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Cross-National Trends in Socioeconomic Inequalities in Adolescent Mental Health: Evidence from 2002–2022

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Abstract

Differences between countries in how social inequalities in adolescents' mental health have evolved over the long term are not yet clearly understood. The influence of wider societal shifts on these patterns is similarly unclear. We investigated three key issues: (1) whether the relationship between family socioeconomic status and both psychological and somatic complaints altered between 2002 and 2022, (2) the degree to which any such changes differed from one country to another, and (3) whether within-country shifts in income inequality, perceived schoolwork pressure, and internet activity helped explain these trends. The analysis drew on data from 903,344 adolescents across 32 countries who participated in the Health Behavior in School-aged Children (HBSC) survey waves conducted between 2002 and 2022. Multilevel modeling was used to examine the research questions.

Psychological and somatic complaints showed a nonlinear upward trend across the study period. Overall, the size of social inequalities in both types of complaints remained fairly constant across the full set of countries, yet the specific trajectories varied markedly between nations. Among the societal factors examined, only rising income inequality accounted for differences in these trends across countries. In nations where income inequality grew during the period, the gap in psychological complaints between socioeconomic groups actually became smaller. The findings underline the continued existence of substantial global differences in adolescents' mental health difficulties and emphasize the need for stronger, more targeted health policies.

Keywords: Cross-national trends, Socioeconomic inequalities, Mental health, Adolescent

Introduction

Research carried out in many European countries has repeatedly demonstrated the presence of social inequalities in adolescents' mental health [1–3]. Young people from families with lower socioeconomic status (SES) tend to report considerably more mental health difficulties than their more advantaged peers. Here, social inequalities in adolescent mental health are defined as the uneven spread of mental health problems across social groups (commonly known as the social gradient), with family affluence serving as the key indicator [4, 5]. Several studies have suggested that the connection between family SES and mental health problems among adolescents may have grown stronger in recent decades. This could be linked to several societal developments, including greater academic demands and performance pressure [6], increased social comparison enabled by social media platforms [7], and heightened competition between social classes [8, 9]. Such changes can create an environment in which young people constantly compare themselves to others, leading to heightened stress and a stronger drive to succeed. Although these broader shifts appear to harm the mental well-being of adolescents in general [8], their effects may be particularly damaging for those from low-SES families [9].

Adolescents from disadvantaged backgrounds are already more exposed to family-related stressors, such as

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parental conflict [2], and are more likely to feel inferior because of their social position. When these existing vulnerabilities combine with new pressures arising from societal trends that encourage comparison and competition (for example, intense school demands and frequent internet use), the overall burden can become excessive. This process of accumulating disadvantage can therefore have a stronger negative impact on the mental health of lower-SES adolescents [10, 11], which may result in a widening of social inequalities in mental health problems over time.

Despite the importance of this topic, relatively few studies have explored international patterns in social inequalities related to adolescent mental health. Most available evidence comes from single-country analyses, which have produced inconsistent results. As examples, research in Scotland from 1998 to 2018 [12] and in Sweden from 2004 to 2020 [13] indicated that social inequalities were becoming larger. In contrast, studies conducted in the Netherlands between 2001 and 2017 [14] and in Norway from 2014 to 2018 [7] pointed to largely unchanged patterns.

Cross-national investigations have either found that the association between family SES and adolescent mental health problems stayed stable over time across different countries [15–17] or reported that inequalities increased for psychological complaints while remaining steady for somatic complaints [18]. These studies highlight clear differences between countries in the way social inequalities in adolescent mental health develop. However, the majority of this work only covered trends up to 2014 and may not have captured the effects of more recent societal changes that could be influencing these inequalities [18].

Except for the work by Elgar *et al*. [9], earlier cross-national research did not examine which broader societal developments might be driving shifts in the time-based patterns of social inequalities affecting adolescents' mental health, nor did it account for why these patterns differ so much across countries. By comparison, Elgar *et al*. [9] showed that nations experiencing rising income inequality also saw social inequalities in psychological complaints grow larger over the years. Building on this, the present study looks beyond purely economic factors. It explores country-level changes in income inequality, perceived schoolwork pressure, and social media use as possible reasons for the varying trends in social inequalities in adolescents' mental health problems across nations. As highlighted previously, these kinds of societal transformations can hit adolescents from low SES families particularly hard, since they layer additional burdens onto the stressors already linked to lower socioeconomic standing [19], which in turn could expand social inequalities over time. Previous investigations have documented rising levels of such stressors — notably schoolwork pressure and social media use — in numerous countries; however, the magnitude of these rises differs sharply between countries [18, 20, 21]. This uneven pace of change may well explain the cross-national differences observed in trends of social inequalities in adolescents' mental health problems. Accordingly, we investigated long-term trends in social inequalities in adolescents' psychological and somatic complaints across 32 countries from 2002 to 2022. Relying on information gathered through the international Health Behavior in School-aged Children (HBSC) study, we focused on three central research questions:

• 1. How much do social inequalities in adolescents' psychological and somatic complaints evolve when averaged across all 32 countries?

• 2. How do these trends in social inequalities in adolescents' psychological and somatic complaints differ across countries?

• 3. How strongly are within-country developments in income inequality, schoolwork pressure, and social media use linked to the observed trends in social inequalities in adolescents' psychological and somatic complaints?

We predicted an overall widening of social inequalities in both psychological and somatic complaints among adolescents during the study period. Yet, because societal changes unfold differently across countries, we also anticipated noticeable variation in these inequality trends between nations. In particular, we expected the strongest increases in social inequalities in adolescents' psychological and somatic complaints to appear in countries that recorded the largest rises over time in income inequality, schoolwork pressure, or social media use.

Materials and Methods

Data

The core dataset for this research is the Health Behavior in School-aged Children (HBSC) study. This is a large-scale, repeated cross-sectional school-based survey conducted every 4 years since 1983 in cooperation with

the World Health Organization (WHO) Regional Office for Europe. The HBSC project regularly assesses health behaviors and overall wellbeing among 11-, 13-, and 15-year-old adolescents in 49 countries and regions throughout Europe, Canada, and Israel. It also provides separate information for certain sub-national areas, including Belgium (Flanders and Wallonia) and Great Britain (England, Scotland, and Wales). For simplicity, all countries and regions are referred to as "countries" in the following sections. To maintain consistency, every participating country followed a uniform international protocol covering measurement tools, sampling methods, and survey procedures [22]. Ethical clearance was granted by the appropriate institutional bodies in each country.

In the current analysis, we focused on the survey waves conducted between 2002 and 2022. To ensure reliable detection of trends and fluctuations, we included only countries that had participated in at least 3 of the 6 available survey cycles (initial sample: nindividuals = 1,224,209; ncountries = 43) [23]. After adolescents with incomplete data on key individual- and country-level variables were removed, the final sample included 903,344 adolescents (female: 50.58%; Mage = 13.56; SDage = 1.64) from 32 countries. Importantly, the excluded cases showed no significant differences from the retained sample in psychological and somatic complaints, gender distribution, age, family structure, or family SES.

Measures

Outcome variables

The psychological and somatic complaints of adolescents served as indicators of their mental health problems. These complaints were evaluated using the HBSC Symptom Checklist [24], which asked about the occurrence of four psychological symptoms—feeling low, feeling irritable or bad-tempered, feeling nervous, and difficulty sleeping—along with four somatic symptoms: headache, stomachache, backache, and dizziness. Respondents reported how often each symptom had been experienced in the previous six months on a five-point scale (1 = about every day to 5 = rarely or never). Subscale scores were obtained by averaging the reverse-coded items, but only for those who answered at least two questions per subscale. Greater average scores corresponded to more frequent complaints. The subscales have demonstrated sound validity and reliability in multi-country research and correlate strongly with additional mental health markers, including emotional problems ($r = -0.79$, $P < 0.001$) [25, 26].

Independent variables

At the individual level, family socioeconomic status was operationalized using the Family Affluence Scale (FAS), an inventory of household material resources [27, 28]. The original version contained four items concerning one's own bedroom, car ownership, computer count, and family holidays. Starting in 2010, the scale was expanded by adding items on bathroom availability and dishwasher ownership [29]. To facilitate cross-country and cross-time comparisons, the summed FAS scores were standardized within each survey year and country, followed by a RIT transformation to account for economic variation [30, 31]. Ridit scores express the relative share of adolescents from less affluent families in a given country and year. The mean ridit value was set to 0.5 for each age group, country, and survey year, ensuring that exactly half the sample fell below and half above the country-year average affluence level.

Income inequality at the country level was indexed using the post-tax Gini coefficient, matched to the relevant survey year and country, and sourced from the Standardized World Income Inequality Database [32] (as HBSC does not collect this metric). The Gini index ranges from 0 (perfect equality) to 1 (maximum inequality) and reflects the degree to which income is unevenly distributed across individuals or households within a national economy; higher values indicate greater inequality.

Schoolwork pressure at the country level was derived from the item asking participants how pressured they felt by their school assignments. Answers were provided on a four-point scale (1 = not at all to 4 = a lot). Country-specific averages were calculated for each survey year, such that elevated means signaled higher overall pressure from schoolwork. This operationalization is commonly used in international comparative investigations [18, 33, 34].

Country-level social media engagement was approximated using internet-use data from PISA waves in 2012, 2015, 2018, and 2022, as HBSC introduced a dedicated social media question only from 2018. Before 2018, the relevant PISA item concerned the typical weekday time spent on the internet outside school [35]. The 2022 version broadened the scope to encompass diverse online activities both in and out of school, such

as gaming or consuming informational content [36]. For temporal consistency, attention was restricted to after-school use. Responses were converted into estimated daily hours using these equivalences: no time = 0, 1–30 minutes = 0.25, 31–60 minutes = 0.75, 1–2 hours = 1.5, 2–4 hours = 3, 4–6 hours = 5, and over 6 hours = 7. Mean daily internet hours were then aggregated by country and survey year. Because the HBSC and PISA schedules do not align perfectly, each HBSC wave was paired with the temporally closest PISA wave, with no more than a 2-year gap.

Control variables

Individual-level controls comprised age (continuous in years), gender (coded 0 for boys and 1 for girls), and family structure (0 when adolescents resided with both biological parents in the main household, 1 otherwise). Country-level controls included the proportion of gross domestic product devoted to social welfare expenditures, obtained from OECD statistics [37], as well as gross national income (GNI) figures for each country and year supplied by the World Bank [38]. To separate within-country variation from stable between-country differences, we further adjusted for the long-term country averages of income inequality, schoolwork pressure, and internet activity across all survey years [39]. This technique, for instance, permits detection of whether fluctuations in schoolwork pressure within a nation arise from changing societal conditions, even in countries that characteristically report elevated pressure levels irrespective of temporal shifts.

Analytical strategy

To investigate links between family SES and adolescents' psychological or somatic complaints, we applied multilevel modeling that accounted for the hierarchical data structure—adolescents nested within country-year combinations, which were themselves nested within countries. Due to convergence difficulties, the school level was omitted from the specifications. We introduced a random slope that allowed the interaction between time and family SES to differ across countries. Temporal patterns were captured using B-splines, which are piecewise polynomial functions that allow localized adjustment of curve smoothness, thereby modeling linear, quadratic, and cubic developments over time [40]. This method offered greater flexibility in describing intricate (non-)linear trajectories than traditional straight-line approaches. The linear, quadratic, and cubic components were merged to form the overall time predictor used in the models.

In the core set of analyses, we estimated three models for each complaint outcome. First, an empty (null) model without any predictors was run to obtain the intraclass correlation coefficients (ICCs) at the individual, country-year, and country levels [41]. Model 1 then added a cross-level interaction term between time and family SES to test whether the SES–complaint relationship shifted across the study period. Next, Models 2a to 2c each incorporated a separate three-way cross-level interaction: income inequality × family SES × time in Model 2a, schoolwork pressure × family SES × time in Model 2b, and internet activity × family SES × time in Model 2c. These terms evaluated whether changes in country-level factors across successive survey waves helped explain the evolving patterns of socioeconomic differences in the two complaint types, with particular attention to variation within countries. Two-way interaction terms were additionally examined to determine whether larger values on the country-level predictors—either when contrasting nations or tracking change within them—corresponded to more pronounced socioeconomic disparities in complaints; these terms reflected both between-country and within-country processes. When evaluating the two-way interactions, the three-way terms were omitted to allow simpler interactions to be interpreted without complication.

Family SES was grand-mean-centered (centering carried out separately for each country and survey year) before inclusion in cross-level interactions. In parallel, the three country-level predictors—income inequality, schoolwork pressure, and internet activity—were centered at the country level [36]. The precise number of observations available for estimation varied slightly across models, depending on missingness patterns at the country-year level. Every analysis was executed in R version 4.2.3 [42] employing the "lme4" [43] and "lmerTest" [44] packages.

Results and Discussion

Table 1 presents descriptive statistics for all study variables, and bivariate correlations appear in the Supplementary Appendices. Variance inflation factors remained safely below the cutoff of 10 in all cases [45], indicating that multicollinearity did not pose a problem.

Table 1. Descriptive statistics of the study variables between 2002 and 2022 (Health Behavior in School-aged Children, N individuals = 902,682, N countries = 32).

Variables	Max	Min	2022	2018	2014	2010	2006	2002
N individuals			169,331	158,205	152,737	159,094	147,039	116,276
Mean (SD)/%			Mean (SD)/%	Mean (SD)/%	Mean (SD)/%	Mean (SD)/%	Mean (SD)/%	Mean (SD)/%
Outcome variables								
Psychological complaints	5	1	2.68 (1.13)	2.36 (1.04)	2.24 (1.02)	2.17 (0.97)	2.18 (0.97)	2.18 (0.94)
Somatic complaints	5	1	2.06 (0.96)	1.84 (0.85)	1.85 (0.86)	1.82 (0.84)	1.79 (0.93)	1.79 (0.80)
Individual-level variables								
Gender (ref. = boys)	1	0	50.87%	51.42%	51.61%	51.60%	51.54%	51.79%
Age	15	11	13.67 (1.64)	13.53 (1.61)	13.63 (1.62)	13.57 (1.64)	13.60 (1.65)	13.54 (1.66)
Family structure (ref. = not living together with both parents)	1	0	75.99%	72.15%	73.43%	73.43%	74.02%	77.63%
Family SES	1	0	0.50 (0.28)	0.50 (0.29)	0.50 (0.29)	0.50 (0.28)	0.50 (0.28)	0.50 (0.28)
Country-level variables								
Income inequality	0.38	0.22	0.29 (0.03)	0.29 (0.03)	0.30 (0.03)	0.30 (0.04)	0.30 (0.04)	0.29 (0.04)
Schoolwork pressure	2.83	1.84	2.51 (0.17)	2.34 (0.22)	2.27 (0.18)	2.22 (0.20)	2.27 (0.20)	2.26 (0.21)
Internet activity	5.33	1.73	—	—	4.75 (0.35)	3.73 (0.30)	3.28 (0.35)	2.54 (0.34)
GNI	0.42	0.00	0.10 (0.12)	0.09 (0.11)	0.10 (0.12)	0.07 (0.09)	0.08 (0.10)	0.05 (0.07)
Social welfare	0.32	0.12	0.23 (0.05)	0.22 (0.05)	0.23 (0.05)	0.23 (0.04)	0.20 (0.05)	0.20 (0.04)

Note: all variables are uncentered for descriptive statistics; internet activity was not available for the survey cycles 2002 and 2006; the number of countries varied due to differences in the availability of country-level variables; descriptive statistics employed listwise deletion for missing data (including psychological and somatic complaints).

Model verification

For psychological complaints, the country-year ICC exceeded the country-level ICC by a small margin, whereas the two ICCs were nearly identical for somatic complaints. For psychological complaints, both the quadratic (B = 0.09, 95% CI: 0.01–0.17) and cubic (B = 0.19, 95% CI: 0.15–0.23) components were statistically significant. Somatic complaints displayed a similar pattern, with significant quadratic (B = 0.26, 95% CI: 0.21–0.38) and cubic (B = 0.23, 95% CI: 0.24–0.30) elements, but a nonsignificant linear term, as visualized in **Figure 1**. Accordingly, throughout the rest of the paper, any mention of "changes over time" should be taken to indicate predominantly nonlinear movement rather than simple linear progression.

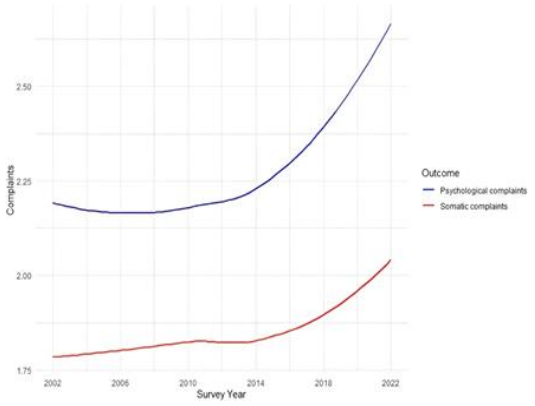

Figure 1. Trends in psychological and somatic complaints between 2002–2022 (Health Behavior in School-aged Children, N individuals = 902,682, N countries = 32). Note: The scale ranges from 1 to 5, with higher scores indicating more somatic or psychological symptoms in the last two weeks.

Changes over time in social inequalities in adolescents' psychological and somatic complaints

According to Model 1 shown in **Table 2**, adolescents experienced a marked rise in psychological complaints

(B = 0.09, 95% CI: 0.08–0.10) and a more modest increase in somatic complaints (B = 0.05, 95% CI: 0.04–0.06) across the study years. These upward shifts match the nonlinear patterns visible in **Figure 1** for both types of complaints. Lower family SES was linked to higher psychological complaints (B = −0.03, 95% CI: −0.04 to −0.02) and slightly higher somatic complaints (B = −0.01, 95% CI: −0.02 to 0.00). Importantly, the interaction between family SES and time failed to reach significance for either outcome. This indicates that the socioeconomic gradient in complaints did not, on average, widen or narrow across all countries over time.

Figures 2 and 3 reinforce this finding by showing largely stable gaps in complaint levels across the three SES groups throughout the entire period. Adolescents from families with below-average affluence consistently reported the highest burden of both psychological and somatic complaints compared with those from average or above-average backgrounds. A notable spike in complaints of both kinds appeared between 2018 and 2022, which could be related to the effects of the COVID-19 pandemic. As a robustness check, we reran the analyses without the 2022 data wave; the key results for Models 1 and 2c remained virtually unchanged.

Table 2. Results of multilevel models predicting psychological and somatic complaints between (Health Behavior in School-aged Children, 2002–2022).

Reworded table								
Variables	**Model 1**		**Model 2c**		**Model 2b**		**Model 2a**	
	Psychological symptoms (N = 902,682; Countries = 32)	**Somatic symptoms** (N = 903,344; Countries = 32	**Psychological symptoms**N = 507,787; Countries = 30)	**Somatic symptoms** (N = 508,234; Countries = 30)	**Psychological symptoms** (N = 891,218; Countries = 32)	**Somatic symptoms** (N = 891,819; Countries = 32)	**Psychological symptoms** (N = 902,682; Countries = 32)	**Somatic symptoms** (N = 903,344; Countries = 32)
Fixed Effects (β with 95% CI)								
Predictors	**M1 Psy**	**M1 Som**	**M2c Psy**	**M2c Som**	**M2b Psy**	**M2b Som**	**M2a Psy**	**M2a Som**
Intercept	−0.52 (−0.59–0.45)***	−0.40 (−0.47–0.34)***	−0.76 (−1.01–−0.52)***	−0.38 (−0.61–−0.15)***	−0.44 (−0.51–−0.37)***	−0.34 (−0.40–−0.28)***	−0.51 (−0.58–−0.44)***	−0.40 (−0.46–−0.34)***
Individual-Level Factors								
Variables	**M1 Psy**	**M1 Som**	**M2c Psy**	**M2c Som**	**M2b Psy**	**M2b Som**	**M2a Psy**	**M2a Som**
Gender (reference = boys)	0.35 (0.34–0.35)***	0.38 (0.38–0.39)***	0.38 (0.37–0.38)***	0.40 (0.39–0.40)***	0.29 (0.29–0.30)***	0.34 (0.34–0.35)***	0.35 (0.34–0.35)***	0.38 (0.38–0.39)***
Age	0.13 (0.13–0.13)***	0.14 (0.13–0.14)***	0.14 (0.13–0.14)***	0.14 (0.14–0.15)***	0.07 (0.07–0.07)***	0.09 (0.09–0.09)***	0.13 (0.13–0.13)***	0.14 (0.13–0.14)***
Household composition (ref. = not living with both parents)	−0.07 (−0.08–−0.07)***	−0.07 (−0.07–−0.07)***	−0.08 (−0.08–−0.07)***	−0.07 (−0.07–−0.07)***	−0.07 (−0.07–−0.07)***	−0.07 (−0.07–−0.06)***	−0.07 (−0.08–−0.07)***	−0.07 (−0.07–−0.07)***
Family socioeconomic status	−0.03 (−0.04 to −0.02)***	−0.01 (−0.02–0.00)**	−0.07 (−0.12 to −0.01)***	−0.03 (−0.09–0.02)	−0.03 (−0.04–−0.02)***	−0.01 (−0.02–0.00)***	−0.03 (−0.04 to −0.02)***	−0.01 (−0.02–0.00)**
Time (year trend)	0.09 (0.08–0.10)***	0.05 (0.04–0.06)***	0.11 (0.06–0.17)***	0.02 (−0.03–0.07)	0.08 (−0.06–0.09)***	0.04 (0.03–0.05)***	0.09 (−0.08–0.10)***	0.05 (0.04–0.06)***

Country-Level Indicators								
Variables	**M1 Psy**	**M1 Som**	**M2c Psy**	**M2c Som**	**M2b Psy**	**M2b Som**	**M2a Psy**	**M2a Som**
Gross National Income (GNI)	−0.03 (−0.08–0.02)	−0.01 (−0.06–0.03)	0.01 (−0.06–0.07)	0.02 (−0.05–0.09)	−0.03 (−0.08–0.01)	−0.01 (−0.06–0.04)	−0.03 (−0.09–0.02)	−0.02 (−0.07–0.03)
Welfare expenditure	−0.05 (−0.09 to −0.01)*	−0.01 (−0.05–0.02)	−0.01 (−0.05–0.02)	−0.01 (−0.05–0.02)	−0.05 (−0.08 to −0.02)*	−0.01 (−0.04–0.02)	−0.04 (−0.08–0.00)*	−0.01 (−0.04–0.02)
Income inequality							−0.05 (−0.12–0.02)	−0.02 (−0.07–0.04)
Average income inequality							0.10 (0.01–0.18)*	0.05 (−0.02–0.00)
Academic pressure					0.19 (0.19–0.19)***	0.13 (0.13–0.14)***		
Mean academic pressure					−0.04 (−0.09–0.01)	−0.03 (−0.08–0.02)		
Online activity			−0.19 (−0.30 to −0.08)**	−0.15 (−0.26 to −0.05)*				
Mean online activity			0.00 (−0.07–0.06)	−0.02 (−0.09–0.04)				
Cross-Level Interaction Terms								
Interactions	**M1 Psy**	**M1 Som**	**M2c Psy**	**M2c Som**	**M2b Psy**	**M2b Som**	**M2a Psy**	**M2a Som**
Family SES × Time	0.00 (−0.00–0.00)	0.00 (−0.00–0.00)	0.01 (−0.00–0.02)	0.01 (−0.01–0.02)	0.00 (−0.01–0.01)	0.00 (−0.00–0.00)	0.00 (−0.00–0.00)	0.00 (−0.00–0.00)
Family SES × Income inequality							−0.02 (−0.03 to −0.01)***	−0.01 (−0.02–0.00)*
Time × Income inequality							−0.01 (−0.02–0.01)	0.00 (−0.01–0.01)
Family SES × Income inequality × Time							0.00 (0.00–0.01)*	0.01 (−0.00–0.00)
Family SES × Academic pressure					−0.01 (−0.06 to −0.03)***	−0.01 (−0.01–0.00)**		
Time × Academic pressure					0.03 (0.03–0.03)***	0.02 (0.02–0.02)***		
Family SES × Academic					0.00 (−0.00–0.00)	0.00 (−0.00–0.00)		

pressure × Time								
Family SES × Online activity			−0.01 (−0.04–0.02)	−0.01 (−0.05–0.02)				
Time × Online activity			0.06 (0.04–0.07)***	0.05 (0.04–0.07)				
Family SES × Online activity × Time			−0.00 (−0.01–0.00)	0.00 (−0.00–0.01)				
Random Effects								
Component	**M1 Psy**	**M1 Som**	**M2c Psy**	**M2c Som**	**M2b Psy**	**M2b Som**	**M2a Psy**	**M2a Som**
SES × Time slope variance	0.02*	0.01*	0.01*	0.00*	0.02*	0.01*	0.02*	0.01*
Model Fit Statistics								
Measure	**M1 Psy**	**M1 Som**	**M2c Psy**	**M2c Som**	**M2b Psy**	**M2b Som**	**M2a Psy**	**M2a Som**
AIC	2,518,675	2,211,851	1,439,264	1,264,086	2,395,363	2,136,670	2,518,694	2,211,885

*P < 0.05, **P < .01, ***P < .001. Note: Results are beta coefficients with 95% confidence interval (CI).

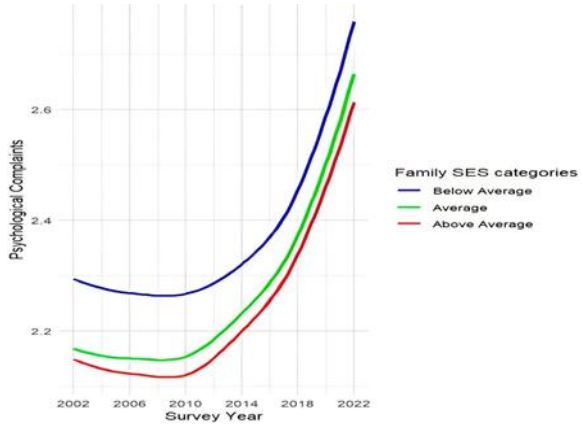

Figure 2. Trends in social inequalities in psychological complaints between 2002–2022 (Health Behavior in School-aged Children, N individuals = 902,682, N countries = 32). Note: the scale ranges between 1 and 5 scores, with higher scores referring to more somatic or psychological symptoms in the last two weeks; three family SES categories are based on the mean and SD of the family SES: above average (mean + 1 SD or higher), average (within ± 1 SD of the mean) and below average (mean – 1 SD or lower).

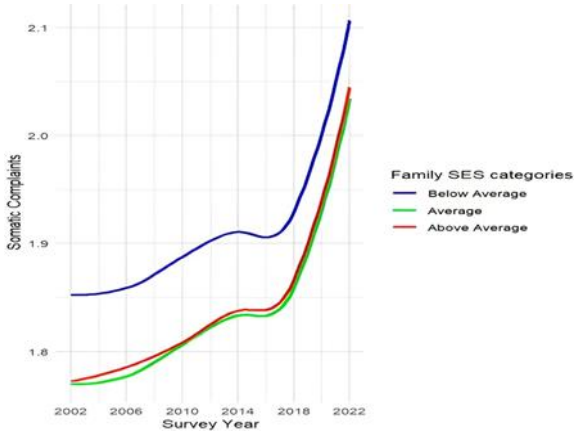

Figure 3. Trends in social inequalities in somatic complaints between 2002–2022 (Health Behavior in School-aged Children; N individuals = 902,682; N countries = 32). Note: the scale ranges between 1 and 5 scores, with higher scores referring to more somatic or psychological symptoms in the last two weeks; three family SES categories are based on the mean and SD of the family SES: above average (mean + 1 SD or higher), average (within ± 1 SD of the mean) and below average (mean – 1 SD or lower).

Variations between countries in the trends in social inequalities in adolescents' psychological and somatic complaints

The significant random slopes observed in Model 1 of **Table 2** indicated considerable cross-country variation in how social inequalities in complaints developed over time, both for psychological (τ = 0.02, P < 0.05) and

somatic (τ = 0.01, P < 0.05) complaints. In most countries, socioeconomic gaps remained fairly constant (as in the Netherlands and England). At the same time, some nations displayed growing gaps (such as Canada and Austria), while others showed shrinking gaps (such as Portugal and Lithuania).

We then explored whether three major societal developments could account for these differing national trajectories. Focusing first on country-level income inequality, Model 2a in **Table 2** indicated no direct association between income inequality and the level of either psychological or somatic complaints. However, the two-way interaction between family SES and country-level income inequality showed a negative relationship with both psychological (B = −0.02, 95% CI: −0.03 to −0.01) and somatic (B = −0.01, 95% CI: −0.02 to 0.00) complaints. This suggests that higher income inequality—whether observed across countries or over time within them—was associated with greater socioeconomic differences in complaints. Results remained consistent when three-way interactions were dropped. To test whether within-country changes in income inequality influenced changes in social inequalities, we examined the three-way interaction (family SES × income inequality × time). This term was statistically significant for psychological complaints (B = 0.00, 95% CI: 0.00–0.01). It showed that in countries experiencing rising income inequality, the socioeconomic gradient in psychological complaints tended to narrow. In contrast, the gradient remained largely unchanged in countries experiencing falling income inequality. **Figure 4** illustrates this pattern, with country groupings noted below the figure.

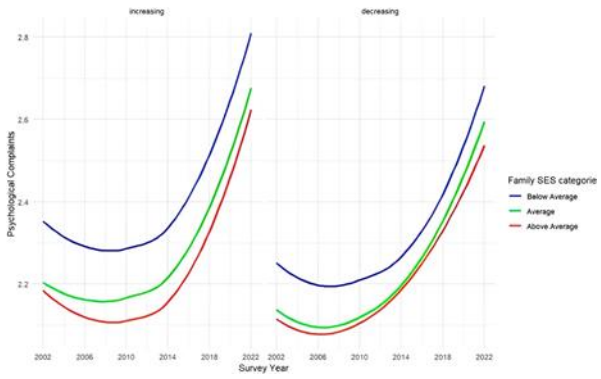

Figure 4. Trends in social inequalities of psychological complaints in countries with increasing versus decreasing income inequality (Health Behavior in School-aged Children, N individuals = 902,682, N countries = 32). Note: the scale ranges between 1 and 5 scores, with higher scores referring to more somatic or psychological symptoms in the last two weeks; three family SES categories are based on the mean and SD of the family SES: above average (mean + 1 SD or higher), average (within ± 1 SD of the mean) and below average (mean – 1 SD or lower); Classification of countries as 'decreasing' or 'increasing' in income inequality was based on GINI values observed in 2002 and 2022; In 17 increasing income inequality countries the average Gini increased from 0.277 in 2002 to 0.293 in 2022, and in 15 decreasing income inequality countries the average Gini decreased from 0.308 in 2002 to 0.295 in 2022. Countries with increasing income inequality were: Austria, Denmark, Finland, France, Germany, Hungary, Italy, Iceland, Latvia, Lithuania, Netherlands, Norway, Slovenia, Slovakia, Spain, Sweden, and Switzerland. Countries with decreasing income inequality included Belgium (Flemish and French), Canada, the Czech Republic, Estonia, Ireland, Israel, Greece, Poland, Portugal, England, Scotland, and Wales.

Regarding schoolwork pressure, findings from Model 2b, displayed in **Table 2**, indicated a clear positive relationship with psychological complaints (B = 0.19, 95% CI: 0.19-0.19) and somatic complaints (B = 0.13, 95% CI: 0.13–0.14). Put differently, young people residing in nations or time frames featuring intensified academic demands tended to show elevated rates of both complaint categories. The two-way interaction between schoolwork pressure and family SES was statistically significant for psychological complaints (B = −0.01, 95% CI: −0.06 to 0.03) and somatic complaints (B = −0.01, 95% CI: −0.01 to 0.00). In essence, the beneficial impact of greater family SES in lowering complaint levels grew stronger under conditions of heightened schoolwork pressure, whether compared across nations or tracked over successive periods. Parallel outcomes surfaced once the three-way interactions were set aside. Yet no reliable three-way interaction emerged between family SES, schoolwork pressure, and time for either complaint type. Consequently, while elevated schoolwork pressure coincided with amplified socioeconomic disparities in complaints, fluctuations in national schoolwork pressure did not appear to shape the direction or extent of those disparities over the years.

Turning to internet activity, Model 2c outcomes in **Table 2** revealed inverse associations with psychological complaints (B = −0.19, 95% CI: −0.30 to −0.08) and somatic complaints (B = −0.15, 95% CI: −0.26 to −0.05). Interestingly, this direct link vanished entirely when interaction terms were removed from the equations. The two-way interaction between family SES and internet activity failed to reach significance for both outcomes when three-way terms were included, indicating that country-level internet engagement did not moderate the overall SES–complaint relationship. Upon removing only the three-way terms, however, the two-way interaction became significant only for psychological complaints. This revealed a sharper protective role of higher family SES against psychological complaints in environments or eras of greater internet engagement. No meaningful three-way interaction (family SES × internet activity × time) surfaced for either complaint. Thus, shifts in national internet activity levels across survey waves showed no systematic tie to evolving patterns of socioeconomic differences in these mental health indicators.

Main findings

This investigation explored the evolution of socioeconomic disparities in adolescents' mental health challenges spanning 2002 to 2022 in 32 nations across Europe and North America. Particular attention was given to the possible contributions of country-level income inequality, schoolwork pressure, and internet activity. Analyses uncovered a sharp, nonlinear uptick in psychological and somatic complaints across the sampled countries, most notably from 2018 onward to 2022. Young people raised in higher-SES households reported markedly lower frequencies of both complaint forms consistently over the full timeframe and across locations. On the whole, this inverse relationship between family affluence and complaint severity held steady when averaged across countries. Still, the trajectories differed noticeably from one country to another: the bulk of nations sustained roughly constant socioeconomic gaps, whereas a handful recorded either expansion or contraction of those gaps. Of the societal elements under scrutiny, solely income inequality helped clarify these between-country differences in inequality trends. Within nations where income inequality grew progressively, socioeconomic divides in psychological complaints tended to contract. Beyond that, wider socioeconomic gaps in both psychological and somatic complaints surfaced in nations or eras marked by stronger income inequality or intensified schoolwork pressure. For psychological complaints specifically, larger gaps also appeared in contexts featuring more widespread internet activity.

Interpretation of the findings

The nonlinear surge in both complaint types likely connects to disruptions from the COVID-19 outbreak and/or additional influences, including possible over-diagnosis or expanded recognition of mental health concerns in line with the prevalence inflation hypothesis [46]. At the same time, the current evidence echoes earlier investigations focused on the preceding decades [14–16] by confirming that socioeconomic inequalities in these complaints remained stable across countries from 2002 through 2022. Such stability underscores the enduring nature of social gradients in adolescent mental well-being. Although cross-national averages suggested stability, substantial country-to-country differences in inequality patterns stood out, consistent with prior observations by Elgar *et al*. [9] and Moor *et al*. [16]. In most countries, the socioeconomic gaps held firm, but in selected nations, the disparities either grew or decreased. Among the societal shifts analyzed here, income inequality alone accounted for part of the cross-national divergence in how psychological complaint inequalities developed. Inside countries registering rising income inequality, the socioeconomic gradient in psychological complaints narrowed over successive waves. This somewhat surprising outcome may reflect the fact that nations entering the period with already sizable gaps in psychological complaints possessed greater potential for subsequent convergence. By the end of the observation window, inequality in psychological complaints appeared to be narrowing between the two groups of countries. An alternative account could involve unmeasured contextual elements that drove the observed contraction of gaps precisely in places experiencing national-level growth in income inequality. It is worth noting that the set of countries showing rising income inequality encompasses every Scandinavian nation. These societies stand out for their robust social democratic frameworks, broad-reaching family support measures, and comprehensive universal healthcare provisions [47, 48]. These features could underlie the observed pattern linking changes in income inequality to shifts in mental health disparities.

Besides examining within-country shifts in social inequality trends over time, the analysis also considered between-country differences and temporal changes by evaluating how strongly income inequality, schoolwork pressure, and internet activity relate to socioeconomic gaps in psychological and somatic complaints. In line with earlier research on country-level income inequality [49, 50], larger socioeconomic disparities in both psychological and somatic complaints emerged in contexts of greater income inequality, whether arising from cross-national contrasts or from rising inequality within nations. Although prior work had not addressed the influence of country-level schoolwork pressure, the present results echo those of Högberg [6], indicating that socioeconomic differences in mental health difficulties are more pronounced in nations with higher academic demands. Together, these observations lend support to the cumulative disadvantage framework [19]. According to this perspective, the interplay between family-level strains (such as parental conflict) [2] and broader societal pressures (including schoolwork pressure and income inequality) can exceed adolescents' coping capacity [9]. For young people from low-SES households—who frequently encounter more family-related challenges—residing in high-pressure school environments may intensify mental health difficulties and thereby enlarge socioeconomic gaps in psychological and somatic complaints. Social comparison mechanisms activated by income disparities and competitive academic settings may reinforce one another, further harming adolescents' mental well-being.

Findings regarding internet activity were somewhat inconsistent. Socioeconomic differences in somatic complaints were not associated with country-level internet activity. This absence of association could stem from near-universal internet access, which may prevent it from creating meaningful distinctions between SES groups regarding somatic symptoms. In contrast, results for psychological complaints were consistent with cumulative disadvantage, revealing wider socioeconomic gaps in psychological complaints among adolescents in nations or periods marked by higher internet activity [10]. A plausible explanation for the divergent pattern across complaint types is that online social comparisons often generate predominantly psychological feelings of inferiority [51]. Such feelings align more closely with emotional distress, including anxiety and depression [52], than with physical somatic manifestations. Although studies exploring the internet activity's contribution to mental health inequalities remain scarce, Boer *et al*. [19] previously reported that rising country-level internet use coincided with higher overall psychological complaints among adolescents. The current study builds upon that work by suggesting that elevated internet activity may disproportionately affect adolescents from lower-SES backgrounds. Nevertheless, additional investigation is required to clarify the interplay between family affluence and internet activity, and to explain why the associations differ for psychological versus somatic complaints—perhaps by examining relative inequalities in these outcomes.

Strengths and limitations

One notable strength of the study lies in its extensive, nationally representative samples combined with consistent recruitment procedures and comparable measurement tools applied repeatedly across countries and over time. This design facilitated a robust examination of cross-national trends. In addition, the analysis relied on well-validated instruments for assessing psychological and somatic complaints [24, 25]. Despite these advantages, several limitations deserve mention. First, the repeated cross-sectional nature of the data precludes firm causal conclusions. For instance, the social selection hypothesis raises the possibility of reverse causation, whereby adolescents experiencing greater mental health difficulties might drift toward lower family SES because of the economic costs associated with their conditions (such as treatment expenses) [53]. Even so, longitudinal evidence suggests that the causal direction examined here is more probable than the reverse [3]. Second, internet activity served only as a proxy for social media engagement; it may not accurately reflect the specific online behaviors of interest, such as social comparison processes [54]. Moreover, the differing survey schedules of HBSC and PISA could reduce the precision of this proxy measure. Finally, although the study concentrated on three key societal developments, additional country-level factors might influence trends in socioeconomic inequalities in adolescent mental health—for example, strained healthcare systems that disproportionately limit access for lower-SES groups, or evolving family structures such as the growing prevalence of single-parent households and shifts in parental engagement. Future research should explore a broader range of country-level variables and their potential impact on these trends.

Conclusion

By examining societal transformations, this study offers a fresh perspective on the dynamics of social inequalities affecting adolescents' mental health. A clear nonlinear rise in both psychological and somatic complaints occurred across countries over the study period, with adolescents from lower-SES families consistently reporting more complaints than their higher-SES peers. On average, socioeconomic inequalities in both complaint types remained stable across countries, yet important differences appeared between nations. Country-level income inequality emerged as the only factor that explained this cross-national variation, especially regarding psychological complaints. Overall, the findings underscore the continued existence of social inequalities in adolescents' mental health problems. They suggest that existing policies may be insufficient to reduce these disparities and call for stronger, sustained policy actions, combined with continued surveillance of these trends.

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