Socioeconomic inequalities in adolescent health: a time-series analysis of 34 countries participating in the HBSC study, 2002 to 2010

Published online February 4, 2015.
http://dx.doi.org/10.1016/S0140-6736(14)61460-4

Frank J. Elgar,[1] Timo-Kolja Pförtner[2] Irene Moor,[2]
Bart De Clercq,[3] Gonneke W. J. M. Stevens,[4] & Candace Currie[5]

[1] Institute for Health and Social Policy and Douglas Mental Health University Institute, McGill University, Montreal, Quebec, Canada
[2] Institute of Medical Sociology, Martin Luther University Halle-Wittenberg, Halle (Saale), Germany
[3] Department of Public Health, Ghent University, Ghent, Belgium
[4] Utrecht Centre of Child and Adolescent Studies, Utrecht University, Utrecht, The Netherlands
[5] Child and Adolescent Health Research Unit, School of Medicine, University of St. Andrews, St. Andrews, United Kingdom

Correspondence

Frank J. Elgar, Institute for Health and Social Policy, McGill University, 1130 Pine Avenue, Montreal, Quebec, Canada H3A 1A3; tel: +1 514 398 1739;

Suggested citation:

Elgar FJ, Pförtner TK, Moor I, De Clercq B, Stevens GW, Currie C. Socioeconomic inequalities in adolescent health 2002-2010: a time-series analysis of 34 countries participating in the Health Behaviour in School-aged Children study. Lancet. 2015 Feb 3. pii: S0140-6736(14)61460-4. doi: 10.1016/S0140-6736(14)61460-4. [Epub ahead of print]

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 = 492788). 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.

Funding

Canadian Institutes of Health Research.

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]

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 in adults,[14,15] 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

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 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.

{For more on the HBSC study, http://www.hbsc.org}

Measures

We measured SES using the HBSC Family Affluence Scale, a four-item index of material assets or common indicators of wealth.[17 and 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 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/m^2), 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 (http://bank.stat.gl/).

***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.[23,25]

Data 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 down-weighting 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 (e.g., $SII_{it} = \alpha + \beta_1 Income_{it} + \beta_2 Gini_{it} + i_{it} + i_{it}$, where observations varied across country i and time t, α was the slope intercept, μ_{it} was the between-country/year error, and ε_{it} was within-country/year error).

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 to 8% of the variation in health to school-level differences and 2 to 6% to cross-national differences (Table 3 and Table 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 X 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 −-·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 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).

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,[14,29,30,31] 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.

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.

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.

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.

Acknowledgments

The study was supported by research grants from the Canadian Institutes for Health Research, the Social Sciences and Humanities Research Council of Canada, and the Canada Research Chairs programme awarded to FJE. The Health Behaviour in School-aged Children study is a WHO collaborative study and funded by public sources in each member country. The Health Behaviour in School-aged Children International Coordinating Centre is located at St Andrew's University, and the databank is managed at the University of Bergen.

TABLE 1

Sample characteristics by survey cycle.

	2002	2006	2010
Individual characteristics:			
Gender (n)			
Female (%)	80 745 (51·5)	85 003 (51·4)	87 497 (51·3)
Males (%)	75 951 (48·5)	80 511 (48·6)	83 081 (48·7)
Age group (n)			
11 years (%)	52 604 (33·6)	52 222 (31·6)	54 414 (31·9)
13 years (%)	54 921 (35·1)	56 813 (34·3)	58 526 (34·3)
15 years (%)	49 171 (31·4)	56 479 (34·1)	57 638 (33·8)
Mean age, in years (SD)	13.55 (1·66)	13·63 (1·65)	13·57 (1·63)
Mean affluence (SD)	4.85 (1·98)	5·25 (1·98)	5·84 (1·92)

Mean physical activity (SD)	3.84 (2·09)	4·05 (2·09)	4·06 (2·05)
Mean body mass index (SD)	-0.11 (1·16)	-0·02 (1·15)	0·04 (1·17)
Mean psychological symptoms (SD)	4.74 (3·82)	4·67 (3·87)	4·63 (3·87)
Mean physical symptoms (SD)	3.12 (3·22)	3·12 (3·28)	3·24 (3·34)
Mean life satisfaction (SD)	7.55 (1·92)	7·58 (1·91)	7·58 (1·89)
Country characteristics			
Mean income per capita, USD (SD)	17 165 (11 432)	29 010 (17 729)	32 593 (19 613)
Mean income inequality (SD)	0.30 (0.05)	0.30 (0.05)	0.31 (0.05)
n (countries)	34	34	34
n (schools)	5 930	6 659	7 339
n (individuals)	156 696	165 514	170 578

Note: SD = Standard deviation. Body mass index is deviation (in SD units) from World Health Organisation international age- and gender-adjusted norms.[18]

TABLE 2

Absolute health inequalities in 492,788 adolescents, 2002 to 2010.

	Physical activity	Body mass index	Psychological symptoms	Physical symptoms	Life satisfaction
Fixed components:					
Constant	3·98 (4·88 – 5·09)	-0·03 (-0·09 – 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 - -0·14) p<0·001	-0·01 (-0·01 – -0·01) p<0·001	0·17 (0·16 – 0·17) p<0·001	0·10 (0·10 – 0·11) p<0·001	-0·18 (-0·19 – -0·18) p<0·001
Gender (female)	-0·60 (-0·61 – -0·59) p<0·001	-0·30 (-0·31 – -0·30) p<0·001	0·83 (0·81 – 0·85) p<0·001	0·64 (0·62 – 0·66) p<0·001	-0·16 (-0·17 – -0·15) p<0·001
Age X gender	-0·08 (-0·08 – -0·07) p<0·001	0.01 (0·01 – 0·02) p<0·001	0·24 (0·23 – 0·25) p<0·001	0·17 (0·16 – 0·18) p<0·001	-0·08 (-0·09 – -0·07) p<0·001
Slope index of inequality (SII)	-0·71 (-0·77 – -0·65) p<0·001	0·06 (0·03 – 0·10) p<0·001	0·53 (0·43 – 0·64) p<0·001	0·09 (0·00 – 0·18) p=0·058	-1·03 (-1·08 – -0·98) p<0·001
Survey cycle	0·11 (0·09 – 0·13) p<0·001	0.03 (0.02 – 0.04) p<0·001	-0.04 (-0.07 – -0.01) p=0·004	0·04 (0·01 – 0·06) p=0·002	0·00 (-0·01 – 0·02) p=0·723
SII X Cycle	-0·04 (-0·07 - -0·04) p=0·001	0·05 (0·03 – 0·06) p<0·001	0.05 (0.00 – 0.10) p=0·036	0.06 (0.02 – 0.11) p=0·002	0·03 (0·00 – 0·05) p=0·020
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

Note: Shown are slope coefficients, 95% confidence interval (in parentheses) and P-values. Affluence ranges from 0 (most affluent) to 1 (least affluent), and thus represents the slope index of inequality (SII). Akaike's information criterion (AIC) and Bayesian information criterion (BIC) are goodness-of-fit indices. Survey cycle was coded 1 (2002), 2 (2006), or 3 (2010).

TABLE 3

Relative health inequalities in 492,788 adolescents, 2002 to 2010.

	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 - -1·32) p<0·001	-0·17 (-0·21 - -0·12) p<0·001	0·87 (0·83 – 0·91) p<0·001	0·64 (0·60 – 0·67) p<0·001	-1·91 (-1·95 – -1·87) p<0·001
Gender (female)	-5·81 (-5·92 - -5·70) p<0·001	-5·24 (-5·35 - -5·12) p<0·001	4·32 (4·20 – 4·43) p<0·001	3·92 (3·81 – 4·03) p<0·001	-1·65 (-1·76 – -1·54) p<0·001
Age X gender	-0·72 (-0·79 - -0·66) p<0·001	0·20 (0·12 – 0·27) p=0·001	1·25 (1·18 – 1·32) p<0·001	1·02 (0·95 – 1·09) p<0·001	-0·85 (-0·92 – -0·78) p<0·001
Relative index of inequality (RII)	-7·01 (-7·56 - -6·46) p<0·001	1·11 (0·53 – 1·70) p<0·001	2·77 (2·22 – 3·31) p<0·001	0·54 (-0·01 – 1·09) p=0·052	-10·83 (-11·38 - -10·27) p<0·001
Survey cycle	0·00 (-0·16 – 0·16) p=0·994	-0·76 (-0·93 - -0·59) p<0·001	-0·16 (-0·31 - -0·01) p=0·033	-0·17 (-0·32 - -0·02) p=0·031	-0·15 (-0·31 – 0·01) p=0.058
RII X cycle	-0·34 (-0·59 - -0·09) p=0·007	0·81 (0·54 – 1·08) p<0·001	0·27 (0·02 – 0·51) p=0·035	0·39 (0·14 – 0·64) p=0·002	0·31 (0·07 – 0·56) p=0.013
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

Note: Shown are slope coefficients, 95% confidence interval in parentheses, and p-values. The relative index of inequality (RII) is the percentage of population health that differs between the most and least affluent groups. Akaike's information criterion (AIC) and Bayesian information criterion (BIC) are goodness-of-fit indices. Survey cycle was coded 1 (2002), 2 (2006), or 3 (2010).

TABLE 4

Absolute and relative health inequalities over three survey cycles of the HBSC study.

Survey Year	Physical activity	Body mass index	Psychological symptoms	Physical symptoms	Life satisfaction
			1. Average health		
2002	4·10 (4·08 – 4·12)	-0·08 (-0·08 - -0·08)	4.67 (4·65 – 4·70)	3·06 (3·04 – 3·07)	3·42 (3·40 – 3·44)
2006	4·02 (4·00 – 4·04)	-0·03 (-0·03 - -0·02)	4.66 (4·65 – 4·69)	3·13 (3·12 – 3·15)	3.42 (3·40 – 3·44)
2010	3·92 (3·91 – 3·93)	0·03 (0·03 – 0·03)	4.63 (4·62 – 4·65)	3·20 (3·19 – 3·20)	3.39 (3·37 – 3·40)
P and direction for trend	<0·001 ↓	<0·001 ↑	0·077	<0·001 ↑	0.003 ↓
			2. Slope index of inequality		
2002	-0·79 (-0·83 - -0·75)	0·15 (0·13 – 0·18)	0·58 (0·51 - 0·65)	0·21 (0·15 - 0·27)	-0·98 (-1·02 - -0·94)
2006	-0·79 (-0·83 - -0·75)	0·16 (0·13 – 0·18	0·68 (0·62 - 0·76)	0·20 (0·14 - 0·26)	-0·97 (-1·01 - -0·94)
2010	-0.83 (-0·86 - -0·79)	0·18 (0·16 – 0·20)	0·67 (0·60 - 0·74)	0·26 (0·20 - 0·32)	-0·95 (0·99 - 0·92)
P and direction for trend	0.001 ↑	<0.001 ↑	0.036 ↑	0.002 ↑	0.020 ↓
			3. Relative index of inequality		
2002	-7·76 (-8·14 – -7·37)	2·67 (2·26 – 3·08)	3·02 (2·65 – 3·40)	1·29 (0·93 – 1·65)	-10·32 (-10·71 – -9·94)
2006	-7·56 (-7·92 – -7·21)	2·66 (2·27 – 3·05)	3·56 (3·20 - 3·93)	1·24 (0·89 – 1·61)	-10·19 (-10·56 – -9·83)
2010	-7·90 (-8·24 – -7·56)	3·08 (2·70 – 3·47)	3·45 (3·10 – 3·81)	1·60 (1·23 – 1·96)	-9·97 (-10·32 – -9·62)
P and direction for trend	0·007 ↑	<0·001 ↑	0·035 ↑	0·002 ↑	0·013 ↓

Note: Average health is a regression-based predicted mean and 95% confidence interval, adjusted for differences in age, gender, and age-by-gender interaction and school- and country-level clustering. The slope index of inequality represents the difference in health

between most and least affluent groups. The relative index of inequality is the percentage of population health that differs between the most and least affluent groups.

TABLE 5

Pooled time-series analysis of health and health inequality (n = 102).

	Physical activity	Body mass index	Psychological symptoms	Physical symptoms	Life satisfaction
			1. Average health		
Constant	3·99 (4.91 – 5.06)	-0·03 (-0·08 – 0·02)	4·67 (4·64 – 4·70)	3·14 (3·08 – 3·20)	7·58 (8·56 – 8·61)
Income per capita	0·06 (0·04 – 0·08) p<0·001	0·04 (-0·02 – 0·09) p=0·178	-0·09 (-0·11 – -0·07) p<0·001	0·04 (0·00 – 0·08) p=0·072	0·08 (0·05 – 0·11) p<0·001
Income inequality	-0·05 (-0·09 – 0·00) p=0·030	0·06 (0·03 – 0·08) p<0·001	0·18 (0·15 – 0·21) p<0·001	0·16 (0·13 – 0·18) p<0·001	-0·01 (-0·06 – 0·04) p=0·620
R^2	0·06	0·06	0·14	0·10	0·09
			2. Slope index of inequality		
Constant	-0·84 (-0.85 – -0.83)	0·13 (0·11 – 0·15)	0·73 (0·69 – 0·77)	0·33 (0·31 – 0·35)	-0·94 (-0·99 – -0·89)
Income per capita	0·07 (0.05 – 0.09) p<0·001	0·12 (0·10 – 0·13) p<0·001	-0·09 (-0·19 – 0·02) p=0·097	0·01 (-0·05 – 0·09) p=0·719	0·18 (0·16 – 0·21) p<0·001
Income inequality	0·00 (-0·01 – 0·01) p=0·822	0·00 (-0·02 – 0·03) p=0·732	0·13 (0·03 – 0·22) p=0·008	0·07 (0·02 – 0·11) p=0·002	-0·10 (-0·18 – -0·02) p=0·009
R^2	0·13	0·37	0·17	0·05	0·43
			3. Relative index of inequality		
Constant	-8·13 (-8·17 – -8·09)	2·29 (1·92 – 2·65)	3·75 (3·55 – 3·95)	1·97 (1·84 – 2·10)	-9·90 (-10·43 – -9·36)
Income per capita	0·70 (0·55 – 0·85) p<0·001	1·98 (1·68 – 2·28) p<0·001	-0·43 (-0·96 – 0·10) p=0·109	0·08 (-0·37 – 0·52) p=0·739	2·04 (1·70 – 2·37) p<0·001

Income inequality	-0·06 (-0·19 – 0·06) p=0·326	0·01 (-0·40 – 0·42) p=0·960	0·61 (0·15 – 1·06) p=0·009	0·38 (0·13 – 0·63) p=0·003	-1·04 (-1·88 – -0·20) p=0·015
R^2	0·11	0·38	0·17	0·05	0·43

Note: Shown are slope coefficients, 95% confidence interval (in parentheses), and P-values. Per capita income and income inequality were standardised in standard deviation units (*z*-scores), as shown in Table 1.

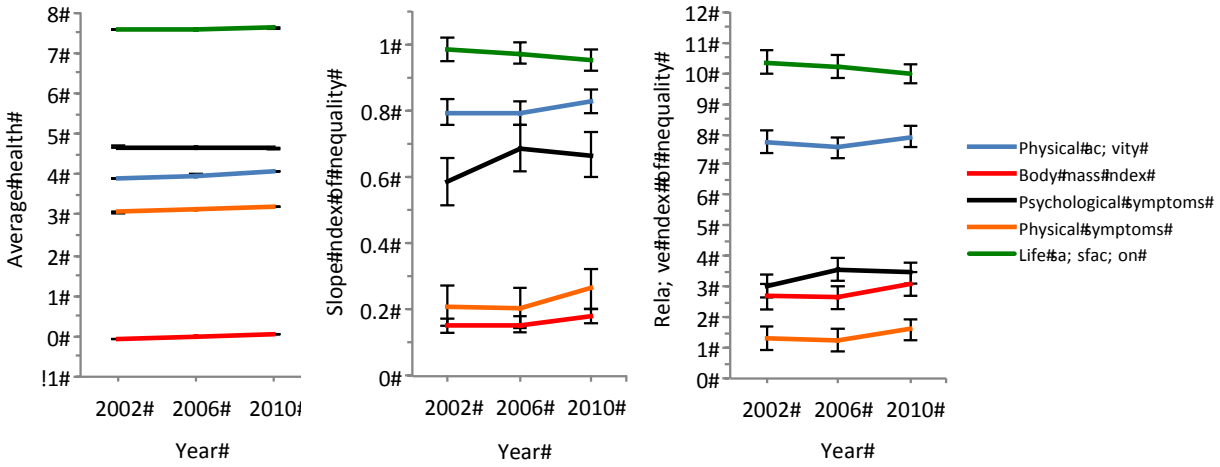

FIGURE. Age- and gender-adjusted trends in average health (left), absolute inequalities in health (centre), and relative inequalities in health (right) in three cross-sectional surveys of adolescents in 34 countries (pooled n = 492,788). Health inequalities in physical activity and life satisfaction were negative values but are displayed here in absolute values with 0 representing perfect health equality between socioeconomic groups. All health inequalities in health trended upward except life dissatisfaction, which trended down ($p<0{\cdot}001$).

References

1 Viner RM, Ozer EM, Denny S, et al. Adolescence and the social determinants of health. Lancet 2012; 379: 1641–52.
2 Commission on Social Determinants of Health. Closing the gap in a generation: health equity through action on the social determinants of health. Final report of the Commission on Social Determinants of Health. Geneva: World Health Organization, 2008.
3 Houweling T, Kunst AE, Looman C, Mackenbach JP. Determinants of under-5 mortality among the poor and the rich: a cross-national analysis of 43 developing countries. Int J Epidemiol 2005; 34: 1257–65.
4 Currie C, Zanotti C, Morgan A, et al. Social determinants of health and well-being among young people. Health Behaviour in School-aged Children (HBSC) study: international report from the 2009/10 survey. Copenhagen: World Health Organization Regional Office for Europe, 2012.
5 West P. Inequalities in health in the early years: is there equalisation in youths? Soc Sci Med 1997; 40: 1283–302.
6 Starfield B, Riley AW, Witt WP, Robertson J. Social class gradients in health during adolescence. J Epidemiol Community Health 2002; 56: 354–61.
7 Moor I, Pförtner TK, Lampert T, Ravens-Sieberer U, Richter M, for the HBSC-Team Deutschland. Socioeconomic inequalities in subjective health among 11- to 15-year-olds in Germany: a trend analysis from 2002–2010. Gesundheitswesen 2012; 74 (suppl): S49–55 (in German).
8 Rajmil L, Herdman M, Ravens-Sieberer U, Erhart M, Alonso J, for the European KIDSCREEN group. Socioeconomic inequalities in mental health and health-related quality of life (HRQOL) in children and adolescents from 11 European countries. Int J Public Health 2014; 59: 95–105.
9 Collishaw S, Maughan B, Natarajan L, Pickles A. Trends in adolescent emotional problems in England: a comparison of two national cohorts twenty years apart. J Child Psychol Psychiatry 2010; 51: 885–94.
10 Elgar FJ, De Clercq B, Schnohr CW, et al. Absolute and relative family affluence and psychosomatic symptoms in adolescents. Soc Sci Med 2013; 91: 25–31.
11 Spencer N. The effect of income inequality and macro-level social policy on infant mortality and low birthweight in developed countries—a preliminary systematic review. Child Care Health Dev 2004; 30: 699–709.
12 Dorling D, Mitchell R, Pearce J. The global impact of income inequality on health by age: an observational study. BMJ 2007; 335: 873.
13 Organisation for Economic Co-operation and Development. Divided we stand: why inequality keeps rising. Paris: Organisation for Economic Co-operation and Development Publishing, 2001.
14 Goesling B, Firebaugh G. The trend in international health inequality. Popul Dev Rev 2004; 30: 131–46.
15 Singh GK, Siahpush M. Widening socioeconomic inequalities in US life expectancy, 1980–2000. Int J Epidemiol 2006; 35: 969–79.
16 Wilkinson R, Pickett K. The spirit level: why more equal societies almost always do better. London: Allen Lane, 2009.

17 Torsheim T, Currie C, Boyce W, Kalnins I, Overpeck M, Haugland S. Material deprivation and self-rated health: a multilevel study of adolescents from 22 European and North American countries. Soc Sci Med 2004; 59: 1–12.
18 Currie C, Molcho M, Boyce W, Holstein B, Torsheim T, Richter M. Researching health inequalities in adolescents: the development of the HBSC Family Affluence Scale. Soc Sci Med; 66: 1429–36.
19 WHO. WHO child growth standards. Head circumference-for-age, arm circumference-for-age, triceps skinfold-for-age and subscapular skinfold-for-age. Methods and development. Geneva: World Health Organization, 2007.
20 Haugland P, Wold B. Subjective health complaints in adolescence. Reliability and validity of survey methods. J Adolesc 2001; 24: 611–24.
21 Cantril H. The pattern of human concern. New Brunswick: Rutgers University Press, 1965.
22 The World Bank. GNI per capita, Atlas method (current US$). http://data.worldbank.org/indicator/NY.GNP.PCAP.CD (accessed March 6, 2014).
23 Solt F. Standardizing the world income inequality database. Soc Sci Q 2009; 90: 231–42.
24 Regidor E. Measures of health inequalities: part 2. J Epidemiol Community Health 2004; 58: 900–03.
25 King NB, Kaufman JS, Harper S. Relative measures alone tell only part of the story. Am J Public Health 2010; 100: 2014–15.
26 Roberts C, Freeman J, Samdal O, et al, for the International HBSC Study Group. The Health Behaviour in School-aged Children (HBSC) study: methodological developments and current tensions. Int J Public Health 2009; 54 (suppl 2): 140–50.
27 Pickett W, Molcho M, Elgar FJ, et al. Trends and socioeconomic correlates of adolescent physical fighting in 30 countries. Pediatrics 2013; 131: e18–26.
28 Beck N, Katz JN. What to do (and not to do) with time-series cross-section data. Am Polit Sci Rev 1995; 89: 634–47.
29 Shaw M, Orford S, Brimblecombe N, Dorling D. Widening inequality in mortality between 160 regions of 15 countries of the European Union. Soc Sci Med 2000; 30: 1047–58.
30 Hargreaves DS, Djafari Marbini A, Viner RM. Inequality trends in health and future health risk among English children and young people, 1999–2009. Arch Dis Child 2013; 98: 850–55.
31 Shaw M, Dorling D, Gordon D, Davey Smith G. The widening gap: health inequalities and policy in Britain. Bristol: Policy Press, 1999.
32 Elgar FJ, Roberts C, Tudor-Smith C, Moore L. Validity of self-reported height and weight and predictors of bias in adolescents. J Adolesc Health 2005; 37: 371–75.
33 Costanza R, Kubiszewski I, Giovannini E, et al. Time to leave GDP behind. Nature 2014; 505: 283–85.