# Adolescents' perceptions of family social status correlate with health and life chances: A twin difference longitudinal cohort study

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**Children from lower-income households are at increased risk for poor health, educational failure, and behavioral problems. This social gradient is one of the most reproduced findings in health and social science. How people view their position in social hierarchies also signals poor health. However, when adolescents' views of their social position begin to independently relate to well-being is currently unknown. A cotwin design was leveraged to test whether adolescents with identical family backgrounds, but who viewed their family's social status as higher than their same-aged and sex sibling, experienced better well-being in early and late adolescence. Participants were members of the Environmental Risk Longitudinal Twin Study, a representative cohort of British twins ($n$ = 2,232) followed across the first 2 decades of life. By late adolescence, perceptions of subjective family social status (SFSS) robustly correlated with multiple indicators of health and well-being, including depression; anxiety; conduct problems; marijuana use; optimism; not in education, employment, or training (NEET) status; and crime. Findings held controlling for objective socioeconomic status both statistically and by cotwin design after accounting for measures of childhood intelligence (IQ), negative affect, and prior mental health risk and when self-report, informant report, and administrative data were used. Little support was found for the biological embedding of adolescents' perceptions of familial social status as indexed by inflammatory biomarkers or cognitive tests in late adolescence or for SFSS in early adolescence as a robust correlate of well-being or predictor of future problems. Future experimental studies are required to test whether altering adolescents' subjective social status will lead to improved well-being and social mobility.**

subjective social status | social gradient in health | adolescence | mental health | educational achievement

The life chances of children depend heavily on the resources of the family that they are born into. Children who grow up in low-income households are more likely to suffer from mental illness, have contact with the justice system, experience educational failure, and die at an earlier age than children from more affluent families (1, 2). The social gradient is one of the most cited and reproduced findings across medicine, social science, and education research (3). This effect is not driven by poverty alone; the gradient is observed even among those at the highest levels of the socioeconomic distribution, where access to health care, adequate nutrition, educational opportunity, and related supports are plentiful (4, 5).

How individuals perceive their social status in relation to others (referred to as subjective social status) also reliably marks differences in health and life outcomes beyond what would be expected given objective circumstances. Adults' subjective social status has been associated with mental (6) and physical health problems (7) and in some studies, relates more strongly to health outcomes than education, income, and/or employment (7, 8). Although less is known about the role of subjective social status earlier in life, adolescents who perceive their family to be higher in terms of socioeconomic status (SES) or social status also tend to report fewer mental health problems, with smaller and less consistent linkages observed with physical health (9).

Unfortunately, limitations in past research have constrained our ability to understand whether, when, and how subjective social status relates to adolescents' well-being. First, it is difficult to comprehensively measure financial and material resources (such as wealth and other assets beyond income), leaving the possibility that unmeasured material differences drive differences in both perceptions of status and in health and well-being. This study used data gathered prospectively across the first 2 decades of life among a birth cohort of 2,232 twins to test whether adolescents' perceptions of their family's social status, referred to throughout as subjective family social status (SFSS), are robustly associated with key indicators of health and well-being.

## Significance

Despite growing up in the same family, siblings do not always see their family's social standing identically. Eighteen-year-old twins who rated their family as having higher social standing, compared with their cotwin's rating, had fewer difficulties negotiating the transition to adulthood: they were less likely to be convicted of a crime, not in education, employment, or training, and had fewer mental health problems. The same pattern of findings was not seen earlier in adolescence when the twins were aged 12 y. By late adolescence, young people's beliefs about where their family was located in a hierarchical social system signaled how well they were doing, irrespective of their families' access to objective financial resources and their earlier psychological vulnerabilities.

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A twin difference design was used to control for poverty status, access to financial resources, and other environmental and genetic factors shared by children within the same family. This design controls for one of the largest validity threats to the interpretation of prior correlational findings and provides a stringent and rare opportunity to test whether associations are robust to within-family controls for access to financial resources. If adolescents' subjective social status is independently linked to social gradients in their life outcomes, then this would support investing in intervention trials targeting status-based perceptions to determine whether such associations have directional or causal features. However, if gradients in health and well-being are fully accounted for by access to material and financial resources, then altering perceptions might improve young people's view of their social position, but such changes are unlikely to influence their life chances or well-being.

Second, developmentally, it is not known when young people's social status perceptions first begin to correlate with health and well-being. Developmental theory suggests that subjective social status should become more strongly linked to well-being indicators across adolescence, a time that is marked by heightened social awareness, cognitive maturation, and increased sensitivity to social comparisons (10). That is, young people are expected to become more aware and responsive to social hierarchies as they develop a more stable and fully evolved sense of their social position (11, 12). Because prior research has focused on adults and older adolescents, we begin by testing whether prior linkages between older adolescents' SFSS and well-being hold when subjected to both regression and cotwin controls. We then test whether similar patterns are observed in early adolescence, at age 12, and whether perceptions of social status in early adolescence predict future well-being. Prospectively, we describe how stable adolescents' views of their social standing are across adolescence and test whether they become more closely calibrated with their objective family SES over time.

Third, most studies have relied on individuals to report on both their subjective social status and their well-being, raising the possibility that common method bias (i.e., gathering information on both the predictor and outcome from the same source [13]) accounts for linkages. Here, multiple modes of data collection and sources of information—self-, parent, and teacher report; administrative records; standardized cognitive testing; and biological assays—were used to test whether common method bias explains observed associations.

More specifically, this study tested whether

1) adolescents who viewed their family as having higher SFSS had fewer difficulties with respect to mental health, physical health, education, and training and fewer criminal convictions after statically accounting for objective childhood family SES and childhood risks;

2) adolescents with higher SFSS experienced fewer difficulties than their same-sex sibling born at the same time and into the same objective family circumstances, providing a stringent test, by design, of whether unmeasured confounding due to objective SES accounted for linkages between SFSS and well-being;

3) adolescents' SFSS was more strongly associated with well-being indicators in late vs. early adolescence and whether SFSS in early adolescence predicted future well-being; and

(4) adolescents' SFSS was linked with both self-reported and alternatively sourced indicators of well-being as a robustness check of whether common method bias accounted for linkages between adolescents' SFSS and well-being.

Adolescents' SFSS was measured at ages 12 and 18 using an adapted version of the MacArthur subjective social status measure (14), which asked adolescents to choose the rung of a ladder that best represented their family's socioeconomic position relative to others across the country. Higher ratings corresponded to the perception that their family was better off relative to others. Mental health; IQ; inflammatory biomarkers; educational achievement; optimism toward the future; not in education, employment, or training (NEET) status; and crime were assessed via multiple methods at age 18. Multiple sources of mental health and cognitive ability measures were available at age 12. Assessments of family SES, neighborhood poverty, risk of poor mental health and cognitive functioning, and negative appraisal bias (negative affect and neuroticism) were also gathered from multiple sources and included in multiple regression models to control for potential confounding. All analyses were conducted in Stata/SE version 14.

## Results

The Environmental Risk (E-Risk) Longitudinal Twin Study sample represents the full range of objective family social position with families drawn equally from local areas ranging from the most to the least deprived in the United Kingdom (*SI Appendix*, Fig. S1). Within families, there was substantial variation in adolescents' perceptions of their families' social standing (age 18: $r = 0.44$, 95% confidence interval [95% CI] = [0.39, 0.50], $P < 0.001$) despite the fact that objective socioeconomic background is perfectly correlated between siblings raised in the same household (1.0). As shown in Fig. 1, adolescents' well-being at age 18 was significantly associated with both objective SES (black bars) and SFSS (blue bars), although there was substantial variation in the strength of associations depending on the domain. Four of 5 indicators of adolescents' mental health as well as optimism for the future were more strongly associated with SFSS than with objective SES. Conversely, IQ, one of the inflammation biomarkers, and educational achievement were more strongly correlated with objective SES than with SFSS. NEET status, crime, and the remaining mental and physical health indicators were similarly correlated with both SES and SFSS.

**Do Young People Who View Their Families as Having Higher Social Status Experience Fewer Difficulties in Late Adolescence?** Table 1 displays cross-sectional associations at age 18 between adolescents'

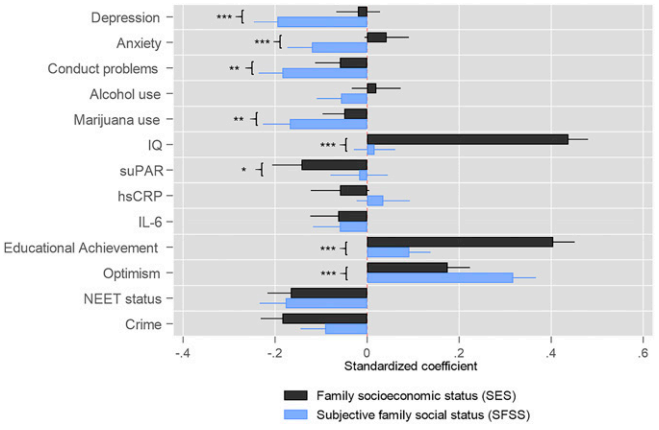


**Fig. 1.** Multiple regression coefficients of adolescents' indicators of well-being at age 18 with SFSS at age 18 and family SES at age 5 ($INDICATOR_i = \beta_0 + \beta_1 \times SES_i + \beta_2 \times SFSS_i + \varepsilon_i$). Bars represent standardized multiple regression coefficient estimates, with black bars representing coefficients for SES and blue bars representing coefficients for SFSS. Lines indicate 95% CIs. Regression error terms ($\varepsilon_i$) were clustered at the family level to account for correlation of the error terms within family. *N* varies by indicator based on the availability of complete data on the dependent variable (*SI Appendix*, Table S1 has *N* of each variable). Significance is based on *P* values for tests of equality of $\beta_1$ with $\beta_2$. hsCRP, high-sensitivity C-reactive protein; IL-6, interleukin 6; suPAR, soluble urokinase plasminogen activator receptor. *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

**Table 1. Associations between adolescents' SFSS at age 18 and well-being indicators at age 18**

| | | Model 1: Unadjusted | | | | Model 2: Covariate adjusted | | | | Model 3: Twin differences | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Well-being indicator | *N* | *B* | SE | $\beta$ | *P* | *B* | SE | $\beta$ | *P* | *B* | SE | $\beta$ | *P* |
| Depression | 2,063 | **−0.81** | **0.10** | **−0.20** | **0.000** | **−0.75** | **0.10** | **−0.19** | **0.000** | **−0.61** | **0.15** | **−0.13** | **0.000** |
| Anxiety | 2,060 | **−0.26** | **0.06** | **−0.11** | **0.000** | **−0.28** | **0.07** | **−0.12** | **0.000** | **−0.23** | **0.11** | **−0.08** | **0.026** |
| Conduct problems | 2,053 | **−0.63** | **0.08** | **−0.20** | **0.000** | **−0.47** | **0.08** | **−0.15** | **0.000** | **−0.41** | **0.11** | **−0.14** | **0.000** |
| Alcohol use | 2,063 | **−0.11** | **0.06** | **−0.05** | **0.046** | −0.10 | 0.06 | −0.05 | 0.082 | −0.06 | 0.08 | −0.02 | 0.430 |
| Marijuana use | 2,066 | **−0.24** | **0.04** | **−0.18** | **0.000** | **−0.20** | **0.04** | **−0.15** | **0.000** | **−0.12** | **0.06** | **−0.08** | **0.047** |
| IQ | 2,056 | **3.30** | **0.51** | **0.16** | **0.000** | −0.31 | 0.34 | −0.02 | 0.364 | 0.17 | 0.64 | 0.01 | 0.791 |
| suPAR | 1,444 | **−0.08** | **0.04** | **−0.07** | **0.024** | −0.02 | 0.04 | −0.01 | 0.656 | −0.02 | 0.04 | −0.02 | 0.579 |
| hsCRP | 1,430 | 0.03 | 0.05 | 0.01 | 0.612 | 0.05 | 0.05 | 0.03 | 0.321 | 0.02 | 0.07 | 0.01 | 0.744 |
| IL-6 | 1,440 | **−0.07** | **0.03** | **−0.08** | **0.006** | −0.05 | 0.03 | −0.06 | 0.077 | −0.08 | 0.05 | −0.08 | 0.093 |
| Educational achievement | 2,061 | **0.27** | **0.03** | **0.23** | **0.000** | **0.05** | **0.02** | **0.05** | **0.019** | −0.04 | 0.04 | −0.04 | 0.270 |
| Optimism | 2,061 | **1.62** | **0.11** | **0.38** | **0.000** | **1.25** | **0.11** | **0.29** | **0.000** | **0.82** | **0.16** | **0.18** | **0.000** |
| NEET status | 2,066 | **−0.10** | **0.01** | **−0.23** | **0.000** | **−0.07** | **0.01** | **−0.16** | **0.000** | **−0.08** | **0.02** | **−0.17** | **0.000** |
| Crime | 2,060 | **−0.07** | **0.01** | **−0.16** | **0.000** | **−0.02** | **0.01** | **−0.06** | **0.029** | **−0.04** | **0.02** | **−0.10** | **0.021** |

Estimates from bivariate and multiple regression models where health and well-being indicators at age 18 are regressed on adolescents' SFSS at age 18 in unadjusted (model 1); adjusted with covariates for age 5 SES and negative affect as well as age 12 neuroticism, externalizing behaviors, and IQ (model 2: $INDICATOR_i = \beta_0 + \beta_1 \times SFSS_i + \beta_2 \times \boldsymbol{X}_i + \varepsilon_i$, where $\boldsymbol{X}$ represents a set of individual covariates); and twin difference models [model 3; where for twin $i$ with sibling $j$: $INDICATOR_i - INDICATOR_j = \beta_0 + \beta_1 \times (SFSS_i - SFSS_j) + \varepsilon_i$]. Results did not differ when sex was included as a covariate. Crime was the only indicator for which a sex × SFSS interaction term was statistically significant in model 1 ($B = 0.05$, SE = 0.02, $P = 0.02$, with a stronger association for females); however, this interaction was not significant in model 2 or 3. Full-information maximum likelihood estimation was applied so that *N* values correspond to complete data available on each of the dependent variables. *SI Appendix*, Table S2 provides a full listing of the number of cases available for each covariate, independent variable, and dependent variable in each model. Regression error terms $(\varepsilon_i)$ were clustered at the family level to account for correlation of the error terms within family. Estimates for dichotomous indicators (NEET status and crime) are from linear probability models; findings are substantively similar if logistic models are used. Boldfaced results indicate $P < 0.05$. hsCRP, high-sensitivity C-reactive protein; IL-6, interleukin 6; suPAR, soluble urokinase plasminogen activator receptor.



SFSS and key indicators of well-being. Unadjusted coefficients (Table 1, model 1) are presented alongside covariate-adjusted estimates (Table 1, model 2), which control for objective SES using childhood measures of family SES, economic hardship as reported by parents, and neighborhood-level poverty assessed via geocoded administrative and survey data. The multiple regression models also control for childhood negative affect assessed by interviewers during in-home assessments as well as age 12 externalizing behaviors (rated by parents and teachers), neuroticism (rated by interviewers), and IQ.

Two main findings are displayed in Table 1. First, in the unadjusted models (Table 1, model 1), adolescents who rated their family as having lower social status at age 18 experienced worse health and well-being based on 12 of the 13 indicators ($\beta$ values ranged from −0.05 for self-reported alcohol use to $\beta = 0.38$ for optimism toward the future). Second, in the covariate-adjusted regression models (Table 1, model 2), adolescents' lower perceptions of their family's social standing at age 18 remained significantly associated with worse ratings on 8 of the 13 indicators of health and well-being at age 18, including anxiety, depression, conduct problems, marijuana use, educational attainment, optimism toward the future, NEET status, and crime (magnitude of associations ranged from $\beta$ values of 0.05 to 0.29).

**Do Adolescents with Higher SFSS Experience Fewer Problems after Controlling for Objective Financial Resources by Design (Family-Level Fixed Effects)?** One explanation for the remaining associations between adolescents' SFSS and key indicators of health and well-being is that adolescents' appraisals merely index unmeasured variation in objective family resources. To address this possibility, the twin design was leveraged to control for access to objective financial resources during childhood as well as for other environmental and genetic factors that are shared between siblings within the same family. Here, we tested the hypothesis that differences in SFSS among children growing up in the same family (i.e., with identical financial resources at the household level) would be correlated with sibling differences in mental health, inflammatory biomarkers, IQ, educational achievement, optimism toward the future, NEET status, and crime. The siblings were same-aged and same-sex twin pairs, which also controlled for potential sex-linked or period-based influences on the estimates.

As shown in Table 1, model 3, at age 18, in the most restrictive twin difference models, adolescents' SFSS remained significantly associated with all of the indicators that were robust to regression-based controls, except for alcohol use and educational attainment (for which effect size estimates reduced by ∼50% and were no longer statistically significant at the $P < 0.05$ level). Notably, in both the multiple regression-controlled and cotwin models, adolescents' ranking of their family as lower social status at age 18 was not independently associated with lower IQ or elevated inflammatory biomarkers, and initial associations with educational achievement were accounted for by factors shared by the siblings raised in the same family vs. sibling differences in social status perceptions.

**Are Young Adolescents' Perceptions of Their Families' Social Standing Robustly Linked with Concurrent and/or Future Wellbeing Indicators?** In contrast to the findings at age 18, we found little evidence to support SFSS as a marker of well-being when the twins were in early adolescence. At age 12, adolescents' SFSS was significantly associated with only 1 of the 8 well-being indicators (depressive symptoms) after adjusting for shared genetic and environmental factors in the twin difference models (Table 2); however, this association did not hold for informant-rated depressive symptoms ($\beta = 0.03$, 95% CI = [−0.03, 0.09], $P = 0.348$). Adolescents' SFSS at age 12 was also not a robust predictor of future indicators of well-being; across the unadjusted and cotwin models, adolescents' SFSS was consistently related to only 1 of the age 18 well-being indicators (depressive symptoms: $\beta = -0.07$, 95% CI = [−0.13, −0.002], $P = 0.043$), although this association did not hold in the multiple regression-controlled models after accounting for earlier depressive symptoms and other covariates (*SI Appendix*, Table S3*B*). Again, this association did not hold for informant-reported (teacher and parent) depressive symptoms (twin difference model: $\beta = 0.00$, 95% CI = [−0.07, 0.06], $P = 0.976$). Given the lack of

**Table 2. Associations between adolescents' SFSS at age 12 and well-being indicators at age 12**

| | | Model 1: Unadjusted | | | | Model 2: Covariate adjusted | | | | Model 3: Twin differences | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Well-being indicator | *N* | *B* | SE | *β* | *P* | *B* | SE | *β* | *P* | *B* | SE | *β* | *P* |
| Mental health | | | | | | | | | | | | | |
| Depression | 2,130 | **−1.00** | **0.24** | **−0.12** | **0.000** | **−0.80** | **0.23** | **−0.10** | **0.001** | **−0.71** | **0.31** | **−0.08** | **0.022** |
| Anxiety | 2,130 | **−0.40** | **0.12** | **−0.09** | **0.001** | **−0.23** | **0.11** | **−0.05** | **0.044** | 0.00 | 0.15 | 0.00 | 0.978 |
| Conduct problems | 2,120 | −0.24 | 0.13 | −0.05 | 0.060 | −0.16 | 0.11 | −0.04 | 0.142 | −0.33 | 0.17 | −0.08 | 0.056 |
| Alcohol/cigarette use | 2,117 | −0.05 | 0.02 | −0.06 | 0.051 | −0.04 | 0.02 | −0.05 | 0.075 | −0.05 | 0.04 | −0.06 | 0.199 |
| Marijuana/drug use | 2,117 | **−0.11** | **0.05** | **−0.06** | **0.028** | **−0.10** | **0.05** | **−0.05** | **0.036** | −0.10 | 0.08 | −0.06 | 0.187 |
| Cognitive performance | | | | | | | | | | | | | |
| Math ability | 1,374 | 0.05 | 0.05 | 0.04 | 0.270 | −0.02 | 0.04 | −0.02 | 0.523 | 0.06 | 0.05 | 0.05 | 0.244 |
| English ability | 1,638 | 0.02 | 0.04 | 0.02 | 0.568 | −0.05 | 0.04 | −0.03 | 0.219 | 0.05 | 0.05 | 0.04 | 0.280 |
| IQ | 2,128 | −0.55 | 0.66 | −0.02 | 0.401 | **−2.21** | **0.56** | **−0.10** | **0.000** | −0.74 | 0.55 | −0.05 | 0.180 |

Estimates from bivariate and multiple regression models of health and well-being indicators at age 12 on adolescents' SFSS at age 12 in unadjusted (model 1), adjusted with covariates for age 5 SES and negative affect as well as age 12 neuroticism and externalizing behaviors (model 2: $INDICATOR_i = \beta_0 + \beta_1 \times SFSS_i + \beta_2 \times \boldsymbol{X}_i + \varepsilon_i$, where $\boldsymbol{X}$ represents a set of individual covariates), and twin difference models [model 3; where for twin $i$ with sibling $j$: $INDICATOR_i - INDICATOR_j = \beta_0 + \beta_1 \times (SFSS_i - SFSS_j) + \varepsilon_i$]. Results did not differ when sex was included as a covariate, and sex did not moderate any of the associations between SFSS and well-being indicators. Full-information maximum likelihood estimation was applied so that *N* values correspond to complete data available on each of the dependent variables. *SI Appendix*, Table S2 provides a full listing of the number of cases available for each covariate, independent variable, and dependent variable in each model. Regression error terms $(\varepsilon_i)$ were clustered at the family level to account for correlation of the error terms within family. Among the 6 well-being indicators available at both age 12 and age 18, there were significant age × SFSS interactions in models of conduct problems ($\beta = -0.32$, $P = 0.005$), alcohol use ($\beta = -0.54$, $P < 0.001$), and IQ ($\beta = 0.56$, $P < 0.001$), all corresponding to stronger associations at age 18. Boldfaced results indicate $P < 0.05$.

concurrent or prospective associations between SFSS measured in early adolescence and well-being indicators, the remaining robustness checks for common method variance focus only on age 18.

With respect to changes in SFSS over time, there was a significant amount of change in the rank ordering of adolescents' perceptions of their family's social status across adolescence (stability coefficient, $r = 0.23$, 95% CI = [0.19, 0.28], $P < 0.001$). Adolescents' perception of their family's social status also became more strongly correlated with objective assessments of childhood SES (parental reports of education, employment, and income measured at age 5) between age 12 ($r = 0.15$, 95% CI = [0.10, 0.20], $P < 0.001$) and age 18 ($r = 0.33$, 95% CI = [0.28, 0.37], $P < 0.001$; SES × age interaction: $\beta = 0.27$, 95% CI = [0.19, 0.34], $P < 0.001$).

**Does Common Method Bias Account for Remaining Associations between Adolescents' SFSS and Mental Health Indicators?** We used informant reports and administrative records to test whether remaining associations between adolescents' SFSS and well-being could be accounted for by common method bias in cases where adolescents reported on both their SFSS and well-being.

At age 18, informant reports were available for all 4 of the mental health indicators that remained significant in the most restrictive cotwin models: depression, anxiety, conduct problems, and marijuana use. As shown in Fig. 2, adolescents' SFSS was significantly associated with both self and alternatively sourced measures of both depressive symptoms and conduct problems/crime, even after estimating associations in the most stringent cotwin control models.

As detailed previously in Table 1, alternatively sourced or objective measures were also available for cognitive functioning, inflammatory biomarkers, and educational attainment, for which no robust associations were documented, and for a key social and economic indicator (NEET status), which did remain associated with adolescents' SFSS across both regression and cotwin-controlled models.

## Discussion

Results from this study advance our understanding of how adolescents' perceptions of their families' social status relate to health and well-being in 3 main ways. First, the cotwin design provided the unique opportunity to address one of the largest validity threats in prior research and to test whether associations between adolescents' SFSS and well-being are robust to within-family controls for shared financial resources and other factors that are shared at the family level. Based on a recent meta-analysis (9), only 50% of prior studies have included any objective measure of SES as a control for this potential confound. Here, we account for objective SES statistically using multiple measures of family and neighborhood SES as well as by design, holding access to financial and social resources constant between children growing up in the same family. At age 18, associations between adolescents' subjective social status and depression,

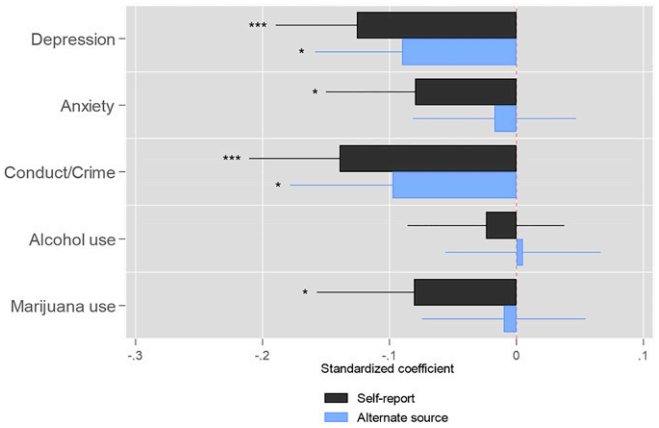


**Fig. 2.** Cross-sectional twin difference associations of adolescents' SFSS at age 18 with self-reported vs. alternative source indicators of mental health at age 18. Bars represent the standardized coefficients from cotwin models where twin difference scores of mental health indicators at age 18 (vertical axis) are regressed on twin difference scores of adolescents' SFSS [for twin $i$ with sibling $j$: $INDICATOR_i - INDICATOR_j = \beta_0 + \beta_1 \times (SFSS_i - SFSS_j) + \varepsilon_i$]. Lines indicate 95% CIs. Regression error terms $(\varepsilon_i)$ were clustered at the family level to account for correlation of the error terms within family. Crime at age 18 was used in place of a direct informant-reported measure of conduct problems at age 18. *N* varies by indicator based on the availability of complete data on the dependent variable (*SI Appendix*, Table S1 has *N* of each variable). Colors indicate data collection method of self-report vs. alternatively sourced (mother and teacher report of mental health and administrative records of official crime). Significance is based on *P* values for tests of equality with 0. $*P < 0.05$; $***P < 0.001$.

anxiety, conduct problems, optimism toward the future, NEET status, and crime were robust to within-family controls for shared family-level factors, including access to objective financial and related resources. That is, young people's perceptions of their social status—over and above their access to financial resources and earlier risks for mental health problems and negative appraisal bias—were independently associated with costly outcomes by late adolescence. Where young people believe they stand in a hierarchical social system appears to serve as a robust signal of how well they are doing in terms of mental health, social, and economic indicators, irrespective of both where they (objectively) come from and their psychological vulnerabilities present earlier in life.

It is important to note that the cross-sectional nature of the data at age 18 leaves us unable to rule out reverse causation (e.g., that adolescents who are depressed or who have committed a crime consequently rated their families as having lower social standing). If reverse causation is operating and negative yet relatively common experiences, such as criminal justice system involvement, mental health problems, or unemployment, are leading adolescents to view their social worth as lower than it objectively is, then these linkages could provide important insights into how negative social status perceptions are formed. Furthermore, the cotwin design does not exclude the possibility of unshared confounding factors affecting both perceptions of status and well-being; however, this concern is partially mitigated by the inclusion of covariate-adjusted models that include measures of major threats to the interpretation of the association, such as childhood negative affect, neuroticism, and early emerging mental health problems. Future research and experimental studies are required to answer questions related to directionality and causal impacts that could not be addressed here.

Second, between the ages of 12 and 18 y, we saw considerable shifts in adolescents' perceptions of their social standing as well as evidence that adolescents' SFSS becomes more accurately calibrated to their family's SES as they age. These findings are consistent with developmental theory positing that young people develop a more stable, fully evolved, and accurate sense of their social position as they move through adolescence (10, 11). Similarly, we saw little evidence that how adolescents view their families' social standing in early adolescence was reliably associated with concurrent or future well-being. The emergence of stronger status-related associations with mental health in late vs. early adolescence requires replication, but it is consistent with our previous findings in a population-representative US sample (15) in which subjective social status was more strongly related to mental health among older (those age 14 and up) vs. younger (those 13 and under) adolescents. Ideally, future research will include more frequent repeated assessments of perceived social standing to determine exactly when status-based perceptions emerge as a robust correlate of well-being.

Third, we found little evidence that adolescents' status-based perceptions are independently associated with cognitive functioning or that adolescents' SFSS is implicated in the "biological embedding" of social hierarchies as measured by inflammatory biomarkers in late adolescence. The use of alternatively sourced measures and a sibling comparison analysis suggested that the participants' backgrounds and not their subjective perceptions about their families' social status best accounted for the link between their social status ratings and their levels of inflammatory biomarkers, cognitive function, and academic achievement. These findings are consistent with results from a recent meta-analysis reporting smaller and less robust effects for measures of physical health or for outcomes that are objectively measured via biomarkers (9). However, it should be noted that biomarkers of inflammation, in particular, consisted of 1-time measures of dynamic physiologic processes, which absent repeated sampling, may have included too much measurement error to detect an underlying relationship.

With respect to mental health outcomes, the use of informant measures was critical in establishing that concurrent linkages could not be attributed solely to shared method variance, as adolescents' SFSS by age 18 was robustly associated with self-rated, informant-rated, and administrative data indicators of mental health and behavior. Our results are also consistent with prior research demonstrating that subjective social status is the SES indicator most consistently related to mental health (16). Within our multiple regression analyses, the magnitude of the SFSS and mental health association was 10-fold higher than the SES and mental health association for depression; 3-fold higher for anxiety, conduct problems, and marijuana use; and nearly 2-fold higher for optimism. Overall, these findings demonstrate that young people's perceptions of their social status—not only their access to financial and other resources—are independently associated with key mental health and social indicators but not with physical health or cognitive functioning by late adolescence.

Young people growing up in Britain and other high-income countries are facing unprecedented barriers to mobility during the transition to adulthood: educational debt, average age of first home ownership over 30 y, fluctuating wages, and high rates of insecure employment (the so-called "precariat") (17). Growing levels of inequality and low expectations of social mobility are also posing a threat to population health (18) and to child and adolescent health more generally (19). Inequality has been shown to weaken people's beliefs in socioeconomic opportunity, which in turn reduces the likelihood that young people will engage in behaviors that promote social mobility (20). Close to 20% of the young people in Britain and in this cohort are currently not in training, education, employment, or work (NEET). Risk for economic insecurity and disengagement is already high among contemporary youth, and creative strategies are required to encourage social mobility, especially among vulnerable youth.

Understanding whether and how the emergence of the "status syndrome" (21) impedes, promotes, or is simply a downstream symptom of young peoples' social mobility and health will require randomized trials and interventions targeting status-based perceptions (22). Rigorous tests of whether experimentally induced changes in social status perceptions have measurable impacts on well-being are now required. With that said, it is important to acknowledge that focusing on adolescents' status-based perceptions will not fully address larger structural inequalities and injustices. Rather, testing whether altering adolescents' status-based perceptions improve well-being will comprise one component among a suite of strategies. As increasing numbers of young people face economic uncertainly and barriers to social mobility, experimental and innovative approaches targeting both adolescents and society are urgently needed.

## Materials and Methods

A more detailed report of the study design, measures, and descriptive data is available in *SI Appendix*. The premise and analysis plan for this project were preregistered on https://sites.google.com/site/dunedineriskconceptpapers/documents. Analyses were performed in StataSE 15 with regressions constructed using sem; regression model specifications are detailed in the captions of relevant tables and figures. Analyses reported here were checked for reproducibility by an independent data analyst who recreated the code by working from the manuscript and applied it to a fresh dataset. Given the relatively small and highly selected set of well-being indicators, corrections were not made for multiple hypothesis testing.

**Study Sample.** Participants are members of the E-Risk Longitudinal Twin Study, which tracks the development of a nationally representative birth cohort of 2,232 British children born in England and Wales in 1994 to 1995. Details about the sample have been reported previously (23). Briefly, the E-Risk sample was constructed in 1999 to 2000 when 1,116 families with same-sex 5-y-old twins (93% of those eligible) participated in home visit

assessments. This sample comprised 56% monozygotic and 44% dizygotic twin pairs; sex was evenly distributed within zygosity (49% male). Families were recruited to represent the UK population of families with newborns in the 1990s on the basis of residential location throughout England and Wales and mother's age. Older mothers having twins via assisted reproduction were underselected to avoid an excess of well-educated older mothers.

At follow-up, the study sample represents the full range of socioeconomic conditions in the United Kingdom as reflected in the families' distribution on a neighborhood-level socioeconomic index (A Classification of Residential Neighborhoods [ACORN] developed by CACI Inc. for commercial use in Great Britain [24]). E-Risk families' ACORN distribution closely matches that of households nationwide: 25.6% of E-Risk families live in "wealthy achiever" neighborhoods compared to 25.3% nationwide; 5.3 vs. 11.6% live in "urban prosperity" neighborhoods, 29.6 vs. 26.9% live in "comfortably off" neighborhoods, 13.4 vs. 13.9% live in "moderate means" neighborhoods, and 26.1 vs. 20.7% live in "hard-pressed" neighborhoods. E-Risk underrepresents urban prosperity neighborhoods, because such households are likely to be childless.

Follow-up home visits were conducted when the children were aged 7 y (98% participation), 10 y (96% participation), 12 y (96% participation), and 18 y (93% participation; $n = 2{,}066$). There were no differences between those who did and did not take part at age 18 in terms of SES assessed when the cohort was initially defined ($\chi^2 = 0.86$, $P = 0.65$), age 5 IQ scores ($t = 0.98$, $P = 0.33$), or age 5 internalizing or externalizing behavior problems ($t = 0.40$, $P = 0.69$ and $t = 0.41$, $P = 0.68$, respectively). Home visits at ages 5, 7, 10, and 12 y included assessments with participants as well as their mother (or primary caretaker); the home visit at age 18 included interviews only with the participants. Each twin participant was assessed by a different interviewer.

Additionally, with parents' permission, questionnaires were mailed to the children's teachers who returned questionnaires for 94% of children at age 5, 91% of the 2,232 E-Risk children (93% of those followed up) at age 7, 86.3% of the 2,232 E-Risk children (90.1% of those followed up) at age 10, and 80% of the 2,232 E-Risk children at age 12 (83% of those followed up).

The Joint South London and Maudsley and the Institute of Psychiatry Research Ethics Committee and the Duke University Ethics Committee approved each phase of the study. Parents gave informed consent, and twins gave assent between 5 and 12 y and then, informed consent at age 18.

**SFSS.** SFSS was measured at ages 12 and 18 using an adapted version of the MacArthur SES measure (14). Adolescents were shown an image of a ladder with 5 rungs and told the following: "this ladder represents how things are in the United Kingdom. At the top of the ladder are all the people who have the best jobs, lots of money, live in nice places, and go to the best schools. At the bottom of the ladder are those people who don't have enough money, don't live in a nice place, and might not have a job. Now think about your family—where would they be on the ladder?" Adolescents were instructed to indicate which rung best represents their family's position, with the lowest rung [1] representing "poor" and the highest rung [5] representing "rich."

**Objective SES.** Objective SES was assessed in childhood using measures of family SES, economic hardship as reported by parents, and neighborhood-level poverty assessed via geocoded administrative and survey data. Family SES was measured via a composite of parental income, education, and occupation when participants were aged 5. Family socioeconomic disadvantage was assessed at age 5 using a count of 6 socioeconomic disadvantages, and neighborhood-level SES was derived from census and other survey-based geodemographic discriminators.

**Indicators of Health and Wellbeing.** Detailed descriptions of measures are contained in *SI Appendix*, Table S1, and descriptive statistics of study measures for the E-Risk sample are displayed in *SI Appendix*, Table S2. Briefly, at age 18, mental health, IQ, inflammatory biomarkers, educational achievement, optimism toward the future, NEET status, and crime were assessed by personal interviews, informant reports, blood assays, standardized tests, and administrative record searches. At age 12, mental health, school performance, and IQ were assessed using a combination of self-report, teacher-report, and standardized testing methods. Measures of teacher- and parent-reported mental health, interviewer-rated neuroticism, and IQ at age 12 were also available and used as covariates in the regression-controlled models to account for preexisting mental health vulnerabilities, cognitive abilities, and negative affect and appraisal bias.

The dataset reported in this article is not publicly available due to lack of informed consent and ethical approval but is available on request by qualified scientists. Requests require a concept paper describing the purpose of data access, ethical approval at the applicant's institution, and provision for secure data access. We offer secure access on the Duke University and King's College London campuses. All data analysis scripts and results files are available for review.

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