Socioeconomic inequalities in adolescent health 2002–2010: a time-series analysis of 34 countries participating in the Health Behaviour in School-aged Children study

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Summary

Background **Information about trends in adolescent health inequalities is scarce, especially at an international level. We examined secular trends in socioeconomic inequality in five domains of adolescent health and the association of socioeconomic inequality with national wealth and income inequality.**

Methods **We undertook a time-series analysis of data from the Health Behaviour in School-aged Children study, in which cross-sectional surveys were done in 34 North American and European countries in 2002, 2006, and 2010 (pooled n 492 788). We used individual data for socioeconomic status (Health Behaviour in School-aged Children Family Affluence Scale) and health (days of physical activity per week, body-mass index *Z* score [zBMI], frequency of psychological and physical symptoms on 0–5 scale, and life satisfaction scored 0–10 on the Cantril ladder) to examine trends in health and socioeconomic inequalities in health. We also investigated whether international differences in health and health inequalities were associated with per person income and income inequality.**

Findings **From 2002 to 2010, average levels of physical activity (3·90 to 4·08 days per week; p<0·0001), body mass (zBMI –0·08 to 0·03; p<0·0001), and physical symptoms (3·06 to 3·20, p<0·0001), and life satisfaction (7·58 to 7·61; p=0·0034) slightly increased. Inequalities between socioeconomic groups increased in physical activity (–0·79 to –0·83 days per week difference between most and least affluent groups; p=0·0008), zBMI (0·15 to 0·18; p<0·0001), and psychological (0·58 to 0·67; p=0·0360) and physical (0·21 to 0·26; p=0·0018) symptoms. Only in life satisfaction did health inequality fall during this period (–0·98 to –0·95; p=0·0198). Internationally, the higher the per person income, the better and more equal health was in terms of physical activity (0·06 days per SD increase in income; p<0·0001), psychological symptoms (–0·09; p<0·0001), and life satisfaction (0·08; p<0·0001). However, higher income inequality uniquely related to fewer days of physical activity (–0·05 days; p=0·0295), higher zBMI (0·06; p<0·0001), more psychological (0·18; p<0·0001) and physical (0·16; p<0·0001) symptoms, and larger health inequalities between socioeconomic groups in psychological (0·13; p=0·0080) and physical (0·07; p=0·0022) symptoms, and life satisfaction (–0·10; p=0·0092).**

Interpretation **Socioeconomic inequality has increased in many domains of adolescent health. These trends coincide with unequal distribution of income between rich and poor people. Widening gaps in adolescent health could predict future inequalities in adult health and need urgent policy action.**

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Introduction

Adolescence is a formative life stage for adult health, but is often neglected in health policy.[1] Health and health behaviours track strongly from early adolescence to adulthood, and inequalities in health are typically established early in life.[2] Socioeconomic status (SES) is a major determinant of these inequalities.[2] To grow up in impoverished and marginalised socioeconomic conditions shortens the lifespan and contributes to poor mental and physical health.[3,4] Some research has suggested that socioeconomic differences in health emerge in early childhood and then diminish in early adolescence, only to re-emerge in adulthood.[5] However, most of the evidence in this area shows social class gradients in health at every stage of the life course, including adolescence.[4,6,7]

For more on the **HBSC study** see http://www.hbsc.org

An understanding of trends in health inequalities and their social determinants is crucial so that policy can be developed to redress them.[2,8] The available evidence in this area relies heavily on local and national samples of young children.[6,7,9] International studies of social inequalities in adolescent health are scarce and, as a result, predictions about future inequalities in adult health are not based on robust information. Findings from the Health Behaviour in School-aged Children (HBSC) study,[4,8,10] which surveys the health of adolescents in North America and Europe, have shown SES differences in health in most countries and health domains, including self-rated health, psychological and physical symptoms, and life satisfaction. However, this research has not focused on trends in health inequalities in adolescence, nor on structural

determinants of adolescent health, such as national wealth or income inequality.[1,11,12]

Income inequality is rising[13] and health inequalities are widening[14,15] in adults, suggesting that socioeconomic differences in adolescent health might have increased in recent years. Since the 1970s, real wages for the bottom half of the workforce have fallen in many countries, while incomes of the top 1% have quadrupled.[12] Income inequality has risen steadily during the past four decades, thus increasing relative deprivation, depleting the social capacity of nations to support health, and contributing to poor health in terms of mental illness, obesity, mortality, and reduced child wellbeing.[16] Thus, rising income inequality might have both worsened adolescent health in general and widened social inequality in adolescent health over time.[12] In a Series on adolescent health, Viner and colleagues[1] concluded that the strongest determinants of adolescent health worldwide are structural factors, such as national wealth, access to education, and income inequality.

We had two goals for this study. Our first objective was to examine secular trends in health inequalities in different domains of adolescent health: physical activity, bodyweight, psychological and physical symptoms, and life satisfaction. We chose these domains to broadly represent mental and physical health and wellbeing. Because adolescent health relates to SES, and SES differences might have widened because of increasing income inequality, we hypothesised that adolescent health inequalities in all health domains grew from 2002 to 2010. Our second objective was to explore whether national wealth and income inequality relate to international differences in adolescent health and health inequalities between SES groups.

Methods

Study design and participants

Data for SES and health used in this time-series analysis were collected in a series of cross-sectional surveys of adolescents in 34 North American and European countries or regions in the 2002, 2006, and 2010 cycles of the HBSC study: Austria, Belgium (French region), Belgium (Flanders region), Canada, Croatia, Czech Republic, Denmark, England, Estonia, Finland, France, Germany, Greece, Greenland, Hungary, Ireland, Israel, Italy, Latvia, Lithuania, Macedonia, Netherlands, Norway, Poland, Portugal, Russia, Scotland, Slovenia, Spain, Sweden, Switzerland, Ukraine, USA, and Wales. The HBSC study included nationally representative samples of participants aged 11 years, 13 years, and 15 years.[4] Stratified samples of schools representing the regional, economic, and public–private distribution of schools in each country were recruited according to a common protocol.[4] We sampled schools with replacement as needed within each strata to ensure consistency between countries and survey cycles in terms of sample composition. The protocol stipulated a standard questionnaire format, item order, and testing conditions. Teachers or trained interviewers distributed the questionnaires in classroom settings.[4]

This research was approved on March 13, 2014, by the Institutional Review Board of the Faculty of Medicine, McGill University (Montreal, QC, Canada). Each member country obtained ethics clearance to conduct the survey from a university-based review board or

Panel 1: Measures of health inequality

We measured absolute health inequality using the slope index of inequality (SII) and relative health inequality using the relative index of inequality (RII).[26] Both absolute and relative measures are useful because they can lead to different conclusions about the size of and changes in inequalities.[27] The SII represents an absolute difference in health between the most and least affluent groups. The RII represents relative inequality in terms of the percentage of population health that differs between the most and least affluent groups. These regression-based indices are calculated by transformation of socioeconomic status (SES) to cumulative rank probabilities (ridit scores) ranging from 0 (highest) to 1 (lowest). The RII is calculated by division of health scores by the population mean and multiplication of the resulting fraction by 100, thus representing the percentage of population health that differs between the highest and lowest SES groups. Unlike other measures of health inequality that compare extreme SES groups (eg, rate ratios), the SII and RII estimate health across the full distribution of SES and are thus better suited to continuous measures of health that have no predefined cut-point and are not affected by differences in the size of socioeconomic groups between countries or over time.[26,27]

	2002 (n=156 696)	2006 (n=165 514)	2010 (n=170 578)
Individual characteristics			
Sex			
Female	80 745 (52%)	85 003 (51%)	87 497 (51%)
Male	75 951 (49%)	80 511 (49%)	83 081 (49%)
Age (years)			
11	52 604 (34%)	52 222 (32%)	54 414 (32%)
13	54 921 (35%)	56 813 (34%)	58 526 (34%)
15	49 171 (31%)	56 479 (34%)	57 638 (34%)
Mean age (years)	13·55 (1·66)	13·63 (1·65)	13·57 (1·63)
Mean affluence	4·85 (1·98)	5·25 (1·98)	5·84 (1·92)
Mean physical activity	3·84 (2·09)	4·05 (2·09)	4·06 (2·05)
Mean body-mass index*	−0·11 (1·16)	−0·02 (1·15)	0·04 (1·17)
Mean psychological symptoms	4·74 (3·82)	4·67 (3·87)	4·63 (3·87)
Mean physical symptoms	3·12 (3·22)	3·12 (3·28)	3·24 (3·34)
Mean life satisfaction	7·55 (1·92)	7·58 (1·91)	7·58 (1·89)
Country characteristics			
Mean income per person (US$)	17 165 (11 432)	29 010 (17 729)	32 593 (19 613)
Mean income inequality	0·30 (0·05)	0·30 (0·05)	0·31 (0·05)
Countries	34	34	34
Schools	5930	6659	7339

Data are n (%) or mean (SD). *Deviation (in SD units) from WHO international age-adjusted and gender-adjusted norms.[19]

Table 1: Sample characteristics by survey cycle

equivalent regulatory body. Participation was voluntary and active, or we sought passive consent from school administrators, parents, and children, as per national human participant requirements. Youth in private and special needs schools and street and incarcerated youth were excluded.

Measures

We measured SES using the HBSC Family Affluence Scale, a four-item index of material assets or common indicators of wealth.[17,18] The scale has four items: "Does your family own a car, van or truck?" (No=0, Yes=1, Yes, two or more=2); "During the past 12 months, how many times did you travel away on holiday with your family?" (Not at all=0, Once=1, Twice or more=2); "How many computers does your family own?" (None=0, One=1, Two or more=2); "Do you have your own bedroom for yourself?" (No=0, Yes=1). This scale has been validated alongside measures of SES that solicit adolescents' reports of parental occupation, educational attainment, or household income, and has been found to have better criterion validity and to be less affected by non-response bias than these other measures.[17]

In the HSBC study, physical activity was measured with the question: "Over the past 7 days, on how many

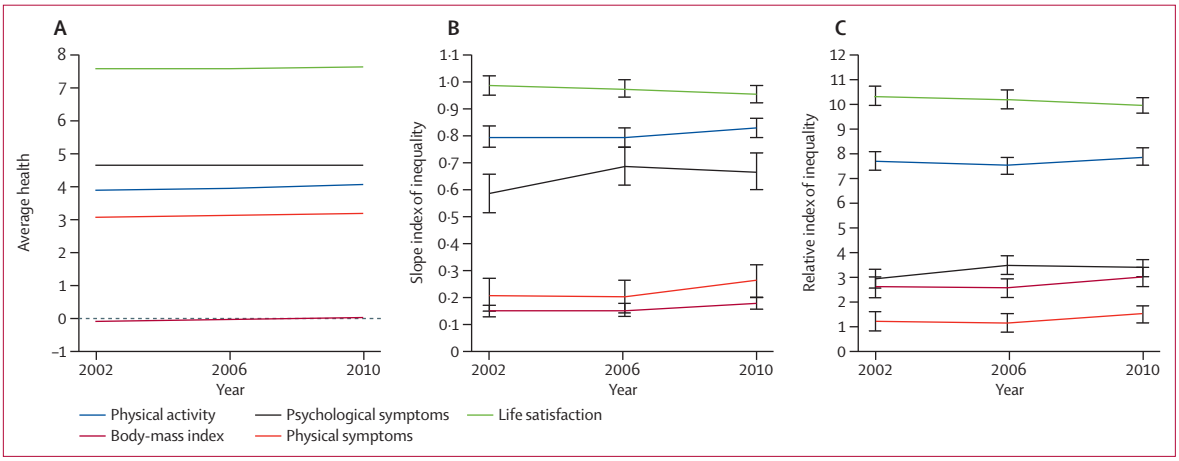

Figure: **Age-adjusted and sex-adjusted trends in (A) average health, (B) absolute inequalities in health, and (C) relative inequalities in health in three cross-sectional surveys of adolescents in 34 countries (pooled n 492 788)**

Health inequalities in physical activity and life satisfaction were negative values (table 2), but are displayed in absolute values, with 0 representing perfect health equality between socioeconomic groups. All health inequalities in health trended upward except for life satisfaction, which trended downward.

	Physical activity	Body-mass index	Psychological symptoms	Physical symptoms	Life satisfaction
Average health*					
2002	3·90 (3·88–3·92)	−0·08 (−0·08 to −0·08)	4·67 (4·65–4·70)	3·06 (3·04–3·07)	7·58 (7·56–7·60)
2006	3·97 (3·96–4·00)	−0·03 (−0·03 to −0·02)	4·66 (4·65–4·69)	3·13 (3·12–3·15)	7·58 (7·56–7·60)
2010	4·08 (4·07–4·09)	0·03 (0·03 to −0·03)	4·63 (4·62–4·65)	3·20 (3·19–3·20)	7·61 (7·60–7·63)
p value for trend	<0·0001	<0·0001	0·0766	<0·0001	0·0034
Slope index of inequality†					
2002	−0·79 (−0·83 to −0·75)	0·15 (0·13–0·18)	0·58 (0·51–0·65)	0·21 (0·15–0·27)	−0·98 (−1·02 to −0·94)
2006	−0·79 (−0·83 to −0·75)	0·16 (0·13–0·18	0·68 (0·62–0·76)	0·20 (0·14–0·26)	−0·97 (−1·01 to −0·94)
2010	−0·83 (−0·86 to −0·79)	0·18 (0·16–0·20)	0·67 (0·60–0·74)	0·26 (0·20–0·32)	−0·95 (0·99 to −0·92)
p value for trend	0·0008	<0·0001	0·0360	0·0018	0·0198
Relative index of inequality‡					
2002	−7·76 (−8·14 to −7·37)	2·67 (2·26–3·08)	3·02 (2·65–3·40)	1·29 (0·93–1·65)	−10·32 (−10·71 to −9·94)
2006	−7·56 (−7·92 to −7·21)	2·66 (2·27–3·05)	3·56 (3·20–3·93)	1·24 (0·89–1·61)	−10·19 (−10·56 to −9·83)
2010	−7·90 (−8·24 to −7·56)	3·08 (2·70–3·47)	3·45 (3·10–3·81)	1·60 (1·23–1·96)	−9·97 (−10·32 to −9·62)
p value for trend	0·0067	<0·0001	0·0346	0·0021	0·0132

Data are regression-based predicted mean (95% CI) or p value. *Adjusted for differences in age, sex, and age-by-sex interaction, and school-level and country-level clustering. †Represents the difference in health between the most and least affluent groups. ‡Percentage of population health that differs between the most and least affluent groups. These results are summarised in the figure.

Table 2: **Absolute and relative health inequalities over three survey cycles of the Health Behaviour in School-aged Children study**

days were you physically active for a total of at least 60 minutes per day?", with responses ranging from 0 to 7 days. Standardised body-mass indices were measured with self-reported weight and height (kg/m²), and then the resulting index was converted to SD units (body-mass index *Z* score; zBMI) that represent deviations from age-adjusted and gender-adjusted international norms according to WHO child growth standards.[19] The frequency of four psychological symptoms (irritability or bad temper, feeling low, feeling nervous, and difficulty sleeping) and four physical symptoms (headache, stomach ache, backache, and feeling dizzy) were measured in the previous 6 months (rarely or never=1, every month=2, every week=3, more than once a week=4, every day=5) with a symptom checklist. The validity of these measures is supported by cross-national studies and qualitative interviews with adolescents.[4,20] Life satisfaction was measured with the Cantril ladder, which ranges from 0 (worst possible life) to 10 (best possible life).[21]

Country data

We obtained data from the World Bank Databank[22] for gross national income per person (Atlas method, US$) and from the Standardized World Income Inequality Database[23] for income inequality for all survey years and countries except for Greenland. This database is estimated with Gini indices of post-taxation income inequality based on the UN University's World Income Inequality Database and Luxembourg Income Study.[23] The Gini index theoretically ranges from 0 (perfect equality with everyone having equal income) to 1 (perfect inequality with one person having all the income). We obtained similar data for per person income and income inequality in Greenland from Statistics Greenland.

Statistical analysis

We analysed the data using STATA 13.1. In the first phase of the study, we used multilevel linear regressions of health that accounted for sample clustering at school and national levels. Countries and schools were random effects and we assumed random intercepts by country and survey year. We applied data weights to account for sampling differences between countries. Specifically, three countries (Germany, Greenland, and Switzerland) had incomplete school identifiers in 2002, so we took school clustering into account in these countries by downweighting their respective samples by a design effect of 1·2. This value is a conservative generic value that is based on published historical precedents for mandatory HBSC items.[24,25] We included in each linear regression model age, sex, age-by-sex interaction, SES, survey cycle (coded 1, 2, or 3), and an SES-by-cycle interaction. This last interaction, when significant, showed an upward or downward trend in the slope index of inequality (SII), which we established by estimating SIIs per survey cycle. We tested trends in relative inequalities in health (RIIs) using similar models of health percentiles (ie, health relative to the population average; panel 1).

In the second phase of the study, we did an ecological analysis of average health and absolute and relative health inequalities in each of the 102 country and year groups in our sample. We applied Prais–Winsten time-series regression models with panel-corrected standard errors to our pooled time-series analyses to adjust for heteroscedasticity and contemporaneous correlations in the data.[28] With these analyses, we tested the relative importance of national per person income and income inequality (standardised to *Z* scores) to average health and health inequalities (eg, $SII_{it}=\alpha+\beta_1 Income_{it}+\beta_2 Gini_{it}+\mu_{it}+\varepsilon_{it}$, where observations varied across country i and time t, α was a constant, β was a slope coefficient, μ_{it} was the between-country and year error, and ε_{it} was the within-country and year error).

For the **Statistics Greenland Stat Bank** see http://bank.stat.gl

	Physical activity	Body-mass index	Psychological symptoms	Physical symptoms	Life satisfaction
Fixed components					
Constant	3·98 (4·88–5·09)	–0·03 (–0·09 to 0·04)	4·66 (4·48–4·84)	3·13 (2·99–3·28)	7·59 (8·51–8·68)
Age	–0·14 (–0·14 to –0·14; p<0·0001)	–0·01 (–0·01 to –0·01; p<0·0001)	0·17 (0·16–0·17; p<0·0001)	0·10 (0·10–0·11; p<0·0001)	–0·18 (–0·19 to –0·18; p<0·0001)
Sex (female)	–0·60 (–0·61 to –0·59; p<0·0001)	–0·30 (–0·31 to –0·30; p<0·0001)	0·83 (0·81–0·85; p<0·0001)	0·64 (0·62–0·66; p<0·0001)	–0·16 (–0·17 to –0·15); p<0·0001
Age × sex	–0·08 (–0·08 to –0·07; p<0·0001)	0·01 (0·01–0·02; p<0·0001)	0·24 (0·23–0·25; p<0·0001)	0·17 (0·16–0·18; p<0·0001)	–0·08 (–0·09 to –0·07); p<0·0001
SII*	–0·71 (–0·77 to –0·65; p<0·0001)	0·06 (0·03–0·10; p=0·0003)	0·53 (0·43–0·64; p<0·0001)	0·09 (0·00–0·18; p=0·0583)	–1·03 (–1·08 to –0·98; p<0·0001)
Survey cycle†	0·11 (0·09 to –0·13; p<0·0001)	0·03 (0·02–0·04; p<0·0001)	–0·04 (–0·07 to –0·01; p=0·0041)	0·04 (0·01–0·06; p=0·0024)	0·00 (–0·01 to 0·02); p=0·7232
SII × cycle	–0·04 (–0·07 to –0·04; p=0·0008)	0·05 (0·03–0·06; p<0·0001)	0·05 (0·00–0·10; p=0·0360)	0·06 (0·02–0·11; p=0·0018)	0·03 (0·00–0·05; p=0·0198)
Random components					
σ^2_{v0} (school)	0·20	0·04	0·29	0·03	0·09
σ^2_{v0} (country)	0·10	0·04	0·24	0·10	0·07
σ^2_{v0} (residual)	3·81	1·25	13·99	1·55	3·30
ICC (school)	0·07	0·06	0·04	0·08	0·05
ICC (country)	0·02	0·03	0·02	0·06	0·02
AIC‡	2 015 103	1 272 122	2 643 273	1 606 686	1 911 237
BIC‡	2 015 181	1 272 198	2 643 351	1 606 763	1 911 314

Data are regression slope coefficient (95% CI; p value). SII=slope index of inequality. ICC=Intraclass correlation. AIC=Akaike's information criterion. BIC=Bayesian information criterion. *Socioeconomic status ranged from 0 (most affluent) to 1 (least affluent), and thus represents the SII. †Coded 1 (2002), 2 (2006), or 3 (2010). ‡Goodness-of-fit index.

Table 3: **Absolute health inequalities in 492 788 adolescents, 2002–10**

Role of the funding source

The funders had no role in the study design, data collection, data analysis, data interpretation, writing of the report, or the decision to submit the paper for publication. The corresponding author had full access to all the data from the study and had final responsibility for the decision to submit to publication.

Results

Survey data were available for a pooled sample of 492 788 adolescents. School response rates varied by country (47–90%, but more than 70% for 21 of 34 countries). Student participant response rates varied by country, but were higher than 70% for almost all national surveys. In our sample, per person income ranged from US$730 (Ukraine, 2002) to $37 530 (Norway, 2010), and rose from an average of $17 165 in 2002 to $32 593 in 2010 (table 1). Income inequality ranged from 0·225 (Denmark, 2002) to 0·436 (Russia, 2010), but did not change significantly in our sample from 2002 to 2010. Sample characteristics and descriptive statistics on the variables that we used in this study are summarised in table 1.

We noted small but statistically significant trends in average health (figure, table 2). From 2002 to 2010, we noted small increases in average physical activity (3·90 to 4·08 days per week of physical activity; p<0·0001), body mass (zBMI –0·08 to 0·03; p<0·0001), physical symptoms (3·06 to –3·20; p<0·0001), and life satisfaction (7·58 to 7·61; p=0·0034; table 2). These trends were significant after we accounted for differences in sample composition (age, gender, and SES) and the multilevel structure of the data. Age and sex interacted in their associations with all health variables (table 3). We did separate analyses (not shown) that showed that age related more strongly to each health variable in female participants than in male participants. Throughout these analyses, we attributed 3–8% of the variation in health to school-level differences and 2–6% to cross-national differences (tables 3 and 4).

As shown in the figure, we noted the largest health inequalities between socioeconomic groups in life satisfaction and the smallest inequalities in physical symptoms. Table 3 shows significant trends in absolute inequalities in health (SII×cycle) in all domains. Table 4 shows a similar pattern of results with respect to RIIs. We then estimated SIIs and RIIs for each survey cycle to establish the direction of these trends.

As shown in table 2 and summarised in the figure, socioeconomic differences increased in four of the five health variables. In 2002, the most and least affluent groups differed by –0·79 days of physical activity per week; by 2010, this difference had increased to –0·83 days (p=0·0008). SIIs also increased in zBMI (0·15 to 0·18; p<0·0001), psychological symptoms (0·58 to 0·67; p=0·0360), and physical symptoms (0·21 to 0·26; p=0·0018). Only in life satisfaction did absolute inequality fall, from a difference of –0·98 in 2002 to –0·95 in 2010 (p=0·0198). Trends in RIIs showed the same pattern. Differences in health between the highest and lowest SES groups, as a percentage of population health, increased in physical activity (–7·76% to –7·90%; p=0·0067), zBMI (2·67% to 3·08%; p<0·0001), psychological symptoms (3·02% to 3·45%; p=0·0346), and physical symptoms (1·29% to 1·60%; p=0·0021). We noted a small but significant downward trend in RIIs in life satisfaction (–10·32% to –9·97%; p=0·0132).

Next, we tested the unique contributions of per person income and income inequality to explain cross-national differences in average health and absolute and relative health inequalities using a series of pooled time-series analyses. The unit of analysis in these ecological analyses was country/year groups (n=102). When we held other differences between countries and over time constant, each SD increase in per person income corresponded to a significant

	Physical activity	Body-mass index	Psychological symptoms	Physical symptoms	Life satisfaction
Fixed components					
Constant	100·35 (98·31–101·40)	99·25 (98·09–100·40)	99·64 (98·66–100·63)	99·44 (98·54–100·34)	99·90 (98·96–100·84)
Age	–1·36 (–1·40 to –1·32); p<0·0001)	–0·17 (–0·21 to –0·12; p<0·0001)	0·87 (0·83–0·91; p<0·0001)	0·64 (0·60–0·67; p<0·0001)	–1·91 (–1·95 to –1·87; p<0·0001)
Sex (female)	–5·81 (–5·92 to –5·70; p<0·0001)	–5·24 (–5·35 to –5·12; p<0·0001)	4·32 (4·20–4·43; p<0·0001)	3·92 (3·81–4·03; p<0·0001)	–1·65 (–1·76 to –1·54; p<0·0001)
Age × sex	–0·72 (–0·79 to –0·66; p<0·0001)	0·20 (0·12–0·27; p<0·0001)	1·25 (1·18–1·32; p<0·0001)	1·02 (0·95–1·09; p<0·0001)	–0·85 (–0·92 to –0·78; p<0·0001)
RII*	–7·01 (–7·56 to –6·46; p<0·0001)	1·11 (0·53–1·70; p=0·0002)	2·77 (2·22–3·31; p<0·0001)	0·54 (–0·01–1·09; p=0·0523)	–10·83 (–11·38 to –10·27; p<0·0001)
Survey cycle†	0·00 (–0·16 to 0·16; p=0·9939)	–0·76 (–0·93 to –0·59; p<0·0001)	–0·16 (–0·31 to –0·01; p=0·0330)	–0·17 (–0·32 to –0·02; p=0·0312)	–0·15 (–0·31 to 0·01; p=0·0578)
RII × cycle	–0·34 (–0·59 to –0·09; p=0·0067)	0·81 (0·54–1·08; p<0·0001)	0·27 (0·02–0·51; p=0·0346)	0·39 (0·14–0·64; p=0·0021)	0·31 (0·07–0·56; p=0·0132)
Random components					
σ^2_{v0} (school)	17·97	10·66	6·47	7·15	10·27
σ^2_{v0} (country)	9·05	11·44	7·88	6·58	7·15
σ^2_{v0} (residual)	353·22	370·69	376·14	380·19	362·84
ICC school	0·07	0·06	0·04	0·03	0·05
ICC country	0·02	0·03	0·03	0·02	0·02
AIC‡	4 184 585	3 618 746	4 228 247	4 246 376	4 127 993
BIC‡	4 184 662	3 618 823	4 228 324	4 246 454	4 128 070

Data are regression slope coefficient (95% CI; p value). RII=relative index of inequality. ICC=Intraclass correlation. AIC=Akaike's information criterion. BIC=Bayesian information criterion. *The percentage of population health that differs between the most and least affluent groups. †Coded 1 (2002), 2 (2006), or 3 (2010). ‡Goodness-of-fit index.

Table 4: **Relative health inequalities in 492 788 adolescents, 2002–2010**

increase in physical activity (0·06 days; p<0·0001) and life satisfaction (0·08; p<0·0001), and a decrease in psychological symptoms (–0·09; p<0·0001; table 5). Per person income also related to international differences in health inequalities in physical activity (0·07; p<0·0001), zBMI (0·12; p<0·0001), and life satisfaction (0·18; p<0·0001). However, with these analyses, we also noted that each standard deviation increase in income inequality uniquely related to less physical activity (–0·05 days; p=0·0295), higher zBMI (0·06; p<0·0001), more psychological (0·18; p<0·0001) and physical (0·16; p<0·0001) symptoms, and larger absolute and relative health inequalities in psychological (0·13; p=0·0080) and physical (0·07; p=0·0022) symptoms and life satisfaction (–0·10; p=0·0092).

	Physical activity	Body-mass index	Psychological symptoms	Physical symptoms	Life satisfaction
Average health					
Constant	3·99 (4·91–5·06)	–0·03 (–0·08 to 0·02)	4·67 (4·64–4·70)	3·14 (3·08–3·20)	7·58 (8·56–8·61)
Income per person*	0·06 (0·04–0·08; p<0·0001)	0·04 (–0·02 to 0·09; p=0·1783)	–0·09 (–0·11 to –0·07; p<0·0001)	0·04 (0·00–0·08; p=0·0717)	0·08 (0·05–0·11; p<0·0001)
Income inequality*	–0·05 (–0·09 to 0·00; p=0·0295)	0·06 (0·03–0·08; p<0·0001)	0·18 (0·15–0·21; p<0·0001)	0·16 (0·13–0·18; p<0·0001)	–0·01 (–0·06 to 0·04; p=0·6197)
R^2	0·06	0·06	0·14	0·10	0·09
Slope index of inequality					
Constant	–0·84 (–0·85 to –0·83)	0·13 (0·11–0·15)	0·73 (0·69–0·77)	0·33 (0·31–0·35)	–0·94 (–0·99 to –0·89)
Income per person*	0·07 (0·05–0·09; p<0·0001)	0·12 (0·10–0·13; p<0·0001)	–0·09 (–0·19 to –0·02; p=0·0967)	0·01 (–0·05–0·09; p=0·7186)	0·18 (0·16–0·21; p<0·0001)
Income inequality*	0·00 (–0·01 to 0·01; p=0·8216)	0·00 (–0·02 to 0·03; p=0·7316)	0·13 (0·03–0·22; p=0·0080)	0·07 (0·02–0·11; p=0·0022)	–0·10 (–0·18 to –0·02; p=0·0092)
R^2	0·13	0·37	0·17	0·05	0·43
Relative index of inequality					
Constant	–8·13 (–8·17 to –8·09)	2·29 (1·92–2·65)	3·75 (3·55–3·95)	1·97 (1·84–2·10)	–9·90 (–10·43 to –9·36)
Income per person*	0·70 (0·55–0·85; p<0·0001)	1·98 (1·68–2·28; p<0·0001)	–0·43 (–0·96 to –0·10; p=0·1088)	0·08 (–0·37–0·52; p=0·7389)	2·04 (1·70–2·37; p<0·0001)
Income inequality*	–0·06 (–0·19 to 0·06; p=0·3259)	0·01 (–0·40–0·42; p=0·9601)	0·61 (0·15–1·06; p=0·0090)	0·38 (0·13–0·63; p=0·0030)	–1·04 (–1·88 to –0·20; p=0·0150)
R^2	0·11	0·38	0·17	0·05	0·43

Data are regression slope coefficient (95% CI; p value). *Standardised in SD units (*Z* scores), as shown in table 1.

Table 5: **Pooled time-series analysis of health and health inequality in 102 countries and cycles**

Discussion

From 2002 to 2010, average body-mass indices and physical symptoms slightly increased and became more unequal between socioeconomic groups. We also noted progressively larger SES differences over successive surveys of physical activity and psychological symptoms. These trends run in parallel to those previously reported in health inequalities in adult and child mortality,[14,29–31] and this study extends this evidence base to many health domains in an international sample of adolescents (panel 2).

With respect to the structural determinants of these trends, national income inequality was negatively related to health overall and positively related to health inequalities. Higher national income inequality related to less physical activity, larger body-mass indices, and more psychological and physical symptoms. Higher national income inequality also related to larger SES differences in psychological and physical symptoms, and life satisfaction.

Some limitations of this study should be noted. First, the SES measure in the HBSC study contained an item (computer ownership) that might have lost sensitivity to SES during the course of this study. Although this loss of sensitivity affects the comparability of raw affluence scores between countries or survey cycles, it is unlikely to have affected SII and RII estimates, which represent the distribution of health across the full distribution of SES in the population.[26,27] Second, estimates of zBMI were based on self-reported height and weight, and investigators of previous HBSC research have noted such BMI estimates to be progressively less accurate and more negatively biased as body mass increases.[32] Third, comparable data for SES and health were available from only three survey cycles. To continue monitoring of these trends with other SES indicators and anthropometric measures of height and weight would be useful. Furthermore, although exact response rates could not be established, fieldworker reports from several countries showed that 5–10% of pupils were absent from the surveys, which inevitably poses the possibility of non-response bias due to illness and truancy.

Despite these caveats, these results still have implications for the social and economic development of nations. Health inequalities in youths shape future inequities in educational attainment, employment, adult health, and life expectancy, and therefore should be made a focus of health policy and surveillance efforts.[1] Further study on and discussion about the distribution of health across developmental stages of the life course are needed. We suggest that monitoring of health inequality trends is importantly different to that of shifts in average health or the prevalence of health problems. Just as economic policy looks beyond general economic growth to tackle the more insidious issue of income inequality,[33] we propose that health policy needs to look beyond average levels of population health and disease prevalence to tackle unjust inequities in health across increasingly disparate socioeconomic conditions. For example, a focus on increased physical activity in adolescents could obscure the need to tackle inequality in physical activity, which has also increased.

Panel 2: Research in context

Systematic review

Adolescent health is shaped and constrained by socioeconomic contexts, but little information exists on trends in adolescent health inequalities, particularly at an international level.[1] We searched PubMed for articles published between Jan 1, 1990, and Jan 13, 2015 (without any language restrictions) and found no similar analysis of trends in both average health and socioeconomic differences in health in an international sample of adolescents.

Interpretation

We noted that health inequalities increased during 2002–10 in mental and physical health, and that national income inequality predicts both poor health in general and the magnitude of SES differences in some health domains. These results are especially disconcerting when we consider their origin—the so-called healthy years of adolescence in a group of rich countries. In light of the accumulation of evidence about the durability of SES differences in health through the life course, the many health and social issues that relate to income inequality, and worldwide trends in rising income inequality, a grim prediction can be made about future population health and social development.[12,16] However, these results also point to international and national policy options that could help improve adolescent health through an addressing of its structural determinants.

In conclusion, we have shown that socioeconomic differences in adolescents' mental and physical health increased from 2002 to 2010 in a large sample of high-income countries. Widening socioeconomic inequalities in adolescent health contrast with improvements seen for children in the early years, with reductions in child poverty and inequalities in child health.[1] Research and policy attention is needed to continue monitoring of these trends and to develop and assess policy approaches to promotion of health and health equity in adolescents.[2]

Contributors

FJE designed the study and had primary responsibility for the analysis, and writing and editing of the manuscript. T-KP, BDC, and IM assisted with the analysis, interpretation of results, and editing of the manuscript. GWJMS assisted with the literature review and editing of the manuscript. CC assisted with interpretation of the results and editing of the manuscript.

Declaration of interests

We declare no competing interests.

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