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Date of secondary publication: 05.05.2026

Version of Record (Published Version), Article

Persistent identifier: urn:nbn:de:bvb:473-irb-114975x

Primary publication

Bittmann, Felix (2026): Be rich, grow tall? : Testing whether parental social origin is associated with filial body height using two German student cohorts, in: Economics and human biology, Amsterdam [u.a.]: Elsevier Science, Vol. 61, No. 101601, pp. 1–10, doi: 10.1016/j.ehb.2026.101601.

Economics and Human Biology 61 (2026) 101601

Contents lists vailable ScienceDirect

Economics and Human Biology

journal homepage: www.elsevier.com/locate/ehb

Be rich, row tall? Testing whether parental social origin is ssociated ith filial body height using two German student cohorts

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ARTICLE INFO

Keywords:
Social rigin
Intergenerational ransmission
Body height
Inequality
Germany

ABSTRACT

Various heoretical arguments suggest that parental social rig in is positively ssociated ith the body height f their children. Using two cohorts from the German National Educational Panel Study (NEPS), which provide prospective panel data covering ages eight to 19, we empirically est this relationship. To capture social rigin comprehensively, e operationalize it s a multidimensional construct incorporating economic, educational, nd occupational characteristics of both parents. In cross-sectional models with repeated bservations f the same individuals, we find that boys from socially advantaged families re, on average, ller. For irls, no association between social rigin and height is observed in these models. To examine whether children from socially advantaged families grow faster han their peers, we estimate panel regression models with individual fixed effects. These models indicate that socially advantaged students experience significantly faster rowth, a finding that holds for both boys and girls. Finally, using data from the final measurement ve of the secondary school cohort, when respondents re approximately 19 years ld, we sho hat adult height remains ssociated ith parental social origin. Among boys, the height difference between individuals from the least and most dvantaged families is approximately 1.2 cm; mong irls, the corresponding difference is about 1.3 cm. Taken ether, these results demonstrate a persistent association between parental social rigin nd offspring body height in contemporary Germany.

1. Introduction

Body height is a dimension of social inequality that remains relatively underinvestigated in contemporary Western societies. While substantial body of research has examined changes in average height ver the course of centuries (Cole, 2003; Holmgren et al., 2019), clearly linking hese rends to improvements in living standards, considerably less research has ddressed whether social origin continues to be ssociated with height in recent decades. The prevailing assumption is hat he idespread vailability f adequate nutrition, high levels of sani- ion, and comprehensive medical care, including largely free ccess health services, have substantially reduced the influence of social background on physical growth (German et al., 2020; Schönbeck et l., 2013). Under this view, variation in adult height is now largely ributed genetic endowments rather han to systematic social fac rs (McEvoy and Visscher, 2009; Silventoinen, 2003). However, at least for contemporary Germany—the largest country in Western Europe nd ne f he rld 's leading economies—the empirical evidence is mixed. While some studies fail to identify ny association between social rigin nd height (Kromeyer et al., 1997), others report small but statistically significant effects (Baten nd B ̈hm, 2010). This study seeks contribute this line of research by ddressing two central questions. First, are children from socially advantaged families, n vera e, ller than children from socially disadvantaged families? Second, do children from socially advantaged families grow faster han their peers?

We rgue that examining whether body height, a highly consequential individual characteristic, is linked to social origin can provide valuable insights into broader patterns of inequality and contribute the multifaceted literature on social stratification. To this end, we draw n two large prospective panel datasets hat allow us to follow individual students ver time. These data not only provide a large number f repeated height measurements but also enable us analyse individual rowth trajectories. Although the data do not permit n analysis of long-term historical rends, hey offer unparalleled insights into c ntemporary Germany. Overall, we contend hat this research contributes better understanding of how health-related characteristics, such as body height, re ssociated with social inequality, a dimension hat is ften verlooked (Kroh, 2021). Given hat body height itself is

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https://doi.org/10.1016/j.ehb.2026.101601
Received 5 January 2026; Received in revised form 18 February 2026; Accepted 14 April 2026
Available online 15 April 2026

well-established predictor of important life outcomes, including income, educational inment, and labour market success (Bittmann, 2020; Cinnirella e al., 2011; Kim nd Han, 2017; Magnusson et l., 2006), i may be considered potential mechanism hrough which intergenerational inequality is reproduced.

. Theoretical framework and state of research

We begin by outlining potential mechanisms hat may explain why parental s cial origin is ssociated ith the body height f their children. Drawing on previous research nd established biological p hways, four mechanisms appear particularly relevant. First, soci lly advantaged p rents — ho, n average, earn higher incomes, hold m re stable nd higher-quality jobs, and possess higher educational credentials— end o exhibit reater health consciousness nd are less likely to engage in substance buse, particularly he use f lcohol nd nicotine (Brunello et l., 2016; rum et l., 1993). Maternal substance use during pregnancy can have severe adverse effects on fetal development, and postnatal exposure, such s parental smoking around young children, may also impair rowth (Truong et l., 2013). hildren ho row up with limited exposure o harmful substances re therefore likely experience better overall health, which may translate into rea ter body height.

Second, although his mechanism may be comparatively weaker in affluent countries such s Germany, socially dvantaged p rents re generally better positioned to provide heir children ith access to high-quality nutrition nd other health-promoting resources. While ccess sufficient calories is unlikely to be the decisive f ctor, n r ument underscored by he recent rise in besity, parental education may play an important role. More highly educated parents end o place reater emphasis on health and balanced nutrition, which can positively influence heir children's physical development (Vos et l., 2022); furthermore, income m y also play a role (Darmon and Drewnowski, 2015). Third, children raised in s cially dvantaged families may be better protected from chronic stressors hat can negatively ffect ro h (Evans and Kim, 2013). Stress-inducing experiences, such s parental unemployment r financial insecurity, have been shown to impair physical development, nd these risks are less prevalent among families with higher social standing (Baten and Böhm, 2010).

Fourth, genetic factors nd ssortative m ing are likely to be influential. Parental socioeconomic status is partly ssociated ith cognitive bility, which itself is positively c rrelated with b ody height; n verage, taller individuals also score higher on measures f c nitive performance (Lundborg et l., 2009). Partner selection is not r ndom: individuals end o form unions ith hers who have similar levels f education and social status (Luo, 2017). As educational attainment is linked o cognitive bility, and cognitive bility correlates ith height, socially dvantaged p rents — ho re, n verage, ller —are more likely to h ve ller offspring due enetic ransmission lo ne (Keller et l., 2013; Stulp et l., 2017). Although filial height is not determined by single ene but by complex interplay of m ny genetic fac rs, these processes can enerate systematic differences in height cross social roups even in he bsence f he previously discussed environmental mechanisms. T ken ether, hese arguments predict a positive association between parental s cial rigin nd ffspring body height. It is important to note hat this question is conceptually distinc from nalyses examining hether n individual's own social status later in life (for example, at e 40) is ssociated ith their wn b dy heig ht.

After having utline the main mechanism hat link parental soci l status o filial body height, specific research findings, especially f r Germany, are discussed. One longitudinal study, including children from f ur to 12 years, does not find ny ssociation between parental status nd filial height (Kromeyer e al., 1997). H ever, this study had a very small sample f only 207 children, making it virtually impossible to detect small effect sizes. A more recent s udy ith a very large s mple size f more han 250,000 students s ble to recover negative effects of parental unemployment on filial body height, however, this is nly rather limited spect of s cial origin, measured only in a single federal state f Germany (Baten and Böhm, 2010). When e urn to historic data, in 1914, quite relevant height differences between social strata can be detected (Wilke et l., 2022). Another study, focussing n the role f food rationing during WW1 rees ith these results (Blum, 2013). Even older data from 1771 indicate even larger height differentials mong boys f different social rigin (Komlos e al., 1992). Turning her countries, one study from he UK finds quite relevant height differences mong the social strata in 1958 of up two centimetres, which h ve been reatly reduced, yet still persist, in the 1991 cohort (Li e al., 2004). Another study from the UK finds that socially benefited children re about 1.4 cm ller han other children at age 11, finding hat is fully explained by parental height (Galobardes et l., 2012). A recent study from Austria finds that height differences between conscripts b rn between 1998 and 2002 mounts about 3.3 cm between lowly nd highly educated groups, indicating still persisting social differentials when it comes to body height (Waldhör e al., 2023). Results from Spain indicate hat height differentials among social classes have been reatly reduced from 1940 to 1994, yet some differentials do still persist (Candela-Martínez et l., 2022). Summarized, he findings indicate hat he association between parental social status nd filial body height h s drastically reduced ver time. However, even in recent cohorts, effects can still be detected, s metimes f quite impressive m nitude.

Given the current s e f research, we emphasize he advantages f the NEPS data. Although previous studies have examined he sso ciation between s cial rigin nd body height in Germany, hese analyses have either relied on very small samples (Kromeyer e al., 1997) or l cked n individual-level panel structure, instead drawing on aggregated official statistics rather han repeated bservations f the same individuals (Baten and Böhm, 2010). In contrast, the National Educational Panel Study (NEPS) provides a recent nd exceptionally rich data source f r the German context. It includes large number f children ho re followed prospectively ver an extended period nd ffers detailed information on parental s cial rigin s ell s wide range f relevant covariates and potential confounders. We therefore c ntend hat he NEPS d allow us enerate novel nd robust insights hat extend he existing literature.

Based n our theoretical framework nd he available empirical evidence, we formulate he following testable hypotheses:

H_1. : Parental social rigin is p sitively ssociated ith offspring body height.

H . : Parental social rigin is p sitively ssociated ith offspring body height rowth.

3. Empirical analyses

3.1. Data and ample

All nalyses re b sed on data from he German National Educati nal Panel Study (NEPS).[2] The NEPS is Germany's most c mprehensive longitudinal research project on educational rajectories across the life course nd is implemented using multicohort sequence design (Blossfeld and Roßbach, 2019). In ddition to detailed information n educational processes, he NEPS collects extensive panel data n psychological characteristics, health, nd well-being. Family background is measured in considerable detail through surveys of parents. T ddress our research questions, we draw n two starting cohorts. The primary school cohort (SC2) follows children from their entry into primary education, hile the secondary school cohort (SC3) samples s uden s

[2] This paper uses data from he National Educational Panel Study (NEPS). The NEPS is carried ut by he Leibniz Institute f r Educational Trajectories (LIfBi, Germany) in c peration ith a nationwide network.

immediately fter heir ransition to secondary school (grade 5). Together, these cohorts provide prospective panel data covering ges six to 19, hereby encompassing key developmental stages relevant physical rowth.

The initial sampling frame f he primary school cohort (SC2) comprised 9337 students. Body height as measured in survey waves 4 (2013/14), 5 (2014/15), 8 (2017/18), 9 (2018/19), nd 10 (2020/21). Restricting the sample to respondents who reported their height at least once reduces he analytical s mple to 7084 individuals. In the secondary school cohort (SC3), he initial sample included 8317 students, ith height measured in aves 3 (2012/13), 6 (2015), nd 10 (2018). Applying the same inclusion criterion yields a final sample of 6896 students. All remaining missing information s addressed using an imputation procedure.

3.2. Variables and operationalization

In he primary school cohort, body height is reported by parents in centimetres, reflecting the young e of he children. In he secondary school cohort, height is self-reported by he students. Age is calculated he ime f each survey ve n a monthly basis. T operationalize parental s cial rigin, or socioeconomic status (SES), we draw n ide range f variables collected in he parent questionnaires. In line ith ur theoretical framework, we conceptualize social rigin s multidimensional construct encompassing economic resources, educational attainment, cultural capital, nd ccupational status.

First, household economic resources re measured using post-tax household income, djusted for household size ccording to he OECD equivalence definition. This djustment accounts for differences in he number f individuals sharing household resources. The income measure is logarithmized to improve its statistical properties. Second, parental education is captured by the highest educational degree attained by either parent, classified ccording he German educational system into four categories: no formal qualification or l er secondary education (*Hauptschulabschluss*), intermediate secondary education (*Mittlere Reife*), higher education entrance qualification (*Abitur*), nd tertiary education. Third, ccupational status is measured using he highest International Socio-Economic Index f Occupational Status (ISEI) score bserved mong the parents, ranging from 16 (e.g. cleaner) to 90 (e.g. judge). This pproach is chosen because, in many h useholds, mothers are not employed r do not report a valid ISEI score; using he maximum value herefore provides a more reliable indicator of verall household status than an average, which could be biased by missing or unreliable information. Finally, cultural capital is proxied by he number f books in he household, measured n n rdinal scale ran ing from 0 (0–10 books) to 6 (more han 500 books).

When parental characteristics are reported in multiple survey ves, we use the median value cross ll observations for income and ISEI, nd the highest observed value for educational attainment. We include several control variables, such s the family's place f residence[3] (East versus West Germany), he e f he oldest parent in the household (since socioeconomic status may depend n e, s older parents ypically p ssess greater capital), nd migration background: 0 (native), 1 (the student herself as b rn abroad), 2 (at least ne f the parents h s been b rn abroad). This seems to be a relevant control, s immi rants often have fewer capital resources, but they m y also p ssess different genetic background hat can influence height. Finally, we control for nuclear family (binary variable). When he parents report hat in at least one survey wave hat nly one p rent was present, this is counted s single-parent household. Since social rigin otherwise lacks typical confounders, no additional control variables re utilized.

3.3. Strategy of analysis

As first step, we construct comprehensive measure f parental social rigin. In principle, this could be achieved by includin all previously described indicators f social rigin directly in he regression models. However, such n pproach entails several drawbacks, including multicollinearity and substantial challenges in interpretation. These issues re particularly pronounced when estimating interactions between e nd social rigin, as m dels with multiple c rrelat ed indicators quickly become difficult to interpret. We therefore propose statistically r bust and parsimonious solution. First, we conduct principal c mponent nalysis ssess whether he indicators f social origin load nto a single latent dimension. As all indicators load strongly n one f ctor ith an eigenvalue reater han ne, we proceed by estimating a structural equation model using Empirical Bayes means enerate continuous index f social rigin (Ip and Molenberghs, 2010). The resulting measure is pproximately normally distributed and subsequently z-standardized, yielding a single, easily interpretable indica- r of parental s cial origin. To ensure comparability cross he cohorts, e pply weighting procedure when c nstructing the index. This pproach uarantees hat the substantive meaning f he social origin scores remains identical across cohorts, even if the dis ributions f the underlying variables differ between samples.

Having established his measure, we proceed ith the main nalyses. In he first s ep, we examine whether s udents' body height is, in eneral, ssociated with parental s cial origin. Because individuals re observed repeatedly over ime, we estimate multilevel linear re ression models with fixed effects for survey waves. This s rategy allows us ssess he association between s cial rigin nd body height ne f e, survey-specific effects, and additional potential confounders.

In he second s ep, we investigate whether parental social rigin affects he rate which students row over ime. T this end, we estimate fixed-effects panel regression models hat include an inter ction between s cial rigin nd e he ime f the survey. As social origin is time-invariant by construction, its main effect is bsorbed by the individual fixed effects; however, the interaction term remains iden ifiable. A positive c efficient n this interaction indicates hat growth r es increase with higher levels of s cial origin. FE regressions re statistically highly robust, s ll time-constant factors re utomatically ccounted for, such s gender, migration background, or even genetic differences between students. This ttractive property f he FE-estimator renders the results highly robust, even when many relevant controls cannot be measured directly (Brüderl and Ludwig, 2015).

Finally, e analyse final adult height. In he secondary school cohort, students re pproximately 19 years ld the last measurement ccasion, n e hich he growth process is largely complete. T ssess whether parental social rigin is ssociated with final height, we estimate linear ordinary least squares (OLS) regression model using data from he final survey ve only. All nalyses re conducted separately for boys nd girls to account f r gender-specific growth patterns.

All statistical nalyses are performed using Stata 18.0. T address item nonresponse, e apply multiple imputation using chained equations. Predictive mean matching is used for continuous and binary variables (Austin and Van Buuren, 2023), rdinal regression models for parental education, nd multinomial logistic regression for migration background. A range f auxiliary variables is included to improve he quality f he imputations, including academic performance, which is correlated with parental s cial origin, cognitive bility, and body height. To ensure high precision, e generate 100 imputed datasets. Additional user-written Stata commands employed in he analyses include *vioplot*[4],

[3] We have lso ested whether here are height differences n a smaller level, using information about districts. However, s ur ests showed hat he intraclass correlation for these models is very low (below wo percent), we have decided to use the simpler models instead, controlling only for East and West.

[4] https://ideas.repec.org/c/boc/bocode/s456902.html

binscatter[5], nd *mimrgns (*Klein, 2014*)*.

4. Results

We begin by presenting descriptive statistics to provide n overview of the NEPS d . Fig. 1 displays violin plots of body height by e and cohort. In all age groups, height is approximately normally dis ributed. At y unger es, average height levels are very similar f r irls nd b ys; however, gender differences iden ver ime nd become most pronounced the end of puberty. To ssess the quality and representa- iveness f he NEPS height d , we compare he reported heigh distributions ith official statistics. The results f his c mp rison re presented in he appendix (Table A1). Differences between he NEPS nd official data are small across most survey waves (with a few exceptions, where differences can mount at most 4.6 cm), indicating ha he NEPS provides high-quality and largely representative information for the Federal Republic f Germany f r he majority f ll survey ves. The distribution of he social rigin index is lso shown in he ppendix (Figure A1). Descriptive statistics for all other variables are reported in Table 1. Note hat binary or categorical variable means can be interpreted as shares (for example, 51% f students in the primary school cohort re girls).

To in a first impression of he association between body heigh nd parental s cial rigin, we present scatterplot ith a fitted regression line p ling all cohorts, es, nd b h genders (Fig. 2). The figure reveals a pronounced p sitive association between s cial rigin nd height up pproximately he average level f social rigin (zero on he standardized scale). Beyond his p int, the slope flattens considerably, indicating that increases in social rigin above the mean re associated ith only m rginal gains in body height nd eventually reach plateau.

We next examine he verall association between parental social rigin nd body height using multilevel regression models. The results are reported in Table 2. In he primary school cohort, the estimated coefficient for boys is approximately 0.29, indicating hat one standard deviation increase in social rigin is ssociated ith n vera ge increase in height f about 0.29 cm. This effect is statistically signific nt he 5% level. For irls, he estimated coefficient is smaller (0.13) nd not statistically significant. A similar pattern emerges in the secondary school cohort. Here in, he association between s cial origin nd height is statistically significant for boys but not f r irls. Taken ether, these findings suggest hat parental s cial origin is relevant for boys' height but not f r irls' height in the cross-sectional models, leading us o partially support Hypothesis 1. While the coefficient n e is not s raightforward o interpret— iven that survey ave indicators re also included as c ntrols —the results confirm hat older children re ller n average. In ddition, s udents ith a migration background re, n average, shorter han heir peers. Single parenthood exhibits a statistically significant negative ssociation with height only for irls in he secondary school cohort.

Then we continue ith the fixed-effect regression models, here e est whether socially benefited children row faster han other children. As ll time-constant variables automatically drop ut f hese models, there is no need o include time-constant controls. The only relevant predictors re e nd he interaction f e with social rigin. The results re shown in Table 3.

The coefficient f ge is statistically significant the 0.1% level in all models. For example, mong boys in the primary school cohor , verage rowth mounts pproximately 6.2 cm per year. The interaction between e nd s cial origin is not statistically significant for boys in the primary school cohort but is highly significant for ll her groups. This indicates that students from families with higher social rigin end row more ithin iven year. The strongest effect is bserved mong boys in the secondary school cohort, for hom annual growth increases by about 0.20 cm when parental s cial origin is ne standard deviation higher. In light f these findings, e accept Hypothesis 2. It is important to note, however, hat growth is observed in this s udy only between ges eight nd 19. F ster growth during his period does not necessarily ranslate into greater final adult height if initial height levels differ across social roups.

Finally, to better understand he association between parental social rigin nd body height a stage when height is essentially fixed, e focus n the last measurement ve f the secondary school cohort, when s udents re approximately 19 years old. We estimate linear (OLS) regression models including all control variables nd compute predicted values of height across levels f social rigin. T allow f r flexible specification without imposing a functional form n he ssociat ion, e recode he continuous s cial origin index into septiles (with 1 indicating very low social rigin nd 7 indicating very high social rigin) and use this categorical specification. The results are presented in Fig. 3.

The results reveal clear p sitive association between p renta l social rigin nd final body height, consistent with the findings from he previous models. While his ssociation is pproximately linear across most f he distribution of s cial origin, it pers ff at very high levels f origin. These general patterns re bserved for both b ys nd irls. Among boys, the difference in predicted final height between individuals from he least and most s cially dvantaged families is approximately 1.24 cm; mong irls, he corresponding difference is about 1.32 cm. For both enders, the height differences between he extreme septiles re statistically significant at he 5% level.

5. iscussion

Although not ll coefficients cross all statistical models reach conventional levels f statistical significance, he overall pattern is clear: children from socially dvantaged f milies re, n verage, taller nd exhibit f ster growth. In he models estimating average height ver childhood nd dolescence, he ssociation with social rigin is more pronounced for b ys than f r irls, for hom the effect is not statistically significant in he pooled models. Importantly, his ender difference does not ppear o be spurious, s he association between parental social rigin and height persists into early adulthood for both enders nd thus represents a stable, long-term effect. In his respect, our findings re broadly c nsistent ith the German study by Baten and B¨hm (2010), who report that unemployment, a condition closely related social rigin, is ssociated with shorter body height. By c ntr st, Kromeyer et l. (1997) do not find relationship between s cial rigin nd height; however, heir nalysis is b sed n a very small sample. Given the exceptionally large sample size available in ur panel d , it ppears hat the effect sizes, while modest, are persistent nd robust. When comparing individuals from he most socially disadvantaged nd most dvantaged roups, the height difference mounts o slightly m re han one centimetre. While this might seems large, his is smaller han differences from Austrian conscripts, here the height difference f rather recent birth cohort (1998–2002) did mount to m re than hree centimetres (Waldhör e al., 2023). F r he 1958 birth cohort in he United Kingdom, the height difference between he most extreme social roups mounts about 2.4 cm (measured age 33), indicating hat our findings re smaller than hat (Li e al., 2004). Overall, ur results are in line with evidence from her European contexts, including studies from Austria, the United Kingdom nd Spain, suggesting hat social radients in body height persist even in highly developed elfare states (Waldhör e al., 2023, Li et l., 2004, andela-Martínez et l., 2022).

While our findings demonstrate hat n ssociation between b dy height nd parental social origin persists in contemporary Western societies, the underlying mechanisms cannot be directly examined ith he available data. In p rticular, enetic factors, potentially mong he most important determinants of height, cannot be ssesed, s he NEPS does not include genetic information or measures of parental height. At

[5] https://michaelstepner.com/binscatter/

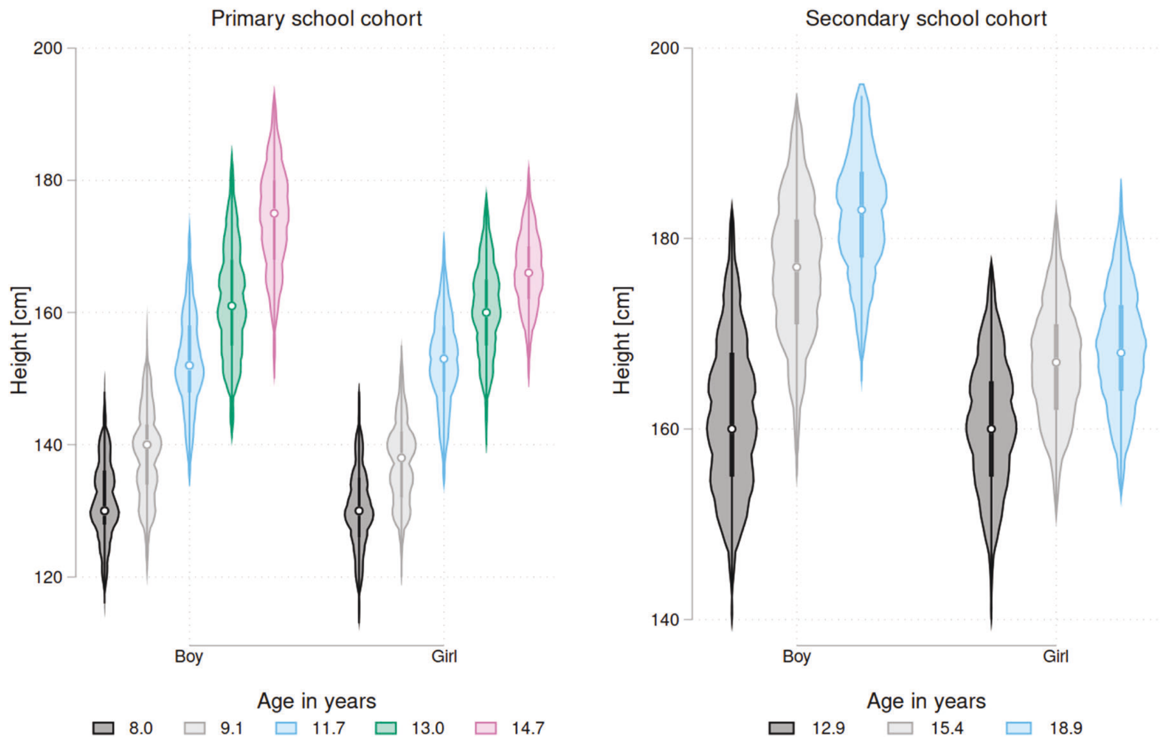

Fig. 1. Distribution of body height by cohort, ender, nd ime of survey.
Source: NEPS SC2/3, imputed data (M=100). Extreme outliers excluded for a clearer depiction.

Table 1
Descriptive sample statistics.

	Primary school cohort					Secondary school cohort				
	mean	sd	med	min	max	mean	sd	med	min	max
Female student#	0.51	0.50	1	0	1	0.48	0.50	0	0	1
Height (t1)	131.2	7.05	130	100	165	160.9	8.51	160	129	190
Height (t2)	137.9	7.45	138	95	170	171.9	8.77	171	147	195
Height (t3)	152.7	7.89	152	114	190	175.7	9.55	175	148	195
Height (t4)	161.1	8.57	160	50	196					
Height (t5)	170.0	8.58	170	117	205					
Age (t1)	8.03	0.37	8.01	6.33	9.92	12.9	0.52	12.9	10.4	15.6
Age (t2)	9.09	0.40	9.09	7.09	11.5	15.4	0.52	15.3	12.8	18.1
Age (t3)	11.7	0.35	11.7	10.7	13.5	18.9	0.53	18.8	16.6	21.9
Age (t4)	13.0	0.40	13.0	11.4	14.8					
Age (t5)	14.7	0.36	14.7	13.6	16.1					
Social origin (std)	0.15	0.97	0.11	-3.20	3.72	-0.15	1.00	-0.21	-3.33	3.83
Education mother#*										
Low	0.18	0.39	0	0	1	0.29	0.45	0	0	1
Intermediate	0.31	0.46	0	0	1	0.32	0.47	0	0	1
High	0.19	0.39	0	0	1	0.15	0.35	0	0	1
Tertiary	0.32	0.47	0	0	1	0.24	0.43	0	0	1
Education father#*										
Low	0.11	0.32	0	0	1	0.18	0.38	0	0	1
Intermediate	0.36	0.48	0	0	1	0.43	0.50	0	0	1
High	0.25	0.43	0	0	1	0.21	0.40	0	0	1
Tertiary	0.28	0.45	0	0	1	0.18	0.39	0	0	1
Parental ISEI*	55.7	15.6	54	16	90	52.0	16.4	53	16	90
Log. equivalent HH income*	7.42	0.44	7.42	4.87	10.1	7.29	0.45	7.30	5.47	10.8
Number f books home*	4.26	1.26	4	1	6	4.23	1.42	4	1	6
Age of older parent	40.0	5.87	40	22	75	44.9	5.65	45	26	76
Migration status#										
Native	0.79	0.41	1	0	1	0.76	0.43	1	0	1
Pupil born broad	0.020	0.14	0	0	1	0.045	0.21	0	0	1
At least one parent born broad	0.19	0.40	0	0	1	0.20	0.40	0	0	1
Living in East Germany#	0.15	0.36	0	0	1	0.19	0.40	0	0	1
Single parent#	0.25	0.44	0	0	1	0.27	0.44	0	0	1
Individuals	7084					6896				

Source: NEPS SC2/3, imputed data(M=100). * Components of social origin. # Mean can be interpreted s share

the same time, it appears unlikely hat other mechanisms, especially nutrition, play a major role in explaining he observed s cial gradients in

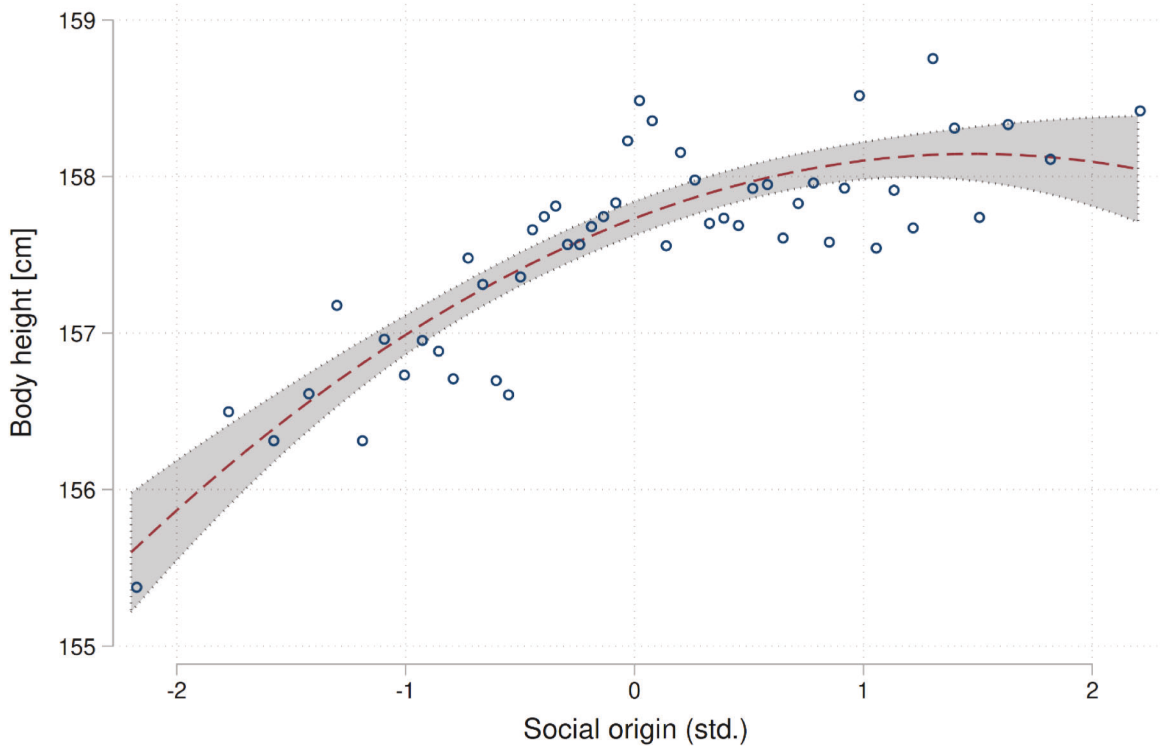

Fig. . Scatterplot between body height and social rigin.
Source: NEPS SC2/3, imputed data (M=100). Results residualized n ender, e, and cohort. Data points have been binned using binscatter for a clear depiction. 95% confidence interval included for the quadratic fit regression line.

able
Multilevel regression models.

	Primary school ohort		Secondary school ohort	
	Boys	Girls	Boys	Girls
Social origin (std)	0.294*	0.130	0.308*	0.226
	[0.012,0.577]	[-0.114,0.375]	[0.018,0.597]	[-0.045,0.497]
Age in years	5.357***	2.425***	1.899***	0.602**
	[4.429,6.286]	[1.645,3.206]	[1.366,2.433]	[0.149,1.056]
German native	Ref.	Ref.	Ref.	Ref.
Immigrant	-0.432	-2.521***	-1.561**	-1.021
	[-2.348,1.485]	[-4.020,-1.021]	[-2.695,-0.427]	[-2.151,0.108]
Parents are immigrants	-0.691*	-0.796**	-1.276***	-1.718***
	[-1.367,-0.015]	[-1.377,-0.215]	[-1.920,-0.631]	[-2.301,-1.135]
Living in East Germany	-0.101	-0.326	0.037	0.421
	[-0.799,0.596]	[-0.942,0.291]	[-0.674,0.747]	[-0.202,1.043]
Age of older parent	0.027	0.036	-0.006	-0.042
	[-0.019,0.073]	[-0.002,0.074]	[-0.063,0.050]	[-0.092,0.009]
Single parent	-0.103	-0.139	-0.086	-0.640*
	[-0.680,0.473]	[-0.656,0.378]	[-0.772,0.599]	[-1.242,-0.037]
Time point 1	Ref.	Ref.	Ref.	Ref.
Time point 2	0.956	4.196***	10.612***	5.085***
	[-0.137,2.049]	[3.277,5.116]	[9.279,11.946]	[3.959,6.210]
Time point 3	1.390	13.466***	9.597***	4.610***
	[-1.979,4.760]	[10.602,16.329]	[6.370,12.824]	[1.887,7.333]
Time point 4	3.328	17.808***		
	[-1.305,7.961]	[13.911,21.704]		
Time point 5	6.538*	19.617***		
	[0.380,12.695]	[14.428,24.806]		
onstant	87.709***	109.908***	137.368***	155.001***
	[80.214,95.203]	[103.532,116.24]	[130.254,144.48]	[148.845,161.15]
Observations	17,310	18,110	10,671	10,017
Individuals	3,462	3,622	3,557	3,339

Source: NEPS SC2/3, imputed data (M=100). 95% confidence intervals based on robust standard errors in brackets. * p < 0.05, ** p < 0.01, *** p < 0.001

height. Never before in human history have societies been s affluent s present-day Germany, here ccess to sufficient and high-quality food is largely ensured, even for socially disadvantaged families. Current public health challenges, such s he obesity pandemic, suggest that unrestricted ccess to calories rather than nutritional deprivation has become the dominant issue, making it improbable that malnutrition cco unts for

Table 3
FE Regression models.

	Primary school ohort		Secondary school cohort	
	Boys	**Girls**	**Boys**	**Girls**
Age in years	6.23***	5.49***	3.39***	1.33***
	[6.18,6.27]	[5.45,5.53]	[3.34,3.45]	[1.29,1.37]
Age # Social origin (std)	0.02	0.10***	0.20***	0.17***
	[-0.03,0.06]	[0.06,0.14]	[0.14,0.26]	[0.12,0.21]
onstant	81.23***	87.43***	120.35***	144.85***
	[80.78,81.68]	[87.03,87.84]	[119.48,121.22]	[144.23,145.47]
Observations	17,310	18,110	10,671	10,017
Individuals	3462	3622	3557	3339

Source: NEPS SC2/3, imputed data (M=100). 95% confidence intervals based on robust standard errors in brackets. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

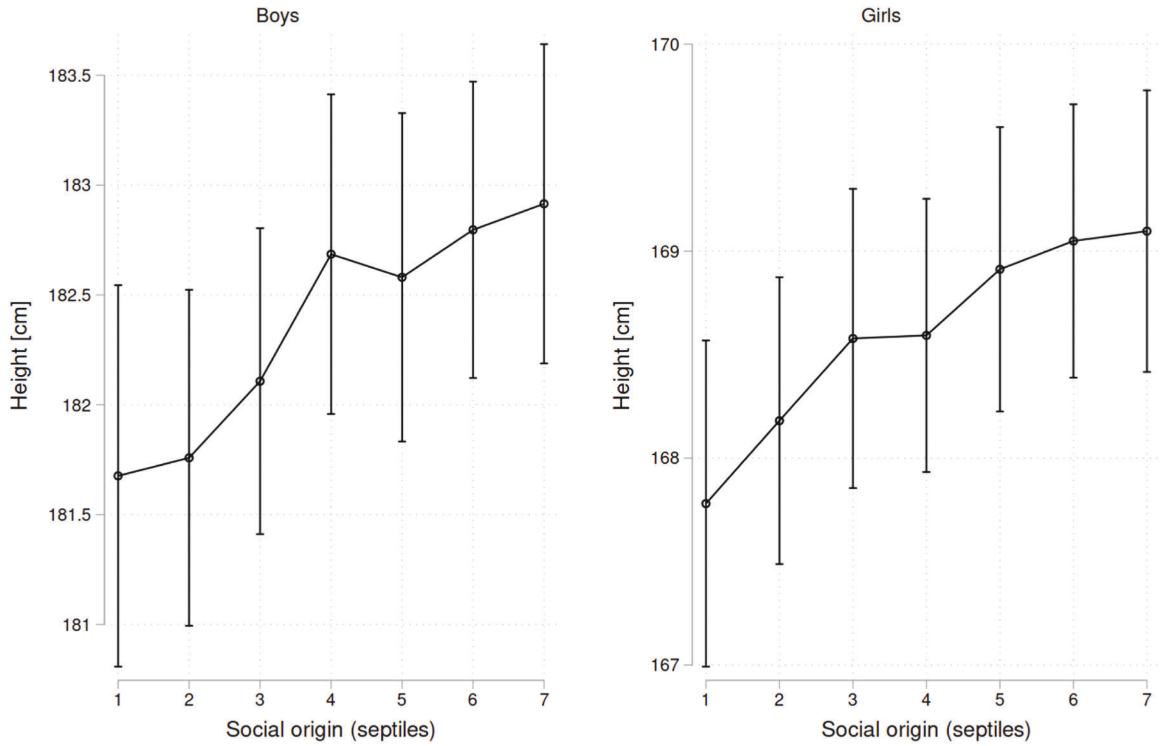

Fig. 3. Relation between social rigin and body height in the last survey   ve   f the secondary school cohort (at age 19).
Source: NEPS SC2/3, imputed data (M=100; N = 3557/3339). 95% confidence intervals included. Control variables: age, place of residence, max. parental   e, migration background, single parent. Septile 1: lowest social   rigin.

socially patterned differences in height (Hoebel et l., 2022; Kimm and Obarzanek, 2002).

The study by Baten and Böhm (2010) nevertheless provides informative clues, s their results indicate a negative association between offspring height and parental unemployment. While unemployment in Germany is unlikely to lead to nutritional deprivation, psychol ical stress and related mechanisms may be relevant. Although genetic endowments are fixed at conception, epigenetic processes (through hich gene expression can be altered by environmental conditions) may play an important role. Stress has been shown   affect such epigene ic mechanisms, raising he possibility hat chronic exposure   poverty-related stress could influence rowth by modulating he expression f rowth-related genes (Mousikou et al., 2023). Physiological details f this process have also been studied in mice (Foertsch et l., 2017). Although this mechanism cannot be tested directly in our study, it ffers a potentially fruitful avenue for future research. Importantly, the effect sizes identified in ur nalyses are modest. This sug ests hat, lthough he association between social rigin and body height persists, it is considerably smaller than it likely was in earlier historical periods. For example, differences mounted   about 4 cm between the lowest and highest social strata in Stuttgart in 1771 (Komlos et al., 1992), nd even around 1900, differences up to 4 cm were reported between l er rank soldiers of different social rigins (Blum, 2013). Body height therefore does not constitute a salient marker by which individuals from different social strata can easily be distinguished; a development hat can be regarded as positive. Nevertheless, hen perating across large populations, even small differences in height may be consequential, particularly iven he well-documented links between body heigh nd occupational success (Bittmann, 2020; Cinnirella, 2011; Thompson et al., 2023). Consequently, body height should not be entirely verlooked s a dimension of social inequality, even in modern nd ffluent societies.

An additional finding, suggested by several f he raphical na lyses, is that social origin matters most   the lower end f the soci economic distribution. In this range, he association between social ri in nd height is strongest, whereas it diminishes nce n verage r boveaverage standard of living is attained. Why exactly this pattern rises remains unclear in the current setting, s the study is neither enetically informed, nor exact living conditions (such s available nutrition) ere measured. While it seems unlikely that in highly developed country such as Germany malnourishment, especially in the early childhood, is common in he lower social strata, it cannot be ruled ut this p int. Given that, we refrain from ffering a general explanation.

Finally, we discuss several limitations f this study. First, ll height measurements re self-reported, either by parents or by the students themselves. Self-reported data may introduce measurement error nd potentially bias the estimates. Nevertheless, we believe that such dis- rtions re likely to be limited. omparisons between the NEPS height data nd official statistics indicate only small deviations. Moreover, because height is measured repeatedly for the same individuals, r nd m measurement error is expected verage ut ver ime, which represents a substantial dvantage f ur panel design compared with s udies relying solely on cross-sectional data. However, we cannot entirely rule out he presence of systematic reporting error—for instance, if parents from s cially dvantaged families c nsistently verestimate heir children's height.[6]

Second, lthough ur measure f social rigin incorporates wide range f indicators, here is no universally accepted definition f his concept, nd lternative perationalizations may emphasize different dimensions. We argue, h ever, hat our multidimensional pproa ch captures several c re spects f social rigin nd thereby provides robust representation f he construct. Third, hile the NEPS ffers large and rich dataset, it does not perfectly represent he entire population of pupils in Germany. In he bsence f comprehensive national student register, it is not p ssible to directly ssess the extent hich the sample deviates from he target population. Although this limitation may ffect the descriptive statistics, it is less problematic f r he multivariable nalyses, as many relevant characteristics, such as region of residence nd migration background, are explicitly controlled for in the estimation models. Also related he datasources is hat he youngest ges in he study re about eight years, meaning that not he entire rowth-process can be investigated. This is especially relevant since children from lower socioeconomic b ckgrounds re ften lready smaller at birth (Howe et l., 2012), meaning that it might be difficult compensate f r his initial disadvantage ver he following years. In her ords, main social height inequalities might lready be present hen he child is b rn nd our study might not pick this up due t temporal design f he two cohorts. Other studies might nt dd data sources that start at birth, so hat no developmental phase is omitted from he analyses. In ny case, his limitation should not be severe s the most relevant utcome, the final body height when individuals stop rowing, is included in the window of bservation.

6. Conclusion

This study examines he association between parental social ri in and students' body height using longitudinal panel data from wo l rge German cohorts covering ages eight o 19. We show hat parental s cial origin is positively ssociated with body height. Children from s cially advantaged families not nly row faster han their peers but lso in greater final adult height. The gap in final height between individuals from he most socially disadvantaged nd he most advantaged f milies exceeds 1.2 cm. These findings hold for both boys nd irls nd indicate that body height remains a relevant, albeit m dest, dimension o f social inequality in contemporary Germany.

Data and ode

Data re available for researchers after registration from http://dx.doi.org/10.5157/NEPS:SC2:11.0.0 nd http://dx.doi.org/10.5157/NEPS:SC3:13.1.0. Complete Stata programming do-files re available from the authors upon request.

CRediT a thorship contribution statement

Felix B ttmann: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Pr ject dministration, Methodology, Investigation, Funding acquisition, Formal nalysis, onceptualization.

Funding

No funding s available for this s udy.

Declaration of Competing Interest

The authors state hat there is no conflict of interest. This s udy did not receive any special funding.

Appendix A

Table A1
omparison of NEPS height measurements o official statistics (in brackets)

mepoint	Average Age	Boys	Girls
Primary school cohort			
1	8.0	130 [130.8]*	130 [129.5]*
2	9.1	140 [136.4]*	138 [135.3]*
3	11.7	152 [149.4]*	153 [151.0]*
4	13.0	161 [159.1]*	160 [159.5]*
5	14.7	175 [170.4]*	166 [163.8]*
Secondary school cohort			
1	12.9	160 [159.1]*	160 [159.5]*
2	15.4	177 [175.2]*	167 [165.1]*
3	18.8	182.4 [181.8]#	168.6 [167.7]#

References: * Robert Koch-Institut: https://www.gbe-bund.de/pdf/3_Koerperlaenge_erw_aufl.pdf (reporting and comparing medians)
German Federal Statistical Office: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Gesundheit/Gesundheitszustand-Relevantes-Verhalten/Tabellen/liste-koerpermasse.html#119168 (reporting nd

[6] To est his, we have included the Big-5 personality rait " onscientiousness " in he models f r he secondary school cohort, where his construct has been measured. However, the conclusions f the models never change nd he coefficient of conscientiousness is never statistically significant. The assumption is hat students with high levels f conscientiousness report heir height diligently.

comparing arithmetic means)

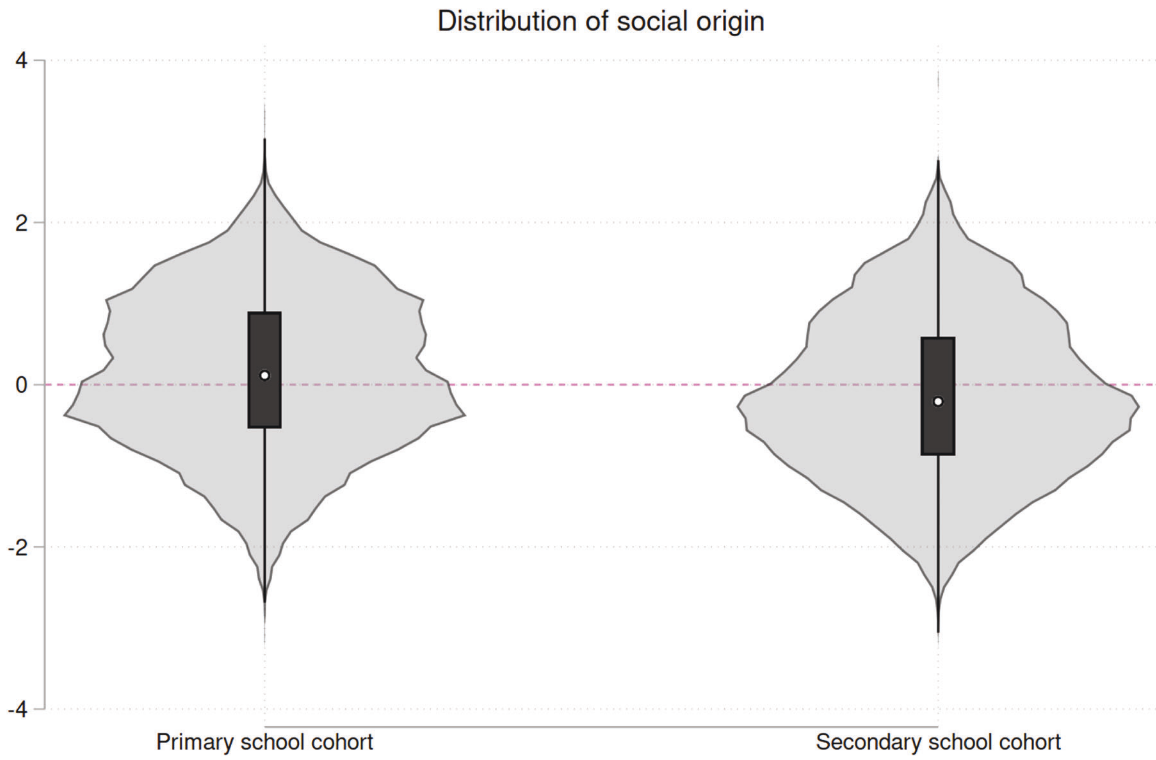

Figure A1. Distribution of social origin by cohort
Source: NEPS SC2/3, imputed data (M=100).

Data availability

The authors do not have permission to share data.

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