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Early-life income inequality and adolescent health and well-being

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Keywords: Income inequality; adolescents; children; health; well-being; causal inference; Health Behaviour in School-aged Children.

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Abstract

A prevailing hypothesis about the association between income inequality and poor health is that inequality intensifies social hierarchies, increases stress, erodes social and material resources that support health, and subsequently harms health. However, the evidence in support of this hypothesis is limited by cross-sectional, ecological studies and a scarcity of developmental studies. To address this limitation, we used pooled, multilevel data from the Health Behaviour in School-aged Children study to examine lagged, cumulative, and trajectory associations between early-life income inequality and adolescent health and well-being. Psychosomatic symptoms and life satisfaction were assessed in surveys of 11- to 15-year-olds in 40 countries between 1994 and 2014. We linked these data to national Gini indices of income inequality for every life year from 1979 to 2014. The results showed that exposure to income inequality from 0 to 4 years uniquely predicted psychosomatic symptoms and lower life satisfaction after controlling lifetime mean income inequality, national per capita income, family affluence, age, and cohort and period effects. Income inequality from 5 to 9 years also related to symptoms and low life satisfaction in females. The cumulative income inequality exposure in infancy and childhood (i.e., average Gini index from birth to age 10) related to more symptoms and lower life satisfaction in adolescence. Finally, individual trajectories in early-life inequality (i.e., linear slopes in Gini indices from birth to 10 years) related to fewer symptoms and higher life satisfaction, indicating that earlier exposures mattered more to predicting adolescent health and wellbeing. These results help to establish the antecedent-consequence conditions in the association between income inequality and health and suggest that both the magnitude and timing of income inequality in early life have developmental consequences that manifest in reduced health and well-being in adolescence.

Keywords: Income inequality; adolescents; children; health; well-being; Health Behaviour in School-aged Children.

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Socioeconomic contexts shape and constrain adolescent health and well-being (Chen & Paterson, 2006). Recent evidence suggests that socioeconomic differences in adolescent health have widened due to rising income inequality (Elgar et al., 2015; Viner et al., 2012). Income inequality also correlates with poor health and social outcomes (Kondo et al., 2009; Wilkinson & Pickett, 2010). An analysis of adolescent health in 34 mostly high-income countries found that national income inequality related to higher body mass indices, less physical activity, and more self-rated mental and physical health symptoms (Elgar et al., 2015). Other research on children and youth found that national or regional income inequality relates to poor self-rated health (Rözer & Volker, 2016), alcohol misuse (Elgar Roberts, Parry-Langdon, & Boyce, 2005), school bullying (Elgar, Craig, Boyce, Morgan, & Vella-Zarb, 2009), physical assaults (Pabayo, Molnar, & Kawachi, 2014), teenage pregnancy (Pickett, Mookherjee, & Wilkinson, 2005), and child maltreatment (Eckenrode, Smith, McCarthy, & Dineen, 2014). Pickett and Wilkinson (2007; 2015) reported that international differences in UNICEF indices of child well-being relate more closely to national income inequality than to country wealth. Based on these and similar data on income inequality, the authors suggested that future improvements in child well-being in rich countries may depend more on reductions in income inequality than on further economic growth (Pickett & Wilkinson, 2015a).

An association between income inequality and health has been found in numerous independent studies. One explanation for this link suggests that inequality affects the quality of public services and infrastructure that support health, including social benefits and cash transfers to low-income families (Evans, 2002; Lynch, Smith, Kaplan, & House, 2000). Another is that

inequality is socially corrosive in that it intensifies socioeconomic hierarchies, erodes social capital that supports health, and consequently contributes to stress-related health and social problems (Chiavegatto Filho, Kawachi, Wang, Viana, & Andrade, 2013; Pickett & Wilkinson, 2015b; Wilkinson & Pickett, 2010). Support for this pathway was recently reported by Rözer and Volker (2016). Using data collected in 30 countries, they found that social trust partially mediated a negative association between national income inequality and poor self-rated health in adolescents and young adults (16 to 25 years). A psychosocial explanation is consistent with developmental models of how early-life exposure to inequality shapes moral development. Arsenio and Gold (2006) theorised that children's exposure to unfairness biases social cognitive schemas such that instrumental goals become valued more than relational goals and that violence and intimidation are learned to be effective ways to succeed in an unjust world. This developmental perspective helps to explain an association between income inequality and school bullying (Elgar et al., 2009).

Each of these explanations implies a temporal precedence of income inequality to poor health. This temporality – a criterion of any causal inference (Gordis, 2013; Kraemer et al., 1997) – has not been firmly established as most analyses of income inequality are cross-sectional. Other limitations of previous studies are a reliance on aggregated health indicators (e.g., mortality, life expectancy) and limited number of country observations. Ecological studies of country differences often lack the statistical power needed to detect contextual effects on health with important statistical controls for country wealth, individual socioeconomic position (SEP), and other individual characteristics.

This study addressed this question of temporality by testing the hypothesis that income inequality in infancy and childhood predicts adolescent health and wellbeing. This hypothesis was based on prior research on the developmental consequences of early childhood stress.

Developmental and epigenetic studies have traced the origins of SEP differences in mental and physical health to early life experiences, specifically to neuroendocrine stress pathways (Gillman, 2005), neuroregulatory centres of the brain that govern attention, social interaction, and emotion (Kim et al., 2013), and cumulative impacts of psychological stress on health (Shonkoff, Boyce, & McEwen, 2009). Longitudinal studies by Evans and colleagues have found that low SEP at age 9 prospectively predicts physiological stress dysregulation, emotion dysregulation, and emotional and behavioural problems in adolescence (ages 13 and 17), after differences in concurrent SEP were controlled (Doan, Fuller-Rowell, & Evans, 2012; Evans & Kim, 2012). This biological embedding of childhood poverty and the durability of socioeconomic differences in health across the life course suggest that early life stressors – like income inequality – relate to health and well-being through similar stress pathways and sensitive periods of development (Bradley & Corwyn, 2002).

Further support for our hypothesis comes from studies of income inequality and adult health. Karlsson and colleagues studied national income inequality and adult health in 19 rich countries in 1990 and 2006 and found evidence of lagged, negative associations between income inequality and activities of daily living and life expectancy (Karlsson, Nilsson, Lyttkens, & Leeson, 2010). Another study of physical health in old age in 16 countries found a negative association between national income inequality (averaged over a 46-year period) and later health (De Vries, Blane, & Netuveli, 2004). Blakely and colleagues used US state-level data on income inequality and self-reported adult health and similarly found that in older adults (45+ years), income inequality experienced up to 15 years previously was more closely related to poor health than inequality measured contemporaneously (Blakey, Kennedy, Glass, & Kawachi, 2000). Lillard and colleagues reported small but statistically significant associations between early life (0 to 4

years) national income inequality in the US and health later in life (Lillard, Burkhauser, Hahn, & Wilkins, 2015). However, this study confounded cohort and period effects because it tracked a single cohort in one country, so income inequality varied synchronously with developmental stages and not between settings or individuals. Other studies have found no significant lagged associations between income inequality and later health. Leigh and Jencks (2007) examined life expectancy, infant mortality, homicide, and suicide in 12 countries and found no association (concurrently or with a 5-year lag) with national income inequality. Similarly, Mellor and Milyo (2003) found no significant lagged association between US state-level income inequality and adult self-rated health after controlling for state fixed-effects.

We are not aware of previous research on lagged associations between income inequality during infancy and childhood and health during adolescence. The few studies that have examined lagged associations with adult health involved different sample characteristics, analytic approaches, statistical controls, and measures of income inequality and health, which complicate efforts to synthesise the evidence. No study has yet used data that provided sufficient heterogeneity in income inequality between populations, time periods, and cohorts. We addressed this knowledge gap using data from a series of repeated, cross-national surveys of adolescent health in the World Health Organisation's Health Behaviour in School-aged Children (HBSC) study. Our approach involved linking individual records on health and well-being in 11, 13 and 15-year-olds to country-level data on income inequality for each survey year and for earlier developmental periods, from 0 to 4 years and from 5 to 9 years. These age groups were chosen to distinguish infancy and early childhood stages of development when social influences begin to extend from the family environment to school and community settings (Lillard et al., 2015).

Examining income inequality and health across age groups across historical time introduces

the well-known challenge of separating age, period and cohort effects and the need to control unmeasured third variables. One approach is fixed effects models (FE) which removes endogeneity in the data by differencing the stable country characteristics from dependent and the independent variables (i.e., at *both* sides of the regression equation). Therefore, an FE model is based on the analysis of differences in differences from country means, and tests only within-country changes across time. Another approach to analysing data from repeated cross-sectional surveys is to specify a random effects (RE) model. The RE model allows for estimation of both within and between country-level effects while accounting for the correlation structure at the country level.

An alternative, hybrid model combines this RE structure with a FE model of the measured independent variable (Fairbrother, 2014). By subtracting country-level means from the independent variables, within-country and between-country effects can be modelled separately. Unlike the FE model, the hybrid model allows for the inclusion of both country-level characteristics and within-country changing characteristics. We applied this hybrid model to data on adolescent health and well-being that were collected in repeated cross-sectional surveys. We accounted for population autocorrelation and isolated within- and between-group effects by separating 'country/year' and 'country' levels of variation (Fairbrother, 2014). This hybrid model enabled us to pool data from repeated cross-sectional surveys while retaining their multilevel structure.

The study tested three hypotheses: (1) that early-life exposure to income inequality in infancy and early childhood relates to adolescent health symptoms and reduced well-being, after controlling differences in lifetime income inequality, national wealth, and individual characteristics; (2) that the accumulation of income inequality throughout infancy and childhood – that is, the total amount of inequality experienced up to age 10 – shares negative associations with

subsequent health and wellbeing, and (3) earlier exposures to inequality matter more to health and wellbeing in adolescence due to formative socioemotional developmental processes in infancy.

Methods

Data sources

Health Behaviour in School-aged Children study. Self-report data on health symptoms were collected in six successive cycles (1994, 1998, 2002, 2006, 2010, and 2014) of the HBSC study (Inchley et al., 2016). Data on life satisfaction were collected in four surveys (2002, 2006, 2010, and 2014). Each cycle included nationally representative samples of 11-, 13- and 15-year-olds from a growing network of countries in Europe and North America, from 20 countries (102,799 students) in 1994 to 39 countries (219,460 students) in 2014. National sample sizes per survey cycle are shown in Supplementary Table 1. The analysis of health symptoms involved pooled samples of 431,956 males and 457,026 females from 20 to 39 countries per survey year (185 to 179 country-survey year groups). The analysis of life satisfaction involved pooled samples of 331,072 males and 346,960 females from 137 country/survey year groups. Greenland was omitted from the study due to a lack of publicly available economic data. Survey data from England, Scotland and Wales were combined with equal weight to correspond to economic data on the United Kingdom. Data from French and Flemish HBSC surveys in Belgium were also combined.

Insert Supplementary Table 1 about here

The HBSC study recruited stratified samples of schools that represented the regional, economic, and public-private distribution of schools in each country according to a common protocol. Schools were sampled with replacement as needed within each stratum to ensure

consistent sample composition between countries (Inchley et al., 2016). The HBSC protocol stipulated a standard questionnaire format, item order, and testing conditions. Teachers or trained interviewers distributed the questionnaires in classroom settings. Each member country obtained ethics clearance to conduct the survey from a university-based review board or equivalent regulatory body. The present study research was approved by the Institutional Review Board of the Faculty of ---, --- University. Student participation in HBSC was voluntary and active or passive consent was sought 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.

Health and well-being. In all six survey cycles, an eight-item health symptom checklist measured four psychological symptoms (irritability or bad temper, feeling low, feeling nervous, and difficulty sleeping) and four physical symptoms (headache, stomach ache, back ache, and feeling dizzy; Torsheim & Wold, 2001). Respondents reported the frequency of each symptom during the previous six months (0 = rarely or never, 1 = every month, 2 = every week, 3 = more than once a week, 4 = every day). These scores were summed to create a health symptom scale that ranged from 0 to 32 points. The validity of this health symptom checklist was supported by cross-national studies and qualitative interviews with adolescents (Gariepy, Sentenac, McKinnon, & Elgar, 2016; Haugland & Wold, 2001). In the four previous survey cycles (2002 to 2014), the HBSC questionnaire also included Cantril's (1965) life satisfaction ladder to measure how respondents felt about their life at present on an 11-point scale ranging from 0 (worst possible life) to 10 (best possible life).

Socioeconomic position. The HBSC Family Affluence Scale (FAS) was used in our study to capture some socioeconomic variation at the individual level. The FAS is an index of material

assets or common indicators of wealth (Torsheim et al., 2004; Currie et al., 2008). It has been validated alongside measures of parental occupation, educational attainment, and household income and found to have better criterion validity and to be less affected by non-response bias than these other measures (Currie et al., 2008). The FAS contained two items in the 1994 survey, "Does your family own a car, van or truck?" (No = 0, Yes = 1, Yes, two or more = 2); "Do you have your own bedroom for yourself?" (No = 0, Yes = 1). A third item was added to the scale in 1998: "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); A fourth item was added for the 2002, 2006, and 2010 surveys: "How many computers does your family own?" (None = 0, One = 1, Two or more = 2). Finally, two more items were added to the FAS for the 2014 survey, thus creating a 6-item scale: "At home, do you have a dishwasher (No = 0, Yes = 1); How many bathrooms (room with a bath) are in your home (None = 0, One = 1, Two = 2, More than two = 3)." To normalise the range and distribution of these data, we transformed the total summary score on the Family Affluence Scale to ridits that represented a relative socioeconomic position (SEP) in each country/survey year group (*j*), ranging from 0 (lowest) to 1 (highest). A ridit is a proportional rank score that represents the proportion (*P*) of observations with lower scores plus one-half the proportion with equal scores:

$$Ridit_j = \sum_{n=1}^{j-1} P_{2n} + P_{2j}/2$$

The ridit effectively transforms an ordinal variable to a de facto interval scale. (Donaldson, 1988; Jansen, 1984).

Country data. Data on country wealth, gross national income (GNI) per person (Atlas method, US dollars), were retrieved for every country and survey year from the World Bank Databank (World

Bank, 2016). Annual data on national income inequality were retrieved from the Standardized World Income Inequality Database (Solt, 2016). This database contains estimated Gini indices of post-taxation income inequality based on the UN University's World Income Inequality Database and Luxembourg Income Study. The Gini index of net income inequality has a theoretical range of 0 (perfect equality with everyone having equal income) to 1 (perfect inequality with one person having all the income). We retrieved Gini indices from 1979 to 2014 in order to cover all possible early life exposures for adolescents aged 11, 13 and 15 years in the HBSC study, including Eastern European countries that were once part of the USSR, Yugoslavia, and Czechoslovakia. The series for most countries started at 1979 because this was birth year for the oldest age group (15 years) in the first survey cycle (1994). Figure 1 shows a high degree of heterogeneity in income inequality between countries and over time.

Insert Figure 1 about here

Data analysis. We examined associations between country-level income inequality and individual health and wellbeing using a group-mean centring approach that separates time-varying and time-invariant country-level effects in a hybrid, multilevel regression framework (Fairbrother, 2014). The survey design of the HBSC study required four levels of variation to be specified: individuals (*i*), schools (*j*), country/survey years (*k*), and countries (*l*):

$$y_{ijkl} = \beta_0(t) + \beta_1 X_{ijkl} + \gamma_{WE}(Z_{kl} - \bar{Z}_l) + \gamma_{BE}\bar{Z}_l + \nu_l + \mu_{kl} + \xi_{jkl} + \tau_{ijkl}$$

Here, individual-level characteristics are specified by X_{ijkl} and β_1 coefficients and country-level variables (Z_{kl}) are permitted to vary between survey years. By subtracting country-level observations from its mean over time ($Z_{kl} - \bar{Z}_l$), we created two variables ($\bar{Z}_l$) and ($Z_{kl} - \bar{Z}_l$) that

were entered to linear regression models. As we described above, this approach is called a hybrid model because it estimates random, within-country effects of individual characteristics (γ_{WE}) and fixed, between-country effects of nationality and time period (γ_{BE}) simultaneously (Fairbrother, 2014). Time, indicated by constant $\beta_0(t)$, was entered to ensure that within-country estimates are not artefacts of a common time trend in the data. $\nu_{l,}$ μ_{kl}, ξ_{jkl}, and τ_{ijkl} represent the random components of the slopes at country, country/survey year, school, and individual levels of variance, respectively.

Using adolescents' birth years, survey years, and nationalities, we linked individual variables (age, SEP, health symptoms, and life satisfaction) to a table of annual income inequality "exposures" from birth to time of the HBSC survey assessment (11, 13, or 15 years). Birth years ranged from 1979 for the 15-year-olds in the 1994 cycle to 2003 for the 11-year-olds in the 2014 cycle. The six cycles from 1994 to 2014 provided a substantial amount of variation in income inequality through historical periods. Staggering age groups and survey cycles in this way provided some protection from confounding age, cohort, and period effects because the age and time period were controlled. Age (13 or 15 years, versus 11 years as the reference category) was modelled as fixed effect at the individual level and time period (in years) was modelled as a random effect at the country level. The time variable was anchored at the first survey cycle in 1994 and thus ranged from 0 to 19 years. The power advantage of the FE/RE hybrid model over conventional cross-sectional ecological analyses (e. g., Pickett and Wilkinson, 2015) and pooled time-series analyses (e.g., Elgar et al., 2015) lies in its capability to model trends in country-level characteristics whilst accounting for the nested data structure.

Regression models of psychosomatic symptoms and life satisfaction contained two country-level exposures: mean lifetime income inequality and mean lifetime gross national income per

capita. The interactions of these variables with time were entered at the country/survey year level to control for inflation in income and secular trends in inequality. To test the first hypothesis about lagged associations between income inequality and health, we subtracted the mean Gini index from birth to 4 years (and from age 5 to 9 years) from lifetime mean income inequality and entered these differences to our models. Second, we tested the association between early exposure to income inequality and health by calculating the cumulative Gini index experienced from birth to age 10 and entering yearly average of this sum to our models. Third, we tested the relative importance of earlier versus later exposures to income inequality by calculating individual linear regression trajectories (slopes) in the Gini index from birth to age 10 and regressing adolescent symptoms and life satisfaction on these calculated slope values. In these analyses, a positive association between trajectories in inequality and adolescent symptoms would indicate that a positive change in inequality during the first ten years of life relates to worse adolescent health (later exposure matters more). A negative association would suggest that a negative change in inequality relates to worse health (earlier exposure matters more). We analysed the data on male and female adolescents separately given normative gender differences in their reports of psychosomatic symptoms and life satisfaction (Inchley et al., 2016).

Goodness-of-fit of these models was reported using Akaike's information criterion (AIC), which is a measure of model deviance (d) adjusted for the number of parameters (q) in the model (AIC = $d + 2q$), and the more conservative Bayesian information criterion (BIC), which also corrects for differences in the number of observations (n) in the model (BIC = $d + log(n)*q$; Burnham & Anderson, 2002). Smaller AIC and BIC values indicate better fit of the data to the model.

Results

Descriptive statistics on the individual-level variables used in the study are summarised in Table 1. The gender and age distributions of the sample were about equal in all survey cycles. During HBSC survey years, per capita income ranged from $4,570 (Ukraine, 2002) to $65,970 (Norway, 2014) and income inequality ranged from 0.21 (Denmark, 2002) to 0.42 (Macedonia, 2014). From 1979 to 2014, income inequality ranged from 0.16 (Slovenia, 1987) to 0.45 (Turkey, 1995) and increased by approximately 21%, from an average of 0.26 (SD = 0.06) in 1979 or first observation thereafter to 0.31 (SD = 0.05) in 2014. The distribution of psychosomatic symptoms was slightly skewed, which is indicative of a mostly healthy sample (mean = 8.10, standard deviation = 6.41, skewness = 0.95). Life satisfaction scores were slightly skewed in the opposite direction (mean = 7.59, standard deviation = 1.93, skewness = -0.98).

Insert Table 1 about here

The analysis of a lagged association between income inequality and psychosomatic symptoms is summarised in Tables 2 (males) and 3 (females). An empty model (not shown) was fitted to calculate intraclass correlations (ICCs) of 0.06 at the country level, 0.02 at the country/year level, and 0.01 at the school level. In Table 2, the results from Model 1 show a significant positive association between symptoms in males and lifetime income inequality (b = 7.03, 95% CI = 5.89, 8.77; Model 1). To facilitate interpretation, it should be noted that this regression coefficient corresponds the full theoretical range of Gini index of income inequality (0 to 1) and not the observed range in our sample (0.16 to 0.45). Males' psychosomatic symptoms positively related to age and negatively related to SEP. With lifetime exposure to income inequality accounted for, we then found a unique contribution of inequality from birth to age 4 to

predicting symptoms in male adolescents (b = 5.10, 95% CI = 3.51, 6.68; Model 2). Exposure to income inequality from age 5 to 9 did not uniquely relate to later symptoms (Model 3).

A similar pattern of results was found in females. As shown in Table 3, lifetime exposure to income inequality was strongly predictive of psychosomatic symptoms (b = 6.77, 95% CI = 5.26, 8.28; Model 1). With this lifetime exposure to inequality accounted for, we again found a unique contribution of income inequality from birth to age 4 to predicting symptoms in female adolescents (b = 4.80, 95% CI = 3.11, 6.48; Model 2) but no such contribution of inequality from age 5 to 9 (Model 3). Females' symptoms also positively related to age group and negatively related to SEP.

Insert Tables 2 and 3 about here

Next, the results of our analyses of a lagged association between income inequality and life satisfaction are shown in Tables 4 (males) and 5 (females). An empty model (not shown) calculated ICCs of 0.08 at the country level, 0.05 at the country/year level, and 0.03 at the school level. In males, we found a significant negative association between lifetime income inequality and life satisfaction (b = -3.48, 95% CI = -4.17, -2.80, Model 1). With lifetime exposure to inequality accounted for, we also found that life satisfaction was uniquely related to income inequality from birth to age 4 (b = -1.75, 95% CI = -2.24, -1.25; Model 2) and to income inequality from age 5 to 9 (b = -2.46, 95% CI = -2.22, -1.58; Model 3).

In females, we also we found a significant negative association between lifetime income inequality and life satisfaction (b = -3.68, 95% CI = -4.41, -2.94, Model 1). With lifetime exposure to inequality accounted for, we also found that life satisfaction was uniquely related to income inequality from birth to age 4 (b = -2.28, 95% CI = -2.80, -1.76; Model 2) and to income inequality

from age 5 to 9 (b = -2.58, 95% CI = -3.49, -1.68; Model 3). In both males and females, life satisfaction was lower in older age groups and positively related to SEP. For both psychosomatic symptoms and life satisfaction in males and females (Tables 2-5), we found the best model fit to the data when income inequality from birth to age 4 was entered.

Insert Tables 4 and 5 about here

We now turn to the analysis of cumulative income inequality and individual trajectories in income inequality from birth to age 10 on psychosomatic symptoms in adolescents in males (Table 6) and females (Table 7). The cumulative income inequality variable shown in Table 6 represents the yearly average Gini index of inequality from birth to age 10 (unlike lifetime mean income inequality shown in the previous tables which included a contemporaneous association). The trend variable shown in Table 7 is the individual regression slope of the Gini index of inequality from birth to age 10. A positive trend means that income inequality increased during this developmental period. With all other differences in age group, SEP, time, and per capita income controlled, we found that cumulative income inequality positively related to psychosomatic symptoms in males (b = 4.30, 95% CI = 3.70, 4.91) and in females (b = 3.95, 95% CI = 3.29, 4.62). Individual trends in income inequality negatively related to psychosomatic symptoms in males (b = -8.17, 95% CI = -15.40, -0.94) and females (b = -13.63, 95% CI = -20.46, -6.81), suggesting that earlier exposures to inequality related more closely to symptoms than later exposures.

Insert Tables 6 and 7 about here

Similar associations were found in life satisfaction in males (Table 8) and females (Table 9) but in reverse. Specifically, cumulative income inequality *negatively* related to life satisfaction in males (b = -1.24, 95% CI = -1.43, -1.05) and females (b = -0.99, 95% CI = -1.20, -0.79), and individual trends in income inequality *positively* related to life satisfaction in males (b = 5.80, 95% CI = 3.60, 8.00) and females (b = 7.43, 95% CI = 5.14, 9.72). As found with psychosomatic symptoms, earlier exposures to income inequality were more closely related to life satisfaction in adolescence than later exposures.

Insert Tables 8 and 9 about here

Discussion

This study examined the consequences of early-life income inequality for adolescent health and well-being. The results supported all three hypotheses. First, income inequality from age 0 to 4 predicted adolescent symptoms and life satisfaction after accounting for the inequality experienced from birth through to age 10. Second, the average level of income inequality experienced during the first 10 years of life uniquely related to adolescent symptoms and life satisfaction, suggesting that a high average level of inequality during infancy and childhood related to worse adolescent outcomes. Third, individual trajectories in income inequality from birth to age 10 related to symptoms and life satisfaction, suggesting that earlier exposures to inequality were more toxic than later ones. Therefore, the intensity and timing of income inequality experienced in early life have implications for adolescent health and well-being. The results were similar in males and females and stood up to numerous statistical controls for between-country and within-country differences, including national per capita income and individual SEP.

These results help to verify the antecedent-consequence conditions in the association between income inequality and health, which is a necessary – though not sufficient – condition of a causal relationship (Gordis, 2013; Pickett & Wilkinson, 2015b). The notion that income inequality acts as a universal, structural determinant of health was previously inferred from its correlations with health and social constructs at the ecological level (e.g., low social trust, violence, mortality). Efforts to verify the precedence of income inequality using longitudinal data were valuable in this regard but were limited by the lack of comparable health data on large samples of individuals drawn from many and diverse economic settings. Previous studies of early-life income inequality and adult health involved 1 to 19 countries and had likely lacked the statistical power needed to compare health consequences of inequality at different life stages (e.g., De Vries et al, 2004; Leigh and Jencks, 2007; Lillard et al, 2015; Karlsson et al., 2010). This study used up to 35 years of data on 40 countries and found robust evidence that infant development in European and North American countries that have historically been more equal, with relatively lower income inequality, subsequently related to fewer physical and mental health symptoms and greater life satisfaction in adolescence. While not longitudinal evidence in the strictest sense in that we did not track individual changes in health nor used data on important contextual factors in infancy and childhood, the exposure to inequality preceded the measurement of the outcome by 11 to 15 years.

The study also addresses the need for developmental studies of income inequality and found that the most sensitive period of development when exposure to inequality most strongly related to adolescent health and wellbeing was the initial years of life: 0 to 4 years. This period coincides with formative developmental processes when brain development is most influenced by deprivation and stress (Bradley & Corwyn, 2002; Gillman 2005; Kim et al., 2013; Shonkoff et al., 2009). Maternal stress and parent-child interactions are possible pathways underlying the

associations reported here. Unfortunately, very little is currently known about how income inequality affects prenatal development, parent-child attachment, early temperament, and parenting styles in various cultural contexts. Some research in US has found that state-level income inequality correlates to preterm births, low birth weight, and infant mortality (Olson, Diekema, Elliot, & Renier, 2010) and to rates of child maltreatment (Eckenrode et al, 2014). Still, international replication and extension of these studies are needed to determine the total impact of income inequality on infant and child development and to devise early interventions that might mitigate these influences in early life.

We also found that income inequality in middle childhood (5 to 9 years) had a negative, lagged association with life satisfaction in adolescence. This result was unexpected given our focus on the first years of life, but it is consistent with Wilkinson and Pickett's (2010) psychosocial hypothesis about the health and social consequences of income inequality. Their theory describes the divisive effects of inequality at a broad social level and not in the home environment where infants and toddlers spend nearly all their time. Therefore, children might become more exposed to the psychosocial consequences of income inequality when they mature enough to form social relationships outside the home, such as play groups, day care centres, and primary schools. According to Arsenio and Gold (2006), exposure to social inequality may influence children's moral development while they develop the cognitive schemas of distributive justice and fairness, an ability that normally emerges between the ages of 3 and 8 (Fehr, Bernhard, & Rockenbach, 2008). These psychosocial and developmental perspectives, alongside other evidence that shows that income inequality correlates with poor self-rated health (Rözer & Volker, 2016), school bullying (Elgar et al., 2009), alcohol misuse (Elgar et al., 2005), and physical assaults among adolescents (Pabayo et al., 2014), support the view that that inequality fosters a harsh social

environment in which children experience more peer rejection, teasing, conflict, and risk behaviours.

There is also a material interpretation of these links between early-life income inequality and adolescent health and well-being that focuses on taxation policies and the coverage and generosity of social security services, income supports, parental leave benefits, health visiting, home nurses, and early childhood education (Evans, 2002). Previous studies found that reduced cash transfers to families and poorer quality health and social services are material consequences of income inequality (Dunn, Burgess, & Ross, 2005) and negatively impact parental behaviours and maternal and child health outcomes (Brownell et al., 2016; Jackson, Brooks-Gunn, Huang, & Glassman, 2000). Mitigating these effects would likely require coordinated policy responses at multiple levels of government given that cash transfers and taxation policies that redistribute income are usually set by national governments whereas the programs and services that respond to the health and social consequences of income inequality typically fall within the mandate of local and regional governments. However, many evidence gaps remain in this area of research that preclude our identifying the most effective policy response.

The strengths of this study include the size and diversity of the sample, the 35-year duration of data collection, and its focus on adolescent health. Another strength was the application of a hybrid multilevel model of between- and within-country effects (Fairbrother, 2014). This model, when fitted to pooled health records from successive HBSC surveys (Inchley, et al., 2016) and Solt's (2016) Standardized World Income Inequality Database, facilitated a powerful analysis of early-life income inequality and adolescent health and well-being.

Limitations of these analyses should also be noted. First, the study assumed zero migration within and between countries from birth to age 15 because adolescents' nationality in the HBSC

study determined the country of income inequality exposure. We did not have information about migration within or between countries, country of birth, age of migration, and country of origin. These uncontrolled variables may have introduced some noise to our results although we do not expect that different results would have emerged had we controlled for differences in migration. Second, we analysed only two indicators of health and well-being in a limited age group of 11- to 15-year-olds. While these indicators provided global assessments of psychosomatic symptoms and life satisfaction using well-validated self-report tools, we cannot extrapolate these results to other domains of health and other age groups. Replications of these findings in other health domains and older age groups would be useful. Third, although exact response rates in the HSBC study could not be established, fieldworker reports from several countries showed that 5 to 10% of pupils were absent from the surveys, which inevitably poses the possibility of non-response bias due to illness and school truancy. Fourth, although we can speculate on the mechanisms involved in these associations, we have not fully examined the health impacts of family contexts (e.g., family structure and quality of family relationships) during the early years of development. Family processes in early life and their links to income inequality and later health in adolescence certainly require further investigation.

Conclusion

Theorists have begun to argue more forcefully for the need to identify upstream health determinants early in the life course and to expand the focus of health research from specific risk and protective factors to social patterns and structures that shape children's chances to be healthy (Viner et al., 2012). The present study addresses a knowledge gap in the literature by showing the health consequences of early-life exposure to national income inequality. Our results were consistent with the hypothesis that inequality alters formative developmental pathways to

adolescent health and well-being. Whilst more research is needed to fully understand the psychosocial and physiological mechanisms involved, it appears that the negative health sequela of income inequality stems from accumulated exposure through the life course, beginning in infancy. The good news is that these results also point to policy options for governments that could minimise these consequences by reducing income inequality and supporting maternal and child health in economically unequal areas.

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Figure 1.

Income inequality (Gini index) in 40 countries, 1979 to 2014.

Table 1.

Summary statistics on key variables by survey year.

	Survey cycle					
	1994	1998	2002	2006	2010	2014
Gender (*n*)						
Male	49,254	60,696	76,680	100,379	104,513	107,673
Female	52,223	63,388	80,927	104,193	107,875	110,767
% Female	51.46	51.08	51.35	50.93	50.79	50.71
Age group (*n*)						
11 years	35,729	42,657	53,317	66,250	67,540	69,978
13 years	34,224	42,402	53,961	69,471	71,551	75,016
15 years	32,478	39,025	49,018	67,455	71,255	71,621
Mean symptoms (SD)	7.92 (5.80)	8.33 (6.05)	7.89 (6.21)	8.06 (6.45)	8.10 (6.55)	8.23 (6.82)
Mean life satisfaction (SD)	-	-	7.55 (1.92)	7.57 (1.94)	7.58 (1.93)	7.64 (1.95)
Mean family affluence (SD)	0.50 (0.28)	0.50 (0.28)	0.50 (0.28)	0.50 (0.28)	0.50 (0.28)	0.50 (0.27)
Mean income inequality (SD)	0.29 (0.05)	0.30 (0.05)	0.30 (0.05)	0.31 (0.05)	0.31 (0.05)	0.31 (0.05)
Mean per capita income,						
$ thousands (SD)	16.40 (6.11)	21.23 (7.52)	23.82 (9.75)	28.68 (12.18)	32.14 (12.30)	33.44 (13.28)
n (students)	101,477	124,084	157,607	204,572	212,388	218,440
n (schools)	1,644	2,340	5,228	7,083	7,655	7,337
n (countries)	20	24	30	37	36	38

Note: Sample sizes by country and survey year are shown in Supplementary Table 1. SD = Standard deviation.

Table 2.

Linear regression models of psychosomatic health symptoms in 11- to 15-year-old males, 1994 to 2014.

Variable	Model 1 b (95% CI)	Model 2 b (95% CI)	Model 3 b (95% CI)
Fixed effects coefficients:			
Constant	5.40** (4.97, 5.83)	5.49** (5.06, 5.92)	5.43** (4.99, 5.87)
Age group			
13 years	0.43** (0.38, 0.47)	0.44** (0.40, 0.49)	0.43** (0.38, 0.47)
15 years	0.89** (0.83, 0.94)	0.90** (0.85, 0.96)	0.88** (0.83, 0.94)
Family affluence	-0.63** (-0.70, -0.57)	-0.63** (-0.70, -0.57)	-0.63** (-0.70, -0.57)
Time (years)	0.02 (-0.01, 0.05)	0.02 (-0.01, 0.05)	0.02 (-0.01, 0.05)
Income inequality:			
Lifetime (Mean)	7.03** (5.89, 8.77)	7.56** (6.62, 9.00)	7.23** (5.77, 8.69)
0 to 4 years (Difference)		5.10** (3.51, 6.68)	
5 to 9 years (Difference)			1.11 (-1.47, 3.68)
Lifetime inequality (Mean) * Time	-0.26** (-0.33, -0.15)	-0.28** (-0.39, -0.18)	-0.25** (-0.36, -0.15)
GNIpc, lifetime (Mean)	-0.02** (-0.03, -0.01)	-0.02** (-0.03, -0.01)	-0.02** (-0.03, -0.01)
GNIpc, lifetime (Mean) * Time	0.00** (0.00, 0.00)	0.00** (0.00, 0.00)	0.00** (0.00, 0.00)
Random effects variances:			
School	0.45	0.48	0.41
Country/year	0.45	0.48	0.41
Country			
Time	0.00	0.00	0.00

Constant	1.63	1.56	1.72
Residual	33.54	33.54	33.54
Goodness of fit:			
-2 log likelihood	-1,376,806	-1,376,786	-1,376,805
AIC	2,753,640	2,753,592	2,753,643
BIC	2,753,793	2,753,702	2,753,819
n (students; schools; country/years; countries)	430,735; 29,971; 185; 40	430,735; 29,971; 185; 40	430,735; 29,971; 185; 40

Note: The reference for age group is 11-year-olds. Lifetime income inequality represents the mean Gini index from birth to the time of the HBSC survey. Early exposure to income inequality is the difference between the mean Gini index at age 0 to 4 (or age 5 to 9) and the lifetime income inequality. GNIpc represents the mean gross national income per capita ($, thousands) from birth to the time of the survey. CI = confidence interval. AIC = Akaike's information criterion. BIC = Bayesian information criterion. *$p < 0.01$. **$p < 0.001$

Table 3.

Linear regression models of psychosomatic health symptoms in 11- to 15-year-old females, 1994 to 2014.

Variable	Model 1 b (95% CI)	Model 3 b (95% CI)	Model 3 b (95% CI)
Fixed effects coefficients:			
Constant	6.58** (6.13, 7.02)	6.63** (6.18, 7.07)	6.66** (6.21, 7.11)
Age group			
13 years	1.62** (1.57, 1.67)	1.63** (1.58, 1.68)	1.62** (1.57, 1.67)
15 years	2.98** (2.93, 3.04)	3.00** (2.94, 3.06)	2.98** (2.92, 3.03)
Family affluence	-0.88** (-0.95, -0.81)	-0.88** (-0.95, -0.81)	-0.88** (-0.94, -0.81)
Time (years)	0.05** (0.01, 0.08)	0.05** (0.02, 0.08)	0.04* (0.01, 0.08)
Income inequality:			
Lifetime (Mean)	6.77** (5.26, 8.28)	7.13** (5.62, 8.64)	6.50** (4.97, 8.04)
0 to 4 years (Difference)		4.80** (3.11, 6.48)	
5 to 9 years (Difference)			2.61 (-0.11, 5.31)
Lifetime inequality * time	-0.26** (-0.37, -0.15)	-0.29** (-0.40, -0.18)	-0.24** (-0.36, -0.13)
GNIpc, lifetime (Mean)	-0.03** (-0.04, -0.02)	-0.02** (-0.03, -0.02)	-0.03** (-0.04, -0.02)
GNIpc, lifetime (Mean) * Time	0.00** (0.00, 0.00)	0.00** (0.00, 0.00)	0.00** (0.00, 0.00)
Random effects variances:			
School	0.38	0.34	0.36
Country/year	0.38	0.34	0.36
Country			
Time	0.00	0.00	0.00

Constant	1.34	1.38	1.37
Residual	39.93	39.93	39.93
Goodness of fit:			
-2 log likelihood	-1,499,880	-1,498,864	-1,498,878
AIC	2,997,788	2,997,795	2,997,786
BIC	2,997,943	2,997,924	2,997,952
n (students; schools; country/years; countries)	456,397; 29,830; 185; 40	456,397; 29,830; 185; 40	456,397; 29,830; 185; 40

Note: The reference for age group is 11-year-olds. Lifetime income inequality represents the mean Gini index from birth to the time of the HBSC survey. Early exposure to income inequality is the difference between the mean Gini index at age 0 to 4 (or age 5 to 9) and the lifetime income inequality. GNIpc represents the mean gross national income per capita ($, thousands) from birth to the time of the survey. CI = confidence interval. AIC = Akaike's information criterion. BIC = Bayesian information criterion. *$p < 0.01$. **$p < 0.001$

Table 4.

Linear regression models of life satisfaction in 11- to 15-year-old males, 1994 to 2014.

Variable	Model 1 b (95% CI)	Model 2 b (95% CI)	Model 3 b (95% CI)
Fixed effects coefficients:			
Constant	7.96** (7.73, 8.20)	7.83** (7.59, 8.07)	8.00** (7.77, 8.23)
Age group			
13 years	-0.33** (-0.34, -0.31)	-0.33** (-0.35, -0.31)	-0.32** (-0.34, -0.31)
15 years	-0.58** (-0.59, -0.58)	-0.58** (-0.60, -0.57)	-0.57** (-0.59, -0.55)
Family affluence	0.88** (0.86, 0.90)	0.88** (0.86, 0.90)	0.88** (0.86, 0.90)
Time (years)	-0.02* (-0.04, -0.00)	-0.01 (-0.03, 0.00)	-0.02* (-0.04, -0.01)
Income inequality:			
Lifetime (Mean)	-3.48** (-4.17, -2.80)	-3.28** (-3.97, -2.59)	-3.44** (-4.12, -2.76)
0 to 4 years (Difference)		-1.75** (-2.25, -1.25)	
5 to 9 years (Difference)			-2.46** (-3.33, -1.58)
Lifetime inequality * time	0.17** (0.12, 0.22)	0.16** (0.11, 0.21)	0.17** (0.12, 0.22)
GNIpc, lifetime (Mean)	0.02** (0.02, 0.03)	0.03** (0.02, 0.03)	0.02** (0.02, 0.03)
GNIpc, lifetime (Mean) * Time	-0.00** (-0.00, -0.00)	-0.00** (-0.00, -0.00)	-0.00** (-0.00, -0.00)
Random effects variances:			
School	0.04	0.04	0.04
Country/year	0.04	0.04	0.04
Country			
Time	0.00	0.00	0.00

Constant	0.16	0.24	0.16
Residual	3.22	3.22	3.22
Goodness of fit:			
-2 log likelihood	-727,181	-727,159	-727,166
AIC	1,454,391	1,454,349	1,454,363
BIC	1,454,553	1,454,522	1,454,536
n (students; schools; country/years; countries)	359,681; 26,070; 137; 40	359,681; 26,070; 137; 40	359,681; 26,070; 137; 40

Note: The reference for age group is 11-year-olds. Lifetime income inequality represents the mean Gini index from birth to the time of the HBSC survey. Early exposure to income inequality is the difference between the mean Gini index at age 0 to 4 (or age 5 to 9) and the lifetime income inequality. GNIpc represents the mean gross national income per capita ($, thousands) from birth to the time of the HBSC survey. CI = confidence interval. AIC = Akaike's information criterion. BIC = Bayesian information criterion.

*$p < 0.01$. **$p < 0.001$

Table 5.

Linear regression models of life satisfaction in 11- to 15-year-old females, 1994 to 2014.

Variable	Model 1 b (95% CI)	Model 2 b (95% CI)	Model 3 b (95% CI)
Fixed effects coefficients:			
Constant	8.22** (7.97, 8.47)	8.04** (7.78, 8.29)	8.27** (8.02, 8.52)
Age group			
13 years	-0.60** (-0.62, -0.58)	-0.61** (-0.62, -0.59)	-0.60** (-0.61, -0.58)
15 years	-0.98** (-1.00, -0.96)	-0.99** (-1.01, -0.97)	-0.97** (-0.99, -0.95)
Family affluence	0.96** (0.93, 0.98)	0.96** (0.93, 0.98)	0.96** (0.93, 0.98)
Time (years)	-0.03** (-0.05, -0.02)	-0.02* (-0.04, -0.00)	-0.04** (-0.05, -0.02)
Income inequality:			
Lifetime (Mean)	-3.68** (-4.41, -2.94)	-3.38** (-4.42, -2.64)	-3.64** (-4.37, -2.91)
0 to 4 years (Difference)		-2.28** (-2.80, -1.76)	
5 to 9 years (Difference)			-2.58** (-3.49, -1.68)
Lifetime inequality * time	0.21** (0.16, 0.26)	0.19** (0.14, 0.24)	0.21** (0.15, 0.26)
GNIpc, lifetime (Mean)	0.02** (0.02, 0.02)	0.02** (0.02, 0.03)	0.02** (0.01, 0.02)
GNIpc, lifetime (Mean) * Time	-0.00** (-0.00, -0.00)	-0.00** (-0.00, -0.00)	-0.00** (-0.00, -0.00)
Random effects variances:			
School	0.01	0.03	0.07
Country/year	0.01	0.03	0.07
Country			
Time	0.00	0.00	0.00

Constant	0.24	0.37	0.21
Residual	3.43	3.43	3.43
Goodness of fit:			
-2 log likelihood	-774,900	-774,865	-774,885
AIC	1,549,831	1,549,761	1,549,802
BIC	1,549,994	1,549,935	1,549,976
n (students; schools;	376,946; 25,944;	376,946; 25,944;	376,946; 25,944;
country/years; countries)	137; 40	137; 40	137; 40

Note: The reference for age group is 11-year-olds. Lifetime income inequality represents the mean Gini index from birth to the time of the HBSC survey. Early exposure to income inequality is the difference between the mean Gini index at age 0 to 4 (or age 5 to 9) and the lifetime income inequality. GNI per capita represents the mean gross national income per capita ($, thousands) from birth to the time of the HBSC survey. CI = confidence interval. AIC = Akaike's information criterion. BIC = Bayesian information criterion.

*$p < 0.01$. **$p < 0.001$

Table 6.

Linear regression analysis of cumulative income inequality and individual trends in inequality during childhood and psychosomatic health symptoms in 11- to 15-year-old males, 1994 to 2014.

Variable	Cumulative effect b (95% CI)	Trend effect b (95% CI)
Fixed effects coefficients:		
Constant	6.28** (6.04, 6.52)	7.51** (7.33, 7.68)
Age group		
13 years	0.43** (0.38, 0.48)	0.41** (0.36, 0.46)
15 years	0.89** (0.84, 0.94)	0.85** (0.80, 0.90)
Family affluence	-0.63** (-0.70, -0.57)	-0.63** (-0.70, -0.57)
Time (years)	-0.06** (-0.07, -0.04)	-0.04** (-0.05, -0.03)
Income inequality:		
Cumulative (0 to 10 years)	4.30** (3.70, 4.91)	
Time trend (0 to 10 years)		-13.63** (-20.46, -6.81)
GNIpc, lifetime (Mean)	-0.02** (-0.02, -0.01)	-0.02** (-0.03, -0.01)
GNIpc, lifetime (Mean) * Time	0.00** (0.00, 0.00)	0.00** (0.00, 0.00)
Random effects variances:		
School	0.46	0.59
Country/year	0.46	0.59
Country		
Time	0.00	0.00
Constant	1.58	1.45

Residual	33.54	33.54
Goodness of fit:		
-2 log likelihood	-1,376,805	-1,376,894
AIC	2,753,636	2,753,814
BIC	2,753,778	2,753,957
n (students; schools; country/years; countries)	430,735; 29,971; 185; 40	430,735; 29,971; 185; 40

Note: The reference for age group is 11-year-olds. Cumulative income inequality during childhood represents the sum of the Gini index from birth to the age of 10. Time trend of income inequality during childhood represents the linear slope of the Gini index from birth to the age of 10. GNIpc represents the mean gross national income per capita ($, thousands) from birth to the time of the HBSC survey. CI = confidence interval. AIC = Akaike information criterion. BIC = Bayesian information criterion. *$p < 0.01$. **$p < 0.001$

Table 7.

Linear regression analysis of cumulative income inequality and individual trends in inequality during childhood and psychosomatic health symptoms in 11- to 15-year-old females, 1994 to 2014.

Variable	Cumulative effect b (95% CI)	Trend effect b (95% CI)
Fixed effects coefficients:		
Constant	7.38** (7.13, 7.63)	8.48** (8.30,8.66)
Age group		
13 years	1.62** (1.57, 1.67)	1.60** (1.55,1.66)
15 years	2.99** (2.93, 3.05)	2.95** (2.89,3.01)
Family affluence	-0.88** (-0.95, -0.81)	-0.88** (-0.94,-0.81)
Time (years)	-0.03** (-0.04, -0.02)	-0.01* (-0.02,-0.00)
Income inequality:		
Cumulative (0 to 10 years)	3.95** (3.29, 4.62)	
Time trend (0 to 10 years)		-8.17* (-15.40,-0.94)
GNIpc, lifetime (Mean)	-0.03** (-0.04, -0.02)	-0.03** (-0.04,-0.02)
GNIpc, lifetime (Mean) * Time	0.00** (0.00, 0.00)	0.00** (0.00,0.00)
Random effects variances:		
School	0.72	0.51
Country/year	0.72	0.51
Country		
Time	0.00	0.00
Constant	0.96	1.15

Residual	39.91	39.92
Goodness of fit:		
-2 log likelihood	-1,498,884	-1,498,945
AIC	2,997,795	2,997,916
BIC	2,997,938	2,998,060
n (students; schools; country/years; countries)	456,397; 29,830; 185; 40	456,397; 29,830; 185; 40

Note: The reference for age group is 11-year-olds. Cumulative income inequality during childhood represents the mean of the Gini index from birth to the age of 10. Time trend of income inequality during childhood represents the linear slope of the Gini index from birth to the age of 10. GNIpc represents the mean gross national income per capita ($, thousands) from birth to the time of the HBSC survey. CI = confidence interval. AIC = Akaike information criterion. BIC = Bayesian information criterion. *$p < 0.01$. **$p < 0.001$

Table 8.

Linear regression analysis of cumulative income inequality and individual trends in inequality during childhood and life satisfaction in 11- to 15-year-old males, 1994 to 2014.

Variable	Cumulative effect b (95% CI)	Trend effect b (95% CI)
Fixed effects coefficients:		
Constant	7.23** (7.13, 7.32)	6.77** (6.69, 6.85)
Age group		
13 years	-0.32** (-0.34, -0.31)	-0.32** (-0.34, -0.31)
15 years	-0.58** (-0.59, -0.56)	-0.57** (-0.59, -0.55)
Family affluence	0.88** (0.86, 0.90)	0.88** (0.86, 0.90)
Time (years)	0.04** (0.03, 0.04)	0.04** (0.03, 0.04)
Income inequality:		
Cumulative (0 to 10 years)	-1.24** (-1.43, -1.05)	
Time trend (0 to 10 years)		5.80** (3.60, 8.00)
GNIpc, lifetime (Mean)	0.03** (0.02, 0.03)	0.03** (0.03, 0.03)
GNIpc, lifetime (Mean) * Time	-0.00** (-0.00, -0.00)	-0.00** (-0.00, -0.00)
Random effects variances:		
School	0.04	0.04
Country/year	0.04	0.04
Country		
Time	0.00	0.00
Constant	0.19	0.23

Residual	3.22	3.22
Goodness of fit:		
-2 log likelihood	-727,187	-727,254
AIC	1,454,398	1,454,537
BIC	1,454,527	1,454,688
n (students; schools; country/years; countries)	359,681; 26,070; 185; 40	359,681; 26,070; 185; 40

Note: The reference for age group is 11-year-olds. Cumulative income inequality during childhood represents the sum of the Gini index from birth to the age of 10. Time trend of income inequality during childhood represents the linear slope of the Gini index from birth to the age of 10. GNIpc represents the mean gross national income per capita ($, thousands) from birth to the time of the HBSC survey. CI = confidence interval. AIC = Akaike information criterion. BIC = Bayesian information criterion. *$p < 0.01$. **$p < 0.001$

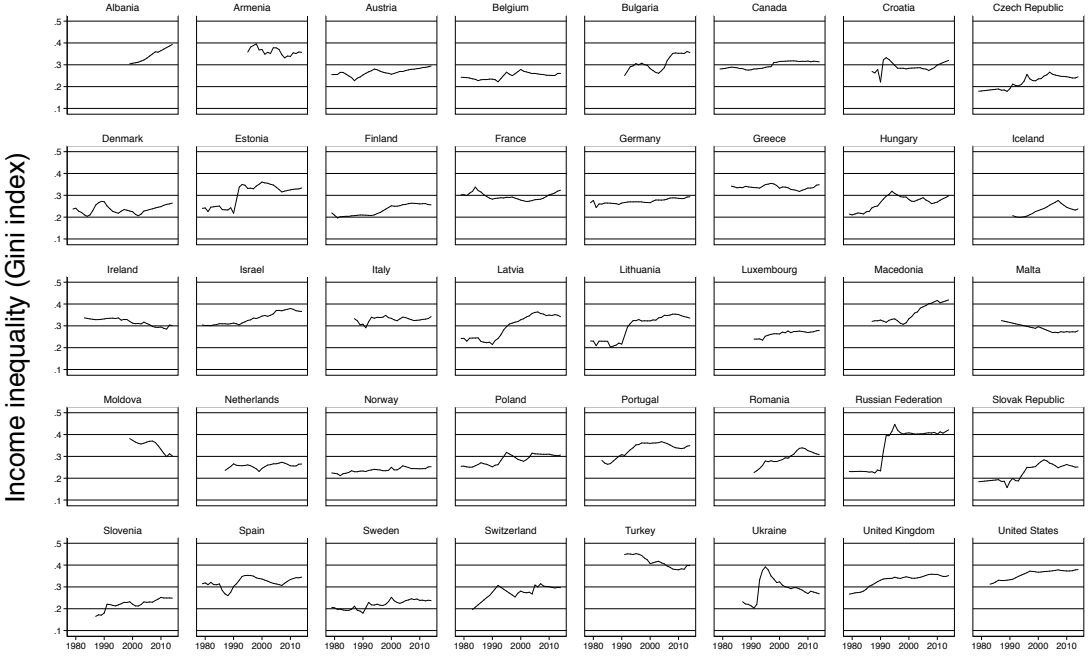
Table 9.

Linear regression analysis of cumulative income inequality and individual trends in inequality during childhood and life satisfaction in 11- to 15-year-old females, 1994 to 2014.

Variable	Cumulative effect b (95% CI)	Trend effect b (95% CI)
Fixed effects coefficients:		
Constant	7.35** (7.24, 7.45)	6.96** (6.87, 7.04)
Age group		
13 years	-0.60** (-0.62, -0.58)	-0.60** (-0.62, -0.58)
15 years	-0.98** (-1.00, -0.96)	-0.98** (-1.00, -0.96)
Family affluence	0.96** (0.93, 0.98)	0.96** (0.93, 0.98)
Time (years)	0.03** (0.03, 0.04)	0.04** (0.03, 0.04)
Income inequality:		
Cumulative (0 to 10 years)	-0.99** (-1.20, -0.79)	
Time trend (0 to 10 years)		7.43** (5.14, 9.72)
GNIpc, lifetime (Mean)	0.02** (0.02, 0.03)	0.03** (0.02, 0.03)
GNIpc, lifetime (Mean) * Time	-0.00** (-0.00, -0.00)	-0.00** (-0.00, -0.00)
Random effects variances:		
School	0.06	0.05
Country/year	0.06	0.05
Country		
Time	0.00	0.00
Constant	0.28	0.35

Residual	3.43	3.43
Goodness of fit:		
-2 log likelihood	-774,916	-774,941
AIC	1,549,859	1,549,911
BIC	1,550,011	1,550,063
n (students; schools; country/years; countries)	376,946; 25,944; 185; 40	376,946; 25,944; 185; 40

Note: The reference for age group is 11-year-olds. Cumulative income inequality during childhood represents the mean of the Gini index from birth to the age of 10. Time trend of income inequality during childhood represents the linear slope of the Gini index from birth to the age of 10. GNIpc represents the mean gross national income per capita ($, thousands) from birth to the time of the HBSC survey. CI = confidence interval. AIC = Akaike information criterion. BIC = Bayesian information criterion. *$p < 0.01$. **$p < 0.001$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Norway
Poland
Portugal
Romania
Russian Federation
Slovak Republic
Slovenia
Spain
Sweden
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Turkey
Ukraine
United Kingdom
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1980
1990
2000
2010
Income inequality (Gini index)
Year

Highlights

- Income inequality during infancy and childhood relates to poor adolescent health.
- Early life exposure to inequality (0-4 years) is most damaging.
- Health and well-being relates the magnitude and timing of early-life inequality.
- The results establish temporality in the association between inequality and health.