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Effect of the COVID-19 pandemic on adolescent mental health and substance use up to March, 2022, in Iceland: a repeated, cross-sectional, population-based study

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Summary

Background Poor mental health in the first year of the COVID-19 pandemic has been well documented in adolescents; however, less is known about the longer-term effect of the pandemic. We aimed to examine adolescent mental health and substance use as well as covariates associated with these outcomes 1 year or more into the pandemic.

Methods A nationwide sample of adolescents aged 13–18 years enrolled in school in Iceland were invited to complete surveys administered during October–November or February–March, 2018, October–November, 2020, February–March or October–November, 2021, and February–March 2022. The survey was in Icelandic for all administrations and offered to adolescents aged 13–15 years in English in 2020 and 2022 and in Polish in 2022. Surveys assessed depressive symptoms (Symptom Checklist-90); mental wellbeing (Short Warwick Edinburgh Mental Wellbeing Scale); and the frequency of cigarette smoking, e-cigarette use, and alcohol intoxication. Covariates comprised age, gender, and migration status as determined by language spoken at home, level of social restrictions based on residency, parental social support, and sleep duration (≥ 8 h nightly). Weighted mixed-effect models were used to determine the effect of time and the covariates on mental health and substance use. The main outcomes were assessed in all participants with more than 80% of the necessary data, and multiple imputation was used to handle missing data. Bonferroni corrections were used to adjust for multiple testing and analyses were considered significant at a p value of $< 0 \cdot 0017$.

Findings 64 071 responses were submitted and analysed between 2018 and 2022. Elevated depressive symptoms and worsened mental wellbeing across girls and boys aged 13–18 years were observed to have been maintained up to 2 years into the pandemic ($p > 0 \cdot 0017$). Alcohol intoxication initially decreased during the pandemic but increased again as social restrictions eased ($p < 0 \cdot 0001$). No changes were observed in cigarette smoking and e-cigarette use during the COVID-19 pandemic. Higher levels of parental social support and an average sleep duration of 8 h or more per night were associated with mental health better outcomes and less substance use ($p < 0 \cdot 0001$). Social restrictions and migration background were inconsistently associated with the outcomes.

Interpretation Population-level prevention targeting adolescent depressive symptoms should be prioritised in health policy in the wake of COVID-19.

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Introduction

Establishing the potential mental health consequences of the COVID-19 pandemic is a public health research priority.¹ The need for high-quality data across the population to address this concern has been highlighted, particularly for vulnerable groups.^{1–3} The accumulating global research indicates an increase in mental health problems⁴ and a decrease in substance use⁵ among adolescents, especially girls and older youth, during the initial waves of the COVID-19 pandemic. However, few studies have examined mental health outcomes and substance use among adolescents as the pandemic evolved and associated social restrictions eased (appendix p 2). Although informative, the generalisability of the findings from these studies has been limited due to

small sample sizes, non-representative samples, or scarcity of pre-pandemic information. To our knowledge, only one population-based, repeated cross-sectional study⁶ to date has examined adolescent mental health and substance use a year into the pandemic in Norway. Although the effect sizes were small, this study found that the increase in depressive symptoms and decrease in alcohol intoxication among adolescents were sustained for up to a year since the COVID-19 pandemic started. However, the frequency of adolescent cigarette smoking remained stable over time, with similar rates before and during the pandemic.

Identifying specific population groups in need of mental health care as the pandemic conditions and associated social restrictions eased is of clinical

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See Online for appendix

Research in context

Evidence before this study

We searched PubMed and Google Scholar for peer-reviewed papers published from Jan 1, 2020, to Oct 20, 2022, with the language restricted to English. We paired the terms “COVID-19”, “coronavirus”, and “pandemic” with “mental health”, “psych*”, “depress*”, “substance use”, “alcohol”, “cigarette”, and “e-cigarette”. In addition to this search, to identify the demographics and clinical characteristics of young people at risk of poor mental health outcomes during the pandemic, we added the following terms to our search: “risk”, “protective”, “ethnicity”, “social support”, “sleep”, “long-term”, and “longitudinal”. These findings were then restricted to the following population: “adolescen*”, “child*”, and “youth”. Additional relevant references on child and adolescent mental health outcomes during the pandemic were found by checking the citations from the identified papers. Since early 2020, a plethora of research has showed an increase in mental health problems and decrease in substance use among adolescents during the first year of the COVID-19 pandemic, but few studies have examined the longer-term effects. Some studies suggest that, 1 year or more into the COVID-19 pandemic, female gender, older adolescents, migration background, and high levels of governmental social restrictions are associated with poorer adolescent outcomes, whereas social support and healthy sleep patterns are associated with better mental health during the pandemic, although the findings have not been consistent across studies. The generalisability of these studies is also limited by small sample sizes, non-representative samples, and missing pre-pandemic information. Only one population-based, repeated cross-sectional study done in Norway (n=227 258) has tracked depressive symptoms, cigarette smoking, and alcohol intoxication among adolescents aged 13–18 years from 2014 to 2021. This study indicated a persistent increase in depressive symptoms and decreased alcohol intoxication, but no change in cigarette smoking. The negative effects during the pandemic were more pronounced in girls and younger adolescents than in boys and older adolescents.

Added value of this study

To our knowledge, the current study is among the first population-based, repeated cross-sectional studies to date to examine mental health problems and substance use among adolescents aged 13–18 years 1–2 years into the COVID-19 pandemic and covariates associated with these outcomes. We found that the increases in depressive symptoms and poorer mental wellbeing observed within the first year of the pandemic were maintained 1–2 years into the pandemic. After the initial decline in substance use during the first year of the pandemic, the prevalence of alcohol intoxication appears to be on the rise as social restrictions have been eased. The initial decrease in cigarette smoking and e-cigarette use within the first year of the pandemic remained stable 1–2 years into the pandemic. The level of social restrictions and migration background were not consistently associated with adolescent mental health and substance use during the pandemic. Parental social support and sleep duration were associated with more positive outcomes, especially among boys aged 13–15 years. Our findings also suggest that in-person contact with peers is more strongly associated with good mental health among adolescent girls than boys.

Implications of all the available evidence

Accumulating evidence from high-income countries indicates the persistence of an increase in mental health problems among adolescents during the pandemic, whereas knowledge on the mental health of adolescents during the pandemic in low-income and middle-income countries is limited. Without robust evidence for vulnerable subgroups, policy makers should consider implementing large-scale, global, evidence-based prevention efforts prioritising depressive symptoms in adolescents to mitigate the negative effect of the pandemic. Additionally, further monitoring of the increase in alcohol intoxication rates following the ease of social restrictions is needed to assess the need for prevention or treatment efforts.

importance to inform public health priorities and develop targeted preventive and treatment interventions.^{1,3,7} The limited research available indicates that the female gender, older adolescents, migration background, and high levels of governmental social restrictions are associated with poorer adolescent mental health and greater substance use (appendix pp 3–5). These findings are inconsistent across studies and have not been adequately examined in large-scale population samples. Furthermore, no study has examined which protective factors might influence adolescent outcomes a year or more into the pandemic.

In this population-based study, we expand upon previous findings^{4,8} and aimed to examine the mental health outcomes of adolescents up to 2 years into the COVID-19 pandemic. We also aimed to examine potential covariates (ie, level of social restrictions,

immigration status, parental social support, and average duration of nightly sleep) associated with mental health outcomes and substance use in the wake of the COVID-19 pandemic. Given that age and gender have most consistently been associated with adolescent outcomes during the pandemic,⁴ we examined the association between each covariate and outcome by age and gender. In accordance with previous findings,^{6,8} we hypothesised that: (1) the elevation in depressive symptoms, especially among girls and older adolescents, and decreased mental wellbeing and substance use noted within the first year of the pandemic, would be maintained a year or more into the pandemic; and (2) increased social restrictions, immigration status, low parental social support, and less than an average of 8 h sleep would be associated with poorer outcomes a year or more into the pandemic.

Methods

Study design and participants

The Youth in Iceland surveys are administered by the Icelandic Centre for Social Research and Analysis (ICSRA) and are designed to identify risk and protective factors at individual, family, peer, school, and community levels associated with adolescent well-being and substance use.

Measures in these surveys are modeled after comparative international studies, such as the European School Survey Project study and the US-based Monitoring the Future Study. Researchers at ICSRA are responsible for choosing survey measures each year, and most of the measures are recurring. New measures are introduced to the survey as needed through a collaboration with different stakeholders, such as the Directorate of Health, Ministry of Education, Ministry of Health, various municipalities, and non-governmental organisations. All students attending elementary and secondary school are invited to participate in the school-based Youth of Iceland surveys. Response rates generally include more than 80% of the entire student population in Iceland. Data from the surveys provide diagnostic information used to inform tailored prevention strategies for each community.

All students aged 13–15 years and 16–18 years in 2018, 2020, 2021, and 2022, enrolled in school in Iceland were invited to participate in this cross-sectional population-based study. Inclusion in the study was dependent on the ability to answer the social surveys in Icelandic (or English in 2020 and 2022, or Polish in 2022). Those aged 13–15 years were surveyed within a year (autumn, 2020), at 1 year (winter, 2021), and at 2 years (winter, 2022) after the first confirmed COVID-19 case in Iceland; those aged

16–18-years were surveyed within a year (autumn, 2020) and at 1 year (autumn, 2021) after the community spread of COVID-19 infections in Iceland (figure 1). Before each survey administration, school administrators notified caregivers of the study and consent forms were sent home to caregivers in which they were asked to opt out of the study if they were not interested in their child participating.

This study was approved by the National Bioethics Committee of Iceland and the Icelandic Data Protection Agency. The protocol for the study has been previously described.⁹

Procedures

The survey was in Icelandic for all administrations and offered to adolescents aged 13–15 years in English in 2020 and 2022 and in Polish in 2022. Students were instructed to answer the survey anonymously. The survey was paper-based in 2018 and electronic in 2020, 2021, and 2022. Teachers distributed the surveys to all students present in class or via a survey link in online class. Detailed information on the study procedure is provided in the appendix (p 1).

The survey collected data on demographic variables, depressive symptoms, mental wellbeing, substance use, parental support, and average hours of sleep per night.

Depressive symptoms were measured using the depression dimension of the Symptom Checklist-90 (SCL-90).¹⁰ Participants rated ten items on depressed mood in the past week on a 4-point Likert scale (from 1=almost never to 4=often). A total score was created, with a higher score indicating more depressive symptoms

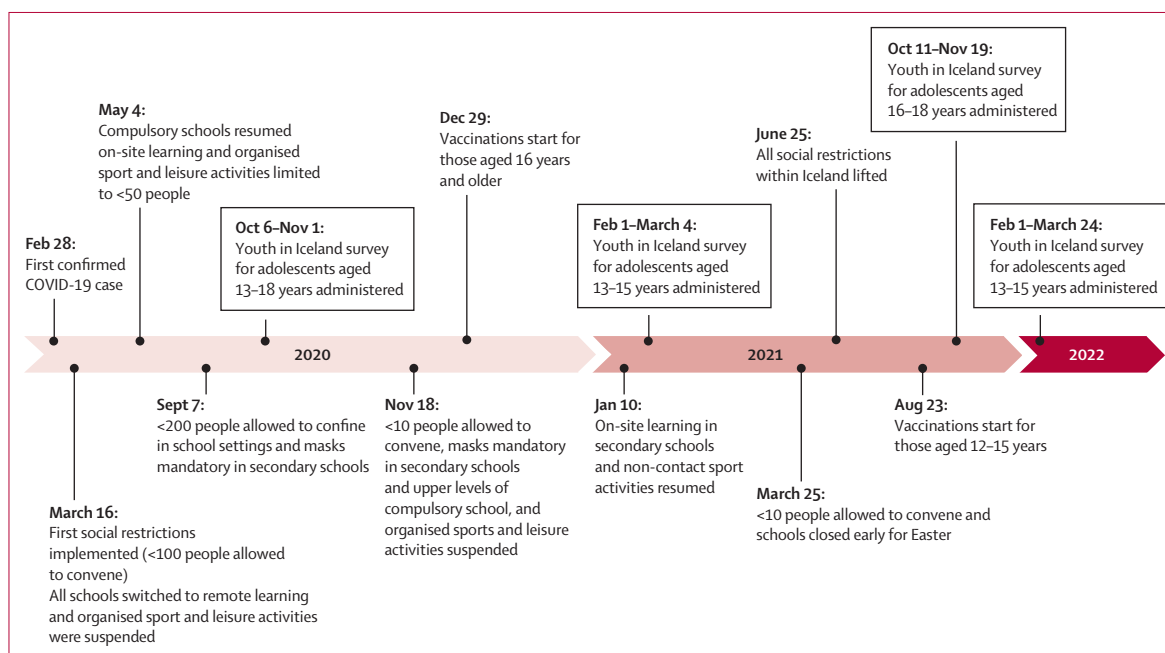


Figure 1: An overview of major milestones associated with the COVID-19 pandemic influencing the lives of adolescents in Iceland. Further details on the social restrictions in Iceland due to the COVID-19 pandemic are provided in the appendix (p 2).

(range 10–40; $\alpha=0.916$). To determine changes in the severity of depressive symptoms over time, cutoff scores based on the top 5% before the pandemic (ie, 2018) were created and categorised as high depressive symptoms. The cutoff scores were determined separately by gender and age. Further information on the SCL-90 is provided in the appendix (p 1).

Mental wellbeing was measured using the Short Warwick Edinburgh Mental Wellbeing Scale.¹¹ Participants rated seven items on self-worth, view towards the future, and social connectedness in the past 2 weeks on a 5-point Likert scale (from 1=none of the time to 5=all of the time). A composite score was created, with a higher score indicating greater wellbeing (range 7–35; $\alpha=0.870$).

A detailed description of the demographic variables, substance use outcomes, and covariates is presented in the appendix (pp 6–7). Regarding the substance use outcomes, participants rated two items on the frequency of e-cigarette and cigarette use in the past 30 days on a 7-point Likert scale (from 1=never to 7=more than 40 times a day). Participants also rated the frequency of alcohol intoxication in the past 30 days (phrased as “How often have you been drunk in the last 30 days?”) on a 6-point Likert scale (from 1=never to 6=more than 20 times). Each of these items on substance use was dichotomised (from 0=never to 1=once or more).

Chronological age (in years), gender (1=male, 2=female, 3=non-binary), language spoken at home (1=only Icelandic, 2=other language together with or without Icelandic) were used to determine the effect of age, gender, and immigration status. With the greatest number of COVID-19 cases and social restrictions implemented in the capital area, residency was dichotomised (0=capital, 1=other) according to the health-care district (coded from 1–7) and used as a measure for the level of social restrictions.

Parental support was assessed with four items regarding ease of obtaining emotional and social support from parents or caregivers rated on a 4-point Likert scale (from 1=very difficult to 4=very easy).¹² A total score was created from the responses, with higher scores indicating greater parental support (range 4–16; $\alpha=0.875$). Participants reported the average sleep duration (from 1=more than 9 h to 6=less than 6 h). Responses were dichotomised (1=duration of ≥ 8 h per night, 2=duration of < 8 h per night) based on the adolescent sleep recommendations by the US National Sleep Foundation.¹³

Statistical analysis

Weighted mixed-effect models were produced using the survey, srvyr, and lme4 packages in R (version 4.1.2). All estimates were adjusted with poststratification weights to account for gender and age distribution differences between the sample and that of Iceland. In creating the post-stratification weights, participants were weighted to match the proportion of those aged 13–18 years in Iceland within their given age group (age [in years] 13,

14, 15, 16, 17, and 18) and gender (female, male, and non-binary) using population data from Statistics Iceland. Given our study design and high response rates, the age and gender distribution of our sample was similar to the proportion of the population of 13–18-year-olds in Iceland for the years the surveys were administered (ie, 2018, 2020, 2021, and 2022). For example, the age distribution in our sample was 34.5% for 13-year-olds, 33.9% for 14-year-olds, and 31.6% for 15-year-olds compared with 34.2% for 13-year-olds, 32.2% for 14-year-olds, and 32.7% for 15-year-olds in the general population. Similarly, gender distribution in our sample was 48.3% girls, 50.3% boys, and 1.4% non-binary compared with 47.5% girls, 50.5% boys, and 2.0% for youth identifying as non-binary in the general population of 13–15-year-olds. In specifying the study design, participants were clustered within health-care district.

Weighted linear mixed models with a link function for ordinal outcomes (depressive symptoms and mental well-being) and weighted logistic mixed models for binary outcomes (cigarette smoking, e-cigarette use, and alcohol intoxication) were generated. Given previously noted differences in outcomes by age groups,⁸ all analyses were examined separately for participants aged 13–15 years and those aged 16–18 years. In all models, chronological age was grand-mean centered. Time was coded according to the days between survey administrations (for those aged 13–15 years: 2018=0, 2020=1004, 2021=1124, and 2022=1489; for those aged 16–18 years: 2018=0, 2020=762, and 2021=1127). To account for students nested within schools across the country, health-care districts (coded from 1 to 7) were included as a random effect in all analyses. The fixed effects differed by model to address each research aim.

In all the analyses, outcomes were measured at four time points for those aged 13–15 years (2018, 2020, 2021, and 2022) and at three time points for those aged 16–18 years (2018, 2020, and 2021). In the first model, we examined the differential effect of the pandemic by chronological age and gender by entering the main and interactive effects of time, age, and gender as fixed effects for each outcome. Secondly, the interaction terms of time and potential moderators (ie, residency, language spoken at home, parental support, and sleep duration) were simultaneously entered as fixed effects to determine whether the pandemic disproportionately affected particular groups of adolescents. Age was included as a covariate in these analyses. Significant interactions were probed with the emmeans package¹⁴ and visualised with the jtools package.¹⁵ All estimates were adjusted with post-stratification weights to account for gender and age distribution differences between the sample and that of Iceland.

Because 30 models (5 outcomes \times 6 models) were examined for participants aged 13–15 years and 16–18 years, Bonferroni corrections were used to adjust

	2018	2020	2021	2022
Age 13 years (n=14 231)				
Gender				
Female	1779/3586 (49.6%)	1465/3075 (47.6%)	1845/4038 (45.7%)	1648/3532 (46.7%)
Male	1805/3586 (50.3%)	1538/3075 (50.0%)	2043/4038 (50.6%)	1819/3532 (51.5%)
Other	1/3586 (<1%)	72/3075 (2.3%)	150/4038 (3.7%)	65/3532 (1.8%)
Icelandic not spoken at home	671/3586 (18.7%)	670/3075 (21.8%)	962/4038 (23.8%)	792/3532 (22.4%)
Living in capital area	2240/3586 (62.5%)	2196/3075 (71.4%)	2591/4038 (64.2%)	2202/3532 (62.3%)
Depressive symptoms	16.97 (0.09)	18.78 (0.14)	19.35 (0.18)	19.34 (0.13)
Mental wellbeing	24.36 (0.17)	22.94 (0.15)	22.49 (0.14)	22.74 (0.13)
Cigarette smoking	46/3586 (1.3%)	32/3075 (1.0%)	62/4038 (1.5%)	42/3532 (1.2%)
E-cigarette use	255/3586 (7.1%)	128/3075 (4.2%)	227/4038 (5.6%)	161/3532 (4.6%)
Alcohol intoxication	31/3586 (0.9%)	31/3075 (1.0%)	55/4038 (1.4%)	42/3532 (1.2%)
Age 14 years (n=13 398)				
Gender				
Female	1677/3364 (49.9%)	1423/3031 (46.9%)	1718/3722 (46.2%)	1538/3281 (46.9%)
Male	1685/3364 (50.1%)	1531/3031 (50.5%)	1868/3722 (50.2%)	1690/3281 (51.5%)
Other	3/3364 (0.1%)	78/3031 (2.6%)	136/3722 (3.7%)	53/3281 (1.6%)
Icelandic not spoken at home	604/3364 (18.0%)	610/3031 (20.1%)	789/3722 (21.2%)	797/3281 (24.3%)
Living in capital area	2038/3364 (60.1%)	2141/3031 (70.6%)	2275/3722 (61.1%)	2012/3281 (61.3%)
Depressive symptoms	17.65 (0.10)	19.39 (0.10)	19.72 (0.18)	19.82 (0.22)
Mental wellbeing	24.32 (0.20)	22.79 (0.10)	22.57 (0.14)	23.00 (0.25)
Cigarette smoking	82/3364 (2.4%)	84/3031 (2.8%)	82/3722 (2.2%)	69/3281 (2.1%)
E-cigarette use	463/3364 (13.8%)	281/3031 (9.3%)	320/3722 (8.6%)	265/3281 (8.1%)
Alcohol intoxication	63/3364 (1.9%)	114/3031 (3.8%)	124/3722 (3.3%)	88/3281 (2.7%)
Age 15 years (n=13 606)				
Gender				
Female	1723/3450 (49.9%)	1389/2997 (46.3%)	1782/3811 (46.8%)	1603/3348 (47.9%)
Male	1728/3450 (50.1%)	1513/2997 (50.5%)	1908/3811 (50.1%)	1696/3348 (50.7%)
Other	0	95/2997 (3.2%)	121/3811 (3.2%)	50/3348 (1.5%)
Icelandic not spoken at home	616/3450 (17.9%)	592/2997 (19.8%)	804/3811 (21.1%)	707/3348 (21.1%)
Living in capital area	2134/3450 (61.9%)	2139/2997 (71.4%)	2397/3811 (62.9%)	2048/3348 (61.2%)
Depressive symptoms	18.14 (0.18)	19.43 (0.21)	19.69 (0.12)	20.08 (0.14)
Mental wellbeing	24.45 (0.22)	22.90 (0.20)	23.03 (0.19)	23.28 (0.09)
Cigarette smoking	186/3450 (5.4%)	92/2997 (3.1%)	104/3811 (2.7%)	91/3348 (2.7%)
E-cigarette use	762/3450 (22.1%)	338/2997 (11.3%)	450/3811 (11.8%)	384/3348 (11.5%)
Alcohol intoxication	208/3450 (6.0%)	186/2997 (6.2%)	241/3811 (6.3%)	177/3348 (5.3%)
Age 16 years (n=7627)				
Gender				
Female	1292/2893 (44.7%)	1265/2531 (50.0%)	1010/2203 (45.8%)	..
Male	1533/2893 (53.0%)	1206/2531 (47.6%)	1123/2203 (51.0%)	..
Other	68/2893 (2.4%)	60/2531 (2.4%)	70/2203 (3.2%)	..
Icelandic not spoken at home	542/2893 (18.7%)	390/2531 (15.4%)	421/2203 (19.1%)	..
Living in capital area	1911/2893 (66.1%)	1707/2531 (67.4%)	1274/2203 (57.8%)	..
Depressive symptoms	19.37 (0.16)	19.47 (0.21)	20.75 (0.25)	..
Mental wellbeing	24.60 (0.30)	23.94 (0.07)	23.48 (0.34)	..
Cigarette smoking	351/2893 (12.1%)	94/2531 (3.7%)	121/2203 (5.5%)	..
E-cigarette use	1010/2893 (34.9%)	321/2531 (12.7%)	474/2203 (21.5%)	..
Alcohol intoxication	628/2893 (21.7%)	317/2531 (12.5%)	389/2203 (17.7%)	..

(Table 1 continues on next page)

for multiple testing and analyses were considered significant at a p value of <0.0017. As a robustness check, all models were also run with and without the survey weights. Missing data were handled with multiple imputation using the mice package (appendix pp 1–2).¹⁶

	2018	2020	2021	2022
(Continued from previous page)				
Age 17 years (n=7604)				
Gender				
Female	1325/2932 (45.2%)	1226/2432 (50.4%)	1071/2240 (47.8%)	..
Male	1570/2932 (53.5%)	1167/2432 (48.0%)	1131/2240 (50.5%)	..
Non-binary	37/2932 (1.3%)	40/2432 (1.6%)	37/2240 (1.7%)	..
Icelandic not spoken at home	463/2932 (15.8%)	393/2432 (16.2%)	348/2240 (15.5%)	..
Living in capital area	1956/2932 (66.7%)	1569/2432 (64.5%)	1461/2240 (65.2%)	..
Depressive symptoms	19.47 (0.21)	22.11 (0.22)	20.77 (0.21)	..
Mental wellbeing	24.74 (0.22)	23.36 (0.06)	23.57 (0.13)	..
Cigarette smoking	436/2932 (14.9%)	136/2432 (5.6%)	183/2240 (8.2%)	..
E-cigarette use	1262/2932 (43.0%)	505/2432 (20.8%)	653/2240 (29.2%)	..
Alcohol intoxication	1040/2932 (35.5%)	607/2432 (25.0%)	744/2240 (33.2%)	..
Age 18 years (n=7605)				
Gender				
Female	1401/3079 (45.5%)	1250/2287 (54.7%)	1121/2239 (50.1%)	..
Male	1621/3079 (52.6%)	1006/2287 (44.0%)	1061/2239 (47.4%)	..
Other	57/3079 (1.9%)	30/2287 (1.3%)	57/2239 (2.5%)	..
Icelandic not spoken at home	419/3079 (13.6%)	370/2287 (16.2%)	315/2239 (14.1%)	..
Living in capital area	2046/3079 (66.5%)	1538/2287 (67.2%)	1584/2239 (70.7%)	..
Depressive symptoms	19.42 (0.16)	21.85 (0.24)	21.03 (0.17)	..
Mental wellbeing	24.96 (0.14)	23.86 (0.18)	23.76 (0.14)	..
Cigarette smoking	594/3079 (19.3%)	163/2287 (7.1%)	237/2239 (10.6%)	..
E-cigarette use	1439/3079 (46.7%)	515/2287 (22.5%)	749/2239 (33.4%)	..
Alcohol intoxication	1544/3079 (50.2%)	782/2287 (34.2%)	1157/2239 (51.7%)	..
Data are n/N (%) or mean (SEM). The sample is weighted for national representativeness. Depressive symptoms range from 10 to 40, with higher scores indicating more depressive symptoms. Mental wellbeing ranges from 7 to 35, with higher scores indicating greater wellbeing.				
Table 1: Demographics for each age group by time of survey administration				

Role of the funding source

The funder of the study had no role in the study design, data collection, data analysis, data interpretation, or writing of the report.

Results

Surveys were administered to students aged 13–15 years on Feb 6–8, 2018, (n=10400), Oct 14–Nov 20, 2020 (n=9103), Feb 1–March 4, 2021 (n=11571), and Feb 1–March 24, 2022 (n=10161). For those aged 16–18 years, the surveys were administered on Oct 15–31, 2018 (n=8904), Oct 6–Nov 20, 2020 (n=7250), and Oct 11–Nov 19, 2021 (n=6682). 64071 responses were submitted and included in the data analysis, with response rates ranging from 61% to 90% (appendix pp 1, 8). Sample sizes and demographic characteristics of all study participants by age group for each survey administration are displayed in table 1. For most age groups, there were significant differences in gender ratio, primary language spoken at home, and residency across years. Mean depressive symptoms and mental well-being and the percentage of young people engaging in cigarette smoking, e-cigarette use, and alcohol intoxication within the past 30 days by time of survey

administration and gender are presented in figure 2. The correlation between the substance use outcomes and depressive symptoms and the frequency of alcohol intoxication by age and time are presented in the appendix (pp 15–16). The average hours of nightly sleep by age and time are shown in the appendix (p 17). As a robustness check, all the following models were run with and without the survey weights and produced substantively similar results.

The three-way interaction between time, age, and gender was not significantly associated with depressive symptoms for participants aged 13–15 years; table 2), suggesting similar immediate and longer-term depressive symptoms for both girls and boys after the COVID-19 pandemic started. The trend towards a greater increase in depressive symptoms with increased age in both age groups was not significant after correcting for multiple testing (table 2). A higher proportion of girls and boys across all age groups reported high depressive symptoms a year or more into the pandemic (2021) compared with the pre-COVID timepoint (2018), with the exception of 18-year-old boys (figure 3).

The interaction models between the covariates and time are presented in the appendix (pp 9–12). Time and

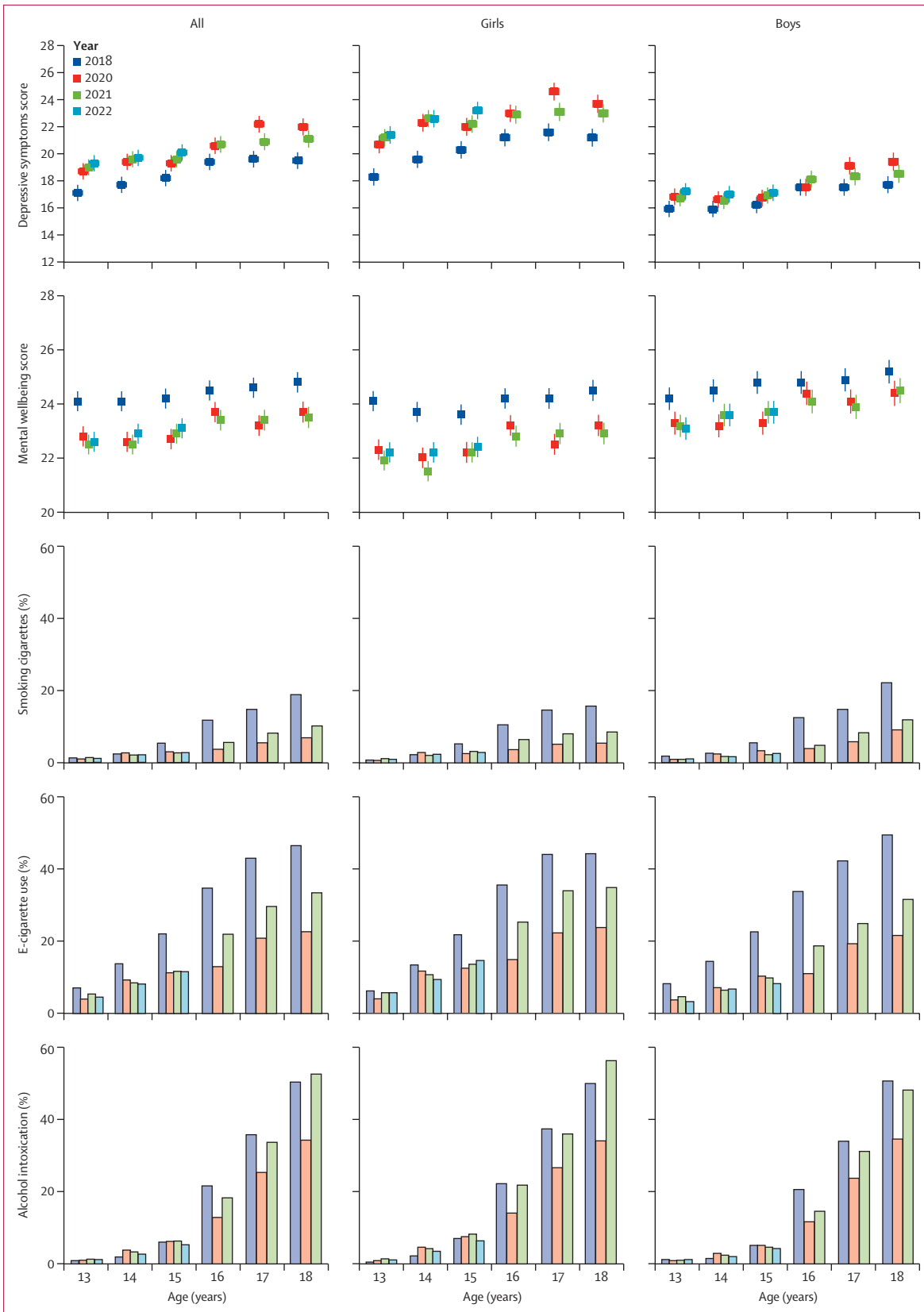


Figure 2: Mean depressive symptoms and mental wellbeing and percentage of participants reporting cigarette smoking, e-cigarette use, and alcohol intoxication
 Data are from before (ie, 2018) and during (2020, 2021, and 2022) the COVID-19 pandemic, by age and gender. The error bars indicate SEM.

	Depressive symptoms		Mental wellbeing		Cigarette smoking		E-cigarette use		Alcohol intoxication	
	IRR (95% CI)	p value	IRR (95% CI)	p value	OR (95% CI)	p value	OR (95% CI)	p value	OR (95% CI)	p value
Age 13–15 years										
Days	1.0001 (1.0000–1.0003)	0.0056	1.0000 (0.9999–1.0001)	0.8381	1.0014 (0.9985–1.0044)	0.3312	1.0008 (0.9993–1.0023)	0.2780	1.0016 (0.9985–1.0048)	0.3074
Age	1.0096 (1.0016–1.0176)	0.0186	1.0109 (1.0045–1.0174)	0.0009	1.8781 (1.5398–2.2906)	<0.0001	1.8058 (1.6382–1.9906)	<0.0001	2.4046 (1.9072–3.0314)	<0.0001
Gender	0.7186 (0.6181–0.8355)	<0.0001	1.2905 (1.1351–1.4671)	0.0001	0.0145 (0.0002–1.2087)	0.0607	0.2115 (0.0278–1.6125)	0.1339	0.0114 (0.0001–1.3259)	0.0652
Days × age	1.0000 (1.0000–1.0000)	0.0528	1.0000 (1.0000–1.0000)	0.5952	0.9999 (0.9997–1.0001)	0.1952	0.9999 (0.9998–1.0000)	0.0388	0.9999 (0.9997–1.0001)	0.3038
Days × gender	1.0001 (1.0000–1.0003)	0.1003	0.9998 (0.9997–0.9999)	0.0018	1.0032 (0.9989–1.0076)	0.1423	1.0011 (0.9990–1.0032)	0.3066	1.0025 (0.9982–1.0069)	0.2503
Age × gender	1.0383 (1.0272–1.0495)	<0.0001	0.9796 (0.9707–0.9887)	<0.0001	1.3257 (0.9761–1.8004)	0.0711	1.1058 (0.9595–1.2745)	0.1649	1.3847 (0.9990–1.9195)	0.0507
Days × age × gender	1.0000 (1.0000–1.0000)	0.3897	1.0000 (1.0000–1.0000)	0.0054	0.9998 (0.9995–1.0001)	0.1773	1.0000 (0.9998–1.0001)	0.5539	0.9998 (0.9995–1.0001)	0.2835
Age 16–18 years										
Days	0.9998 (0.9996–1.0000)	0.0149	1.0000 (0.9998–1.0002)	0.9890	0.9969 (0.9941–0.9996)	0.0256	0.9981 (0.9963–1.0000)	0.0449	0.9979 (0.9961–0.9998)	0.0300
Age	1.0115 (1.0033–1.0197)	0.0058	1.0058 (0.9990–1.0127)	0.0932	1.4283 (1.2969–1.5730)	<0.0001	1.3827 (1.2879–1.4845)	<0.0001	1.9584 (1.8131–2.1152)	<0.0001
Gender	1.4305 (1.1796–1.7348)	0.0003	0.9808 (0.8261–1.1644)	0.8244	7.6287 (0.6015–96.7519)	0.1169	10.7676 (1.8217–63.6452)	0.0088	4.6428 (0.6785–31.7710)	0.1177
Days × age	1.0000 (1.0000–1.0000)	0.0034	1.0000 (1.0000–1.0000)	0.7033	1.0001 (1.0000–1.0003)	0.1081	1.0001 (0.9999–1.0002)	0.3028	1.0001 (1.0000–1.0002)	0.0604
Days × gender	1.0002 (1.0000–1.0005)	0.0607	1.0000 (0.9998–1.0002)	0.9545	1.0032 (0.9992–1.0073)	0.1198	1.0000 (0.9975–1.0026)	0.9871	1.0003 (0.9977–1.0030)	0.8142
Age × gender	0.9908 (0.9797–1.0021)	0.1094	0.9993 (0.9893–1.0094)	0.8930	0.8752 (0.7549–1.0147)	0.0773	0.8672 (0.7815–0.9623)	0.0073	0.9151 (0.8181–1.0235)	0.1203
Days × age × gender	1.0000 (1.0000–1.0000)	0.1046	1.0000 (1.0000–1.0000)	0.7802	0.9998 (0.9996–1.0001)	0.1299	1.0000 (0.9999–1.0002)	0.8197	1.0000 (0.9998–1.0001)	0.9290

IRR=incidence rate ratio. OR=odds ratio.

Table 2: Effect of time, age, gender, and their interactions for 13–18-year-olds on depressive symptoms, mental wellbeing, cigarette smoking, e-cigarette use, and alcohol intoxication

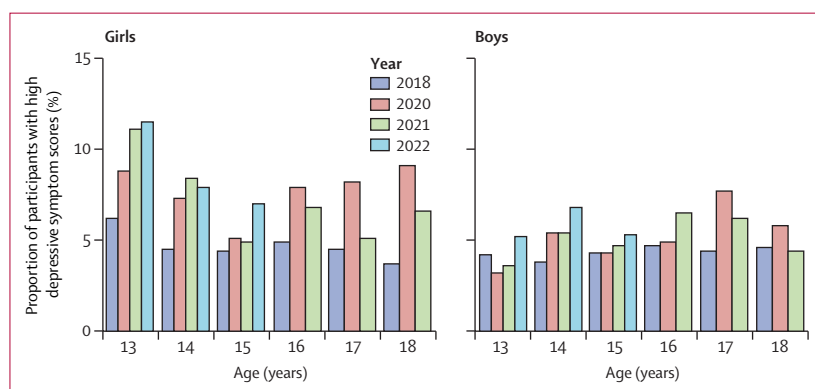


Figure 3: Proportion of adolescents with high depressive symptom scores

High scores were defined by depressive symptoms equal to or higher than those of the 5th percentile and were determined separately for boys and girls for each age group in 2018.

sleep duration were significantly associated with depressive symptoms for 13–15-year-olds (appendix p 9). Specifically, adolescents who had less than 8 h of nightly sleep reported increasingly higher levels of depressive symptoms throughout the pandemic (appendix pp 9, 18),

whereas depressive symptoms decreased from 2020 to 2022 among adolescents who had 8 h or more of nightly sleep. This significant interaction was not observed among 16–18-year-olds (appendix p 10).

Mental wellbeing did not significantly differ by the interaction between time, age, and gender (table 2). Parental social support and sleep duration were significantly associated with mental wellbeing for 16–18-year-olds (appendix pp 9–12). In terms of interactions, higher parental social support was consistently associated with better mental wellbeing throughout the pandemic among those aged 16–18 years, while mental wellbeing improved somewhat once the social restrictions were lifted (ie, 2022) among youth with lower levels of parental social support (appendix pp 9–12, 18). For girls aged 16–18 years, higher levels of mental wellbeing were reported by participants living in the capital area than outside of the capital area in 2018; however, mental wellbeing was comparable regardless of residency in 2020 and then higher levels of mental wellbeing were again reported by girls living in the capital area in 2021 (appendix pp 10–11). Mental wellbeing

among participants aged 16–18 years who had Icelandic as a primary language at home continued to worsen from 2018 to 2021, whereas those who did not have Icelandic as the primary language reported lower mental wellbeing overall, but scores improved slightly in 2021 compared with 2020. This pattern was also observed among 16–18-year-old girls but not boys.

The three-way interaction between time, age, and gender was not significantly associated with cigarette smoking for those aged 13–15 years or 16–18 years (table 2). Higher levels of parental support and at least 8 h of sleep were significantly associated with lower rates of cigarette smoking among 13–15 and 16–18-year-olds (appendix pp 9–12, 18). For both age groups, none of the interaction terms were significant across the sample or stratified by gender (appendix pp 9–12).

The interaction between time, age, and gender was not significantly associated with e-cigarette use (table 2). The interaction between parental social support and time was associated with e-cigarette use for the entire 13–15-year-old sample and among boys (appendix p 9), with steeper reduction rates in e-cigarette use among youth with higher levels of parental social support during the pandemic (appendix p 18). The same interaction was significant among 16–18-year-old boys. None of the other interaction terms were significant for 16–18-year-olds.

The association between the interaction between time, age, and gender and alcohol intoxication was not significant (table 2). Among participants aged 16–18 years, rates of alcohol intoxication appeared to be higher with increasing age more than 1 year into the pandemic (figure 2), but the association between time and age was not significant (table 2).

A higher level of parental social support was associated with lower rates of alcohol intoxication among those aged 13–15 years and 16–18 years, and less hours of sleep was associated with a higher chance of alcohol intoxication in these age groups (appendix pp 9–12). Across the entire sample of 16–18-year-olds and boys, a greater reduction in alcohol intoxication in the first year of the pandemic than in pre-pandemic times and greater increase again in rates of alcohol intoxication during the pandemic (ie, 2020 and 2021) was observed among those living in the capital area compared with those outside the capital area (appendix pp 9–12, 18).

Discussion

Adding to the scarce work on longer-term outcomes⁶ and in accordance with our first hypothesis, this study showed that the increase in depressive symptoms and decrease in mental wellbeing among 13–18-year-olds persisted 1–2 years into the pandemic. This increase in adolescent mental health problems was consistent across gender. Notably, the increase in mental health problems was maintained despite the easing of social restrictions and successful vaccination campaigns, with more than 80% of the population (aged 5 years and older) in Iceland

being fully vaccinated.¹⁷ The findings underline that adolescence is a sensitive period in which universal stress exposure is likely to trigger mental health problems,^{18,19} which persist when left untreated.^{20,21} Importantly, adolescent depressive symptoms are linked to reduced quality of life and are a strong predictor of later major depression.^{20,22,23} Hence, large-scale, evidence-based prevention efforts, such as school-based programmes^{24,25} targeting depressive symptoms, might be necessary.

By contrast with previous findings,^{6,26,27} we found that the decrease in cigarette smoking and e-cigarette use across age groups observed within the first year of the pandemic was maintained 1–2 years into the pandemic across age groups and gender. The social restrictions implemented during the pandemic might have led to fewer adolescents initiating nicotine use in 2020, with the consequence of fewer youth developing the habit of smoking after the social restrictions were eased in 2021 and 2022. Alternatively, other recent trends in nicotine use, such as the use of nicotine pouches, might have replaced cigarette smoking and e-cigarette use.

Among those aged 16–18 years, rates of alcohol intoxication decreased in 2020 but returned to pre-pandemic levels in 2021. These findings were at odds with our hypothesis but might not necessarily reflect a cause for concern given that occasional alcohol consumption among 16–18-year-old adolescents can be considered a sign of a normal social life in Nordic countries. This increase might represent a transient peak in alcohol intoxication in response to social restrictions being eased. However, the combination of increased rates of mental health problems and alcohol intoxication is of concern as substance use might serve as a mechanism to cope with poorer mental health. Future research to closely monitor this relationship is warranted.

By contrast with our hypothesis regarding the covariates and previous findings,^{28,29} neither migration status nor the level of social restriction were consistently associated with adolescent mental health and substance use throughout the pandemic. However, parental social support and getting at least 8 h of nightly sleep on average were robustly associated with better mental health and lower levels of substance use, although adolescents reporting high parental support and healthy sleeping patterns still experienced an increase in mental health problems, e-cigarette use, and alcohol intoxication 1–2 years into the pandemic. Our findings also provide insight into ways to promote good mental health among certain subgroups according to gender and age. For example, high parental social support and healthy sleeping patterns were particularly protective against depressive symptoms and e-cigarette use among boys aged 13–15 years once the social restrictions of the pandemic were eased. Furthermore, compared with girls with higher levels of parental support, girls aged

13–15 years with lower levels of parental social support reported an improvement in mental wellbeing as social restrictions were eased. This finding was not observed among boys. Similarly, girls aged 16–18 years, and girls living in the capital area, where there were greater social restrictions and higher incidence of COVID-19 cases, reported higher levels of mental wellbeing once the social restrictions had been lifted than girls of the same age living outside of the greater Reykjavik capital area. These findings might highlight differences in the social patterns and needs of adolescent girls and boys, suggesting that girls rely more on in-person contact with peers for social support than adolescent boys.

Strengths of this study include its nationwide sample and cross-sectional design. Our use of self-report measures constitutes both a strength and a limitation, because most adolescent mental health problems and behaviours are not documented in the health-care system. However, although our previous work has linked self-reported depressive symptoms to the frequency of visits to paediatric psychiatrists and clinical child psychologists,³⁰ we cannot determine whether the increases in depressive symptoms and substance use have reached clinically meaningful levels. Consistent with previous studies, our global subjective measure of sleep duration was robustly associated with lower mental health problems and substance use, providing partial validity for this measure. Nevertheless, future studies could incorporate daily sleep diaries and actigraphy to improve measurement precision. Caution is also advised in interpreting the association between sleep and depressive symptoms given that sleep disturbances are a symptom of depression. However, the findings might suggest that maintaining a stable daily routine, such as an 8 h or more nightly sleep schedule, could promote good mental health in times of stress. Differences in survey method (ie, offline vs online administrations) influencing pre-pandemic and post-pandemic ratings cannot be excluded.³¹ Finally, our findings are not generalisable to 16–18-year-olds not enrolled in secondary schools (5–20% of the population of Iceland, with dropout rates increasing with age), who might be at higher risk for mental health problems and substance use, and the 10–39% of eligible 16–18-year-old adolescents who opted out of the survey or were not present at the time of survey administration.

In conclusion, this population-based, repeated cross-sectional study showed that the increases in depressive symptoms and poorer mental wellbeing observed among Icelandic adolescents within the first year of the pandemic were maintained 1–2 years into the pandemic. The decrease in cigarette smoking and e-cigarette use within the first year of the pandemic remained stable; however, alcohol intoxication rates appeared to be on the rise. Parental social support and sleep duration were associated with more positive outcomes during the pandemic. Without robust evidence for vulnerable

subgroups, large-scale, global, evidence-based prevention efforts targeting depressive symptoms in adolescents are needed to mitigate the negative effects of the pandemic. Additionally, further monitoring of the increase in alcohol intoxication rates following the ease of social restrictions is required to assess the need for prevention or treatment efforts.

Contributors

TH and IET conceived the research question and designed the study. IET, along with the personnel at Icelandic Centre for Social Research and Analysis, identified the measures used in the surveys in 2018, 2020, 2021, and 2022, and coordinated the administration to all schools in Iceland. TH and IET accessed the data in the study and verified the underlying data. TH, GA, and SYO completed the literature review. TH completed the data analyses and drafted the manuscript, with support from IET, JPA, and HBV. All authors read and approved the final manuscript. All authors confirm they had full access to all the data in the study and accept responsibility for the decision to submit for publication.

Declaration of interests

IET is a staff member at Planet Youth, a youth substance use prevention service organisation that is distributed globally through sale of the Planet Youth Guidance Program, which is based on the Icelandic Prevention Model, from which she receives a salary. All other authors declare no competing interests.

Data sharing

This manuscript was prepared in accordance with the STROBE statement and a detailed description of the study protocol, self-report measures used in this study, and the STROBE checklist can be found in the appendix (p 13). Individual participant data that underlie the results are reported in this Article (after de-identification). In accordance with the Icelandic data protection laws and the terms of approval for the current study that were stipulated by the National Bioethics Committee of Iceland, these data cannot be made publicly available. Interested researchers who provide a methodologically sound proposal can obtain access to deidentified data. Notably, the execution of such a proposal requires approval by the National Bioethics Committee of Iceland. Proposals should be directed to ingaeva@planetyouth.org. To gain access to the data, the researchers will need to attest to and sign a data-access agreement.

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