and Psychiatric Epidemiology* 54(8):987–96. doi: 10.1007/s00127-019-01697-8.

Kim, Min-Hyuk, Seongho Min, Joung-Sook Ahn, Chisoo An, and Jinhee Lee. 2019. "Association between High Adolescent Smartphone Use and Academic Impairment, Conflicts with Family Members or Friends, and Suicide Attempts." *PLOS ONE* 14(7):e0219831. doi: 10.1371/journal.pone.0219831.

Kowalski, Robin M., Gary W. Giumetti, Amber N. Schroeder, and Micah R. Lattanner. 2014. "Bullying in the Digital Age: A Critical Review and Meta-Analysis of Cyberbullying Research among Youth." *Psychological Bulletin* 140(4):1073–1137. doi: 10.1037/a0035618.

Krokstad, Steinar, Daniel Albert Weiss, Morten Austheim Krokstad, Vegar Rangul, Kirsti Kvaløy, Jo Magne Ingul, Ottar Bjerkeset, Jean Twenge, and Erik R. Sund. 2022. "Divergent Decennial Trends in Mental Health According to Age Reveal Poorer Mental Health for Young People: Repeated Cross-Sectional Population-Based Surveys from the HUNT Study, Norway." *BMJ Open* 12(5):e057654. doi: 10.1136/bmjopen-2021-057654.

La Marra, Marco, Giorgio Caviglia, and Raffaella Perrella. 2020. "Using Smartphones When Eating Increases Caloric Intake in Young People: An Overview of the Literature." *Frontiers in Psychology* 11. doi: 10.3389/fpsyg.2020.587886.

Lahti, Henri, Marja Kokkonen, Lauri Hietajärvi, Nelli Lyyra, and Leena Paakkari. 2024. "Social Media Threats and Health among Adolescents: Evidence from the Health Behaviour in School-Aged Children Study." *Child and Adolescent Psychiatry and Mental Health* 18(1):62. doi: 10.1186/s13034-024-00754-8.

Lane, Melissa M., Elizabeth Gamage, Shutong Du, Deborah N. Ashtree, Amelia J. McGuinness, Sarah Gauci, Phillip Baker, Mark Lawrence, Casey M. Rebholz, Bernard Srour, Mathilde Touvier, Felice N. Jacka, Adrienne O'Neil, Toby Segasby, and Wolfgang Marx. 2024. "Ultra-Processed Food Exposure and Adverse Health Outcomes: Umbrella Review of Epidemiological Meta-Analyses." *BMJ* 384:e077310. doi: 10.1136/bmj-2023-077310.

Lemola, Sakari, Nadine Perkinson-Gloor, Serge Brand, Julia F. Dewald-Kaufmann, and Alexander Grob. 2015. "Adolescents' Electronic Media Use at Night, Sleep Disturbance, and Depressive Symptoms in the Smartphone Age." *Journal of Youth and Adolescence* 44(2):405–18. doi: 10.1007/s10964-014-0176-x.

Leonhardt, Marja, and Stian Overå. 2021. "Are There Differences in Video Gaming and Use of Social Media among Boys and Girls?-A Mixed Methods Approach." *International*

1221   *Journal of Environmental Research and Public Health* 18(11):6085. doi:

1222   10.3390/ijerph18116085.

1223 Lim, Amy J., Clement Lau, and Norman P. Li. 2021. "The Moderating Role of Social Network

1224   Size on Social Media Use and Self-Esteem: An Evolutionary Mismatch Perspective."

1225   *Frontiers in Psychology* 12. doi: 10.3389/fpsyg.2021.734206.

1226 Louzada, Maria Laura da Costa, Gabriela Lopes da Cruz, Karina Augusta Aparecida

1227   Nogueira Silva, Ana Giulia Forjaz Grassi, Giovanna Calixto Andrade, Fernanda

1228   Rauber, Renata Bertazzi Levy, and Carlos Augusto Monteiro. 2023. "Consumption

1229   of Ultra-Processed Foods in Brazil: Distribution and Temporal Evolution 2008–

1230   2018." *Revista de Saúde Pública* 57:12. doi: 10.11606/s1518-8787.2023057004744.

1231 Lu, Wenhua, and Katherine M. Keyes. 2023. "Major Depression with Co-Occurring Suicidal

1232   Thoughts, Plans, and Attempts: An Increasing Mental Health Crisis in US

1233   Adolescents, 2011-2020." *Psychiatry Research* 327:115352. doi:

1234   10.1016/j.psychres.2023.115352.

1235 Matos, Rodrigo A., Michelle Adams, and Joan Sabaté. 2021. "Review: The Consumption of

1236   Ultra-Processed Foods and Non-Communicable Diseases in Latin America."

1237   *Frontiers in Nutrition* 8.

1238 Maurya, Chanda, T. Muhammad, Priya Maurya, and Preeti Dhillon. 2022. "The Association

1239   of Smartphone Screen Time with Sleep Problems among Adolescents and Young

1240   Adults: Cross-Sectional Findings from India." *BMC Public Health* 22:1686. doi:

1241   10.1186/s12889-022-14076-x.

1242 McCaffrey, Caoimhe, John McClure, Sukhmeet Singh, and Craig A. Melville. 2024.

1243   "Exploring the Relationship between Sleep and Aggression in Adolescents: A Cross

1244   Sectional Study Using the UK Millennium Cohort Study." *Clinical Child Psychology*

1245   *and Psychiatry* 29(2):577–90. doi: 10.1177/13591045231225824.

1246 McCurdy, Charlie, and Louise Murphy. n.d. "Action to Improve Young People's Mental

1247   Health, Education and Employment."

Merkaš, Marina, Matea Bodrožić Selak, and Ana Žulec Ivanković. 2024. "Problematic Smartphone Use and Communication in Families with Adolescents." *Adolescents* 4(1):107–19. doi: 10.3390/adolescents4010008.

Newson, Jennifer J., Daniel Hunter, and Tara C. Thiagarajan. 2020. "The Heterogeneity of Mental Health Assessment." *Frontiers in Psychiatry* 11:76. doi: 10.3389/fpsyt.2020.00076.

Newson, Jennifer Jane, Vladyslav Pastukh, and Tara C. Thiagarajan. 2022. "Assessment of Population Well-Being With the Mental Health Quotient: Validation Study." *JMIR Mental Health* 9(4):e34105. doi: 10.2196/34105.

Newson, Jennifer Jane, Oleksii Sukhoi, and Tara C. Thiagarajan. 2024. "MHQ: Constructing an Aggregate Metric of Population Mental Wellbeing." *Population Health Metrics* 22(1):16. doi: 10.1186/s12963-024-00336-y.

Newson, Jennifer Jane, and Tara C. Thiagarajan. 2020. "Assessment of Population Well-Being With the Mental Health Quotient (MHQ): Development and Usability Study." *JMIR Mental Health* 7(7):e17935. doi: 10.2196/17935.

Nixon, Charisse. 2014. "Current Perspectives: The Impact of Cyberbullying on Adolescent Health." *Adolescent Health, Medicine and Therapeutics* 143. doi: 10.2147/AHMT.S36456.

Odgers, Candice. 2018. "Smartphones Are Bad for Some Teens, Not All." *Nature* 554(7693):432–34. doi: 10.1038/d41586-018-02109-8.

OFCOM. 2023. "Children and Parents: Media Use and Attitudes 2023."

Ofcom. 2024. "A Window into Young Children's Online Worlds." *Www.Ofcom.Org.Uk*. Retrieved November 22, 2024 (https://www.ofcom.org.uk/media-use-and-attitudes/media-habits-children/a-window-into-young-childrens-online-worlds/).

Orben, Amy, and Andrew K. Przybylski. 2019. "The Association between Adolescent Well-Being and Digital Technology Use." *Nature Human Behaviour* 3(2):173–82. doi: 10.1038/s41562-018-0506-1.

Orben, Amy, Andrew K. Przybylski, Sarah-Jayne Blakemore, and Rogier A. Kievit. 2022.
"Windows of Developmental Sensitivity to Social Media." *Nature Communications* 13(1):1649. doi: 10.1038/s41467-022-29296-3.

Our World in Data. 2024. "Adoption of Communication Technologies per 100 People." Retrieved December 11, 2024 (https://ourworldindata.org/grapher/ict-adoption-per-100-people).

Owens, Eric W., Richard J. Behun, Jill C. Manning, and Rory C. Reid. 2012. "The Impact of Internet Pornography on Adolescents: A Review of the Research." *Sexual Addiction & Compulsivity* 19(1–2):99–122. doi: 10.1080/10720162.2012.660431.

Peter, Jochen, and Patti M. Valkenburg. 2006. "Adolescents' Exposure to Sexually Explicit Online Material and Recreational Attitudes Toward Sex." *Journal of Communication* 56(4):639–60. doi: 10.1111/j.1460-2466.2006.00313.x.

Pew Foundation. 2022. "Share of Those 65 and Older Who Are Tech Users Has Grown in the Past Decade." Retrieved (https://www.pewresearch.org/fact-tank/2022/01/13/share-of-those-65-and-older-who-are-tech-users-has-grown-in-the-past-decade/).

Poushter, Jacob. 2016. "Smartphone Ownership and Internet Usage Continues to Climb in Emerging Economies." *Pew Research Center*. Retrieved December 10, 2024 (https://www.pewresearch.org/global/2016/02/22/smartphone-ownership-and-internet-usage-continues-to-climb-in-emerging-economies/).

Ryu, Seaun, Hajin Jang, and Hannah Oh. 2022. "Smartphone Usage Patterns and Dietary Risk Factors in Adolescents." *The Journal of Nutrition* 152(9):2109–16. doi: 10.1093/jn/nxac098.

Sá, Sofia de, Ana Baião, Helena Marques, Maria do Céu Marques, Maria José Reis, Sandra Dias, and Marta Catarino. 2023. "The Influence of Smartphones on Adolescent Sleep: A Systematic Literature Review." *Nursing Reports* 13(2):612. doi: 10.3390/nursrep13020054.

Sapien Labs. 2022. *Mental State of the World 2021*.

Sapien Labs. 2023a. "Adult Mental Wellbeing after Abuse and Assault in Childhood."

1304 Sapien Labs. 2023b. *Mental State of the World 2022*.

1305 Sapien Labs. 2023c. *Ultra-Processed Food Consumption and Mental Wellbeing*
1306   *Outcomes*.

1307 Sapien Labs. 2024. *Mental State of the World 2023*.

1308 Sapien Labs. 2025. *The Youth Mind: Rising Aggression and Anger*.

1309 Silver, Laura. 2019. "2. In Emerging Economies, Smartphone Adoption Has Grown More
1310   Quickly among Younger Generations." *Pew Research Center*. Retrieved December
1311   10, 2024 (https://www.pewresearch.org/global/2019/02/05/in-emerging-
1312   economies-smartphone-adoption-has-grown-more-quickly-among-younger-
1313   generations/).

1314 Smith, Peter K., Jess Mahdavi, Manuel Carvalho, Sonja Fisher, Shanette Russell, and Neil
1315   Tippett. 2008. "Cyberbullying: Its Nature and Impact in Secondary School Pupils."
1316   *Journal of Child Psychology and Psychiatry, and Allied Disciplines* 49(4):376–85. doi:
1317   10.1111/j.1469-7610.2007.01846.x.

1318 Solecki, Susan. 2022. "The Phubbing Phenomenon: The Impact on Parent-Child
1319   Relationships." *Journal of Pediatric Nursing: Nursing Care of Children and Families*
1320   62:211–14. doi: 10.1016/j.pedn.2021.09.027.

1321 Steinsbekk, Silje, Lars Wichstrøm, Frode Stenseng, Jacqueline Nesi, Beate Wold Hygen,
1322   and Věra Skalická. 2021. "The Impact of Social Media Use on Appearance Self-
1323   Esteem from Childhood to Adolescence – A 3-Wave Community Study." *Computers*
1324   *in Human Behavior* 114:106528. doi: 10.1016/j.chb.2020.106528.

1325 Stephens, Janna, Hailey Miller, and Lisa Militello. 2020. "Food Delivery Apps and the
1326   Negative Health Impacts for Americans." *Frontiers in Nutrition* 7. doi:
1327   10.3389/fnut.2020.00014.

1328 Steptoe, Andrew, Angus Deaton, and Arthur A. Stone. 2015. "Subjective Wellbeing, Health,
1329   and Ageing." *The Lancet* 385(9968):640–48. doi: 10.1016/S0140-6736(13)61489-0.

1330 Stone, Arthur A., Joseph E. Schwartz, Joan E. Broderick, and Angus Deaton. 2010. "A
1331   Snapshot of the Age Distribution of Psychological Well-Being in the United States."

Proceedings of the National Academy of Sciences 107(22):9985–90. doi: 10.1073/pnas.1003744107.

Sun, Xiaoran, K. Farish Haydel, Donna Matheson, Manisha Desai, and Thomas N. Robinson. 2023. "Are Mobile Phone Ownership and Age of Acquisition Associated with Child Adjustment? A 5-year Prospective Study among Low-income Latinx Children." *Child Development* 94(1):303–14. doi: 10.1111/cdev.13851.

Svensson, Robert, Björn Johnson, and Andreas Olsson. 2022. "Does Gender Matter? The Association between Different Digital Media Activities and Adolescent Well-Being." *BMC Public Health* 22(1):273. doi: 10.1186/s12889-022-12670-7.

Taylor, Joseph, Oleksii Sukhoi, Jennifer Newson, and Tara Thiagarajan. 2023. "Representativeness of the Global Mind Project Data for the United States."

Teo, Ethan, Daniel Goh, Kamalakannan M. Vijayakumar, and Jean C. J. Liu. 2018. "To Message or Browse? Exploring the Impact of Phone Use Patterns on Male Adolescents' Consumption of Palatable Snacks." *Frontiers in Psychology* 8. doi: 10.3389/fpsyg.2017.02298.

Tibber, Marc S., Jiayuan Zhao, and Stephen Butler. 2020. "The Association between Self-Esteem and Dimensions and Classes of Cross-Platform Social Media Use in a Sample of Emerging Adults – Evidence from Regression and Latent Class Analyses." *Computers in Human Behavior* 109:106371. doi: 10.1016/j.chb.2020.106371.

Touitou, Yvan. 2013. "Adolescent Sleep Misalignment: A Chronic Jet Lag and a Matter of Public Health." *Journal of Physiology-Paris* 107(4):323–26. doi: 10.1016/j.jphysparis.2013.03.008.

Twenge, Jean M. 2020. "Increases in Depression, Self-Harm, and Suicide Among U.S. Adolescents After 2012 and Links to Technology Use: Possible Mechanisms." *Psychiatric Research and Clinical Practice* 2(1):19–25. doi: 10.1176/appi.prcp.20190015.

Twenge, Jean M., A. Bell Cooper, Thomas E. Joiner, Mary E. Duffy, and Sarah G. Binau. 2019. "Age, Period, and Cohort Trends in Mood Disorder Indicators and Suicide-

Related Outcomes in a Nationally Representative Dataset, 2005–2017." *Journal of Abnormal Psychology* 128(3):185–99. doi: 10.1037/abn0000410.

Twenge, Jean M., Jonathan Haidt, Thomas E. Joiner, and W. Keith Campbell. 2020. "Underestimating Digital Media Harm." *Nature Human Behaviour* 4(4):346–48. doi: 10.1038/s41562-020-0839-4.

Twenge, Jean M., and Gabrielle N. Martin. 2020. "Gender Differences in Associations between Digital Media Use and Psychological Well-Being: Evidence from Three Large Datasets." *Journal of Adolescence* 79:91–102. doi: 10.1016/j.adolescence.2019.12.018.

Twenge, Jean M., Gabrielle N. Martin, and W. Keith Campbell. 2018. "Decreases in Psychological Well-Being among American Adolescents after 2012 and Links to Screen Time during the Rise of Smartphone Technology." *Emotion* 18(6):765–80. doi: 10.1037/emo0000403.

WHO. 2024. "One in Six School-Aged Children Experiences Cyberbullying, Finds New WHO/Europe Study." Retrieved January 9, 2025 (https://www.who.int/europe/news-room/27-03-2024-one-in-six-school-aged-children-experiences-cyberbullying--finds-new-who-europe-study).

World Bank. 2024. "World Bank Open Data." *World Bank Open Data*. Retrieved December 17, 2024 (https://data.worldbank.org).

Xiang, Ming-Qiang, Long Lin, Zi-Rong Wang, Jin Li, Zebo Xu, and Min Hu. 2019. "Sedentary Behavior and Problematic Smartphone Use in Chinese Adolescents: The Moderating Role of Self-Control." *Frontiers in Psychology* 10:3032. doi: 10.3389/fpsyg.2019.03032.

Ybarra, Michele L., Kimberly J. Mitchell, and Jay Koby Oppenheim. 2022. "Violent Media in Childhood and Seriously Violent Behavior in Adolescence and Young Adulthood." *The Journal of Adolescent Health : Official Publication of the Society for Adolescent Medicine* 71(3):285–92. doi: 10.1016/j.jadohealth.2022.03.003.

Young, Emily. 2024. "Frequent Social Media Use and Experiences with Bullying Victimization, Persistent Feelings of Sadness or Hopelessness, and Suicide Risk

1389   Among High School Students — Youth Risk Behavior Survey, United States, 2023."

1390   *MMWR Supplements* 73. doi: 10.15585/mmwr.su7304a3.

1391   Zheng, Xinyu, Weiqing Jiang, Shuyi Peng, Qianyu Liu, Yitong He, Cuihong Huang, Yilin Hua,

1392   Ciyong Lu, and Lan Guo. 2024. "Childhood Adversity and Adolescent Smartphone

1393   Use Across Sexual Orientation and Gender Expression." *JAMA Network Open*

1394   7(4):e246448. doi: 10.1001/jamanetworkopen.2024.6448.

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1398   **Supplementary Data:** Average MHQ scores by age of first smartphone, separated out for

1399   individual ages, rather than for the 18-24 age group overall.

Age	Age of the first smartphone ownership													
	5	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
18	-1.8	-2.1	11.8	9.2	10.8	15.2	19.5	22.8	20.6	21.8	20.1	20.1	20.9	22.9
19	-8.8	-3.5	4.1	14.1	16.0	20.5	26.9	29.0	26.8	26.8	24.2	19.9	20.5	21.8
20	-6.3	24.0	9.2	14.7	22.8	27.3	31.3	33.9	31.7	31.6	29.9	27.5	21.1	24.9
21-24	17.3	33.4	30.0	32.9	34.0	35.1	38.0	39.6	37.2	38.1	37.1	35.5	32.7	30.8

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