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Subjective social status and allostatic load among older people in England: A longitudinal analysis☆

Lindsay Richards [a,*], Asri Maharani [b], Patrick Präg [c]

[a] University of Oxford, Department of Sociology, 42-43 Park End Street, Oxford, OX1 1JD, United Kingdom
[b] Manchester Metropolitan University, Department of Nursing, Faculty of Health and Education, Bonsall St, Manchester, M15 6GX, United Kingdom
[c] CREST, ENSAE, Institut Polytechnique de Paris, 5 Av. Le Chatelier, 91120, Palaiseau, France

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ABSTRACT

Background: Subjective social status has a known association with health, whereby better health outcomes are observed for those with higher perceived status. In this research, we offer new evidence on the status–health relationship using a rigorous methodological approach that considers both observed and unobserved confounders.

Methods: We use 5 waves of data spanning 15 years from the English Longitudinal Study of Ageing and derive a measure of allostatic load with biomarkers as an objective measure of health. We apply 'within–between' panel regression models.

Results: Models reveal the expected association between subjective status and health when comparing participants (the 'between' estimate), but no association when examining temporal variation within participants (the 'within' estimate). When controlling for personality traits including optimism, and parental education, the 'between' association between subjective status and allostatic load is reduced but does not disappear.

Conclusions: Person-level confounders play some role in explaining the observed link between subjective status and health. The exact nature of the link, including the role of psychological pathways and early-life confounders, remains a question for future research.

1. Introduction

Higher socioeconomic status goes along with better health (see e.g. Marmot, 2015; Mackenbach, 2019), and at least since the 1980 Black Report, social scientists have explored the causal pathways linking social position and health (Townsend et al., 1992). The pathways underlying the association include resources, health behaviours, employment conditions, and psychosocial stress. It is to the last of these pathways – psychosocial stress – that we contribute here. Specifically, we examine whether subjective social status (SSS), also defined as the perception of one's standing in a social hierarchy, is a means for social position to "get under the skin" (McEwen, 2012). SSS has been linked to different dimensions of health including mortality (Demakakos et al., 2018), mental and self-rated health (Präg et al., 2016), immune function (Cohen et al., 2008), inflammation (Demakakos et al., 2008), cardiovascular health (Tang et al., 2016), and brain function (Gianaros et al., 2007), among other specific physiological functions (see Hoebel and Lampert (2020) for a review).

SSS tends to be higher among those with higher socioeconomic status on objective dimensions – education, income, and social class – yet subjective and objective status are not perfectly correlated. The association of SSS and health holds in many studies after controlling for various dimensions of socio-economic status, demonstrating that SSS is not merely picking up on the effect of objective status or resources (Präg,

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* Corresponding author.
E-mail addresses: Lindsay.richards@sociology.ox.ac.uk (L. Richards), A.Maharani@mmu.ac.uk (A. Maharani), patrick.prag@ensae.fr (P. Präg).

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2020; cf. Singh-Manoux et al., 2005). In some studies, SSS is estimated to have a stronger association than objective indicators of socioeconomic status (e.g. Netuveli and Bartley, 2012; Singh-Manoux et al., 2005). These findings suggest that SSS is more than a dimension of, or a reflection of, objective status. Indeed, evidence on the sources of perceived status shows it to be correlated with social, as well as economic, dimensions of status including gender and ethnicity (Lindemann and Saar, 2014; Gianaros et al., 2007). The persistent finding that higher SSS is associated with better health has had a key role in the literature on the sociology of health and wellbeing, and in social epidemiology, because it has suggested that there is something about the *feeling* of low status – variously conceptualized as a cognitive or emotional process - that is damaging to health and wellbeing. From this body of work, the psychosocial theory posits that the experience of being low down in the social hierarchy is a stressful one, and this stress with its associated feelings of inferiority, shame, and frustration trigger physiological reactions, and these in turn bring about poor health (Wilkinson, 1996; Marmot, 2004). Social epidemiological accounts have often emphasised the cognitive aspect of SSS, namely that it provides a good 'all-encompassing' summary, or cognitive average, of socioeconomic position (Singh-Manoux et al., 2005).

To date, most evidence has come from cross-sectional studies, and those that utilise longitudinal data have typically relied on just two waves. In this context, our study makes three contributions to the literature on SSS and health. First, we use allostatic load as our outcome measure of health. As an indicator of the cumulative wear and tear of life's stressors (McEwen, 1998), allostatic load is a good theoretical fit to pick up on the consequences of long-standing status differences (see McEwen and Stellar, 1993; McLoughlin et al., 2022). We assume that processes of 'embodiment', to use Krieger's (2005) phrasing, "we literally incorporate, biologically, the world in which we live, including our societal and ecological circumstances" (p. 351) – take place subconsciously. As an objective, biological, measure of health, allostatic load has the advantage that it is not affected by reporting bias. Second, we use five waves of longitudinal data from the English Longitudinal Study of Ageing, a representative sample of people aged over 50 in England. This sample allows us to control for both observed and unobserved time-constant confounders. To this end, we make use of the 'between–within' model. We also consider likely (observed) confounders including personality traits, non-cognitive skills, and control (Hoebel and Lampert, 2020; Steptoe and Wardle, 2017; Cundiff et al., 2013). Most previous studies linking SSS to health have not accounted for wealth, despite evidence that it is an important covariate of SSS, particularly at the high end of the status scale (Andersson, 2018). Further, we account for conditions during childhood – parents' socioeconomic status and childhood trauma – that may influence health and social status. Thus, a third contribution is that we include a more robust set of controls that include time-varying wealth (in addition to income) and relevant features of the respondents' childhoods. We acknowledge the likely life-course implications of our sample, as status may depend on labour market status – which is heavily contingent upon age –, as well as possible gender differences, as mentioned in robustness checks and the Discussion section.

1.1. Theoretical links between subjective social status and health

The theoretical links between perceived status and health outcomes arise mainly from the epidemiological literature in which the main candidates for explaining the SSS gradient in health are threefold. The psychosocial mechanism, firstly, is causal in nature and is perhaps most associated with the work of Marmot, Wilkinson and Pickett, and others, who show that it is not just absolute socio-economic status that matters for health outcomes, but also one's relative position in the hierarchy (Marmot, 2004; Wilkinson, 1996; Wilkinson and Pickett, 2009). Psychosocial theory posits that individuals who perceive themselves as lower in the social hierarchy find this a stressful experience regardless of their material standing; in other words, it is possible to have resources that cover all of one's physical needs but perceiving oneself to be of lower standing than others brings detrimental psychological reactions. These reactions include stress, dissatisfaction, resentment, a sense of inferiority, shame and incompetence, and status anxiety (Charlesworth et al., 2004; Wilkinson, 1996; Marmot, 2004; Adler et al., 2000). SSS by this account is the result of social comparison processes. Being aware that one's social standing is below that of others in the social context brings about lower SSS (Jackson et al., 2015) and has been shown to have detrimental effects on health and wellbeing (Präg et al., 2014).

The physiological reactions to perceiving oneself to be low status occur through psychoneurobiological mechanisms. The chronic stress of low social status brings about dysregulation in the neuroendocrine systems that include the hypothalamic-pituitary-adrenal axis and the sympathetic-adrenal-medulla (Hoebel and Lampert, 2020). Adler et al. (2000), for example, find that low SSS is associated with higher cortisol in a laboratory setting, indicating a greater presence of chronic stress. Negative emotions and stress also stimulate proinflammatory responses in turn leading to increased risk of type 2 diabetes, cardiovascular disease, and some cancers. In this account, the physiological stress reactions are seen as the result of perceived low status. Low status may itself lead to stronger stress reactions (Muscatell et al., 2016), meaning having higher SSS may act as a resilience resource for dealing with stress. Nonetheless, several studies examining the mechanisms of action of SSS on health did not find an effect, thus casting some doubt on the role of stress. Cundiff et al. (2020), for example, list many studies with null findings, therefore showing no relationship between cardiovascular responses to stress and SSS. In an earlier review, Boylan et al. (2018) found no reliable association between social status and cardiovascular responses to stress in a laboratory setting, and Lê-Scherban et al. (2018) similarly did not establish a link between SSS and cortisol reactivity.

A second possible explanation for the observed association between SSS and health outcomes is methodological rather than causal. In this account, SSS is thought to 'mop up' the measurement error of socioeconomic status (SES). Studies typically control for one or more dimensions of SES including education, social class, and income, but often miss other potentially important factors such as assets, wealth (including expected future wealth), and debt. Andersson (2021) makes an important distinction between "left out" factors such as college prestige or field of study that are not captured by standard education measures, and what respondents "read in", namely the personal circumstances and "idiosyncratic hierarchies" that inform individual status. To the extent that there is measurement error in assessing socioeconomic status, this explanation might suggest that resource-based explanations have been underplayed. Indeed, in many studies, SSS is specifically conceptualized as an all-encompassing measure of socio-economic position, one that better synthesises individual (or "intangible" – Chen et al., 2012) aspects of social identity and socioeconomic position (Singh-Manoux et al., 2005; Demakakos et al., 2018; Chen et al., 2012). Here, SSS might be seen as a 'cognitive average' of socio-economic position (Andersson, 2015). Nevertheless, the fact that many studies cannot fully control away the SSS effect after extensive socioeconomic controls, including parents' and partners' positions (Präg, 2020), is often taken as an indication of a direct pathway of SSS to health (Nobles et al., 2013; Tang et al., 2016; Cundiff and Matthews, 2017). An additional point, on conceptualization and measurement, is that the relationship between SSS and health runs in both directions. Health, Nobles et al. (2013) suggest, is a constituent component of social status. They point out that the wage penalties for poor health are well-known (e.g. Dahl, 1993), as is the social stigma and loss of esteem ("loss of self") that comes with a disability, chronic illness, and health decline (Scambler, 2009).

A third possibility, also a non-causal account, is that the statistical relationship between SSS and health is an artefact of a third factor. In such accounts, SSS and health are understood to have a causal factor in common that is (often) omitted from analyses. Such third factors include those specifically theorized to explain the pathway from SSS to health.

Adler et al. (2000), for example, argue that SSS is associated with "psychological factors that may predispose individuals to better health trajectories" (p. 590). These include pessimism, control over life, and both active and passive coping styles. Steptoe and Wardle (2017) use the term 'life skills' to capture a set of non-cognitive skills, including "characteristics and capabilities thought to increase chances of success and wellbeing" (p. 4354) that are associated with both socioeconomic status and health outcomes. In other words, these skills may explain the mechanisms linking social status and health. Steptoe and Wardle include the following characteristics in their study: determination, conscientiousness, emotional stability, self-control, and optimism; these traits are shown to be associated with social lives, wealth and income, and a range of health indicators both objective and subjective.

While these psychological factors and life skills may mediate the SSS-health relationship, an additional important factor to consider is the childhood experience. Studies have shown the 'long arm of childhood' (Hayward and Gorman, 2004), whereby the socioeconomic conditions of childhood continue to exert a sizeable effect on health throughout adulthood (Präg and Richards, 2019). Assuming these early life experiences influence SSS as well as health, these could be another source of unmeasured or 'missing' variation in many studies and are often hindered by the limited availability and reliability of such measures.

1.2. Previous longitudinal studies of SSS and health

Studies utilising longitudinal approaches remain relatively scarce in this literature, despite the clear advantages of establishing robust associations and elucidating underlying mechanisms. We review here some recent examples of overtime research and their findings; the majority of evidence here comes from study designs utilising two waves. Demakakos et al. (2018), for example, used data from the English Longitudinal Study of Aging (ELSA) to show that a decrease in SSS over ten years is associated with an increased risk of all-cause mortality. This effect was stronger among the 50-64-year-olds than among those over the age of 65. The effect of SSS in this study was reduced, but not explained away, by controlling for wealth, health behaviours, and depressive symptoms. Also using two waves of ELSA data, D'Hooge et al. (2018) use biomarkers as the outcome measure and have a control for baseline. They explore whether SSS mediates the SES-health relationship and find that material class has a small indirect effect through SSS and that SSS has a significant direct effect on health assessed by biomarkers. In another study, using a sample of new mothers in five locations in the USA, Guardino and Dunkel Schetter (2022) find an association between SSS and allostatic load six months later. Finally, O'Leary et al., 2021, using MIDUS data, also used a two-points-in-time model, and showed a relationship between SSS at time 1 and chronic health conditions at time 2, and that negative affect mediates the relationship.

Using longitudinal twin data, Rivenbark et al. (2020) find that perceptions of family status are associated with multiple indicators of self-rated health and well-being. Despite the strong evidence in this study that SSS and health are associated even among those from identical family backgrounds, this study also acknowledges the possibility of reverse causation, namely that poor health reduces status perceptions.

A small number of studies explicitly set out to determine the direction of causality between SSS and health. Using two waves of the Indonesia Family Life Survey, for example, Nobles et al. (2013) provide empirical support for the reverse causality hypothesis using a structural equation model with cross-lagged effects, that nurse-assessed health in 2000 influenced SSS in 2007, but the opposite is not true, i.e. SSS in 2000 did not influence health in 2007. A similar result comes from Euteneuer et al. (2021) who conduct a cross-lagged panel analysis using two waves of the Innovation Sample of the German Socio-economic Panel. Their results show that baseline SSS predicted self-reported physical and mental health two years later, but also that physical health (not mental health) at baseline predicted SSS at follow-up.

2. Research questions and preview of findings

In contrast to these previous longitudinal studies of SSS and health, we use five waves of data with repeated measures of SSS and biomarker indicators of health. We make use of one of the standard 'ladder' questions phrased in terms of occupation, income, and education, and use the biomarkers to develop a measure of allostatic load. Our first research question is as follows: Is there an association between SSS and allostatic load within the same individuals over time? The answer to this question, to preview our findings, is that we see the expected association 'between' participants, but find no association between SSS and allostatic load in the 'within' analysis, where each participant serves as their own control case. Based on the answer to this first question, we then proceed to ask our second research question: what person-level characteristics can account for the 'between' association? We suggest that personality traits, including optimism as well as the big 5, and parental education are likely contenders, but these account for just some of the variation, leaving open questions to be answered by future studies.

3. Methods

We use five waves of the English Longitudinal Study of Ageing (ELSA), a nationally representative, biennial household panel survey that collects information on the demographic characteristics, socioeconomic position, and comorbidities of individuals aged 50+ in England. Details of the study design are given elsewhere (see Steptoe et al., 2013; Banks et al., 2021). ELSA was started in 2002, and so far, there are nine waves. Our study predominately uses waves 2, 4, 6, 8, and 9 (in the following referred to as the time points T1-T5), as biomarker information was collected in those waves (Banks et al., 2021). At T1 the mean age of participants was 64.0 rising to 72.3 at T5. In Waves 8 and 9, nurse data and biomarkers were available for only a subset of the sample. For full details of the methodology, see the Supplementary Materials; here in brief: for the main analysis, we use the nine biomarkers that are available in each wave. As a robustness check, we check a restricted number of time points for which additional biomarkers are available. We drop participants for whom biomarker information is missing (e.g. those participating in proxy interviews). For the main analysis, we use the complete-case sample (4505 individuals, 10,893 observations). In the additional analysis, we use multiple imputation for missing covariates and missing time points (10,355 individuals, 51,633 observations). Full details about the case selection can be found in the Supplementary Materials. We undertake additional analysis to address concerns about selection, see the Robustness Checks section and Supplementary Materials.

3.1. Ethics approval

Ethics approval was obtained by the ELSA team as follows: ELSA Wave 2 received ethical approval from the London Multi-Centre Research Ethics Committee on August 12, 2004 (MREC/04/2/006). ELSA Wave 4 received ethical approval from the National Hospital for Neurology and Neurosurgery and Institute of Neurology Joint Research Ethics Committee on October 12, 2007 (07/H0716/48). ELSA Wave 6 received ethical approval from the NRES Committee South Central - Berkshire on November 28, 2012 (11/SC/0374). ELSA Wave 8 received ethical approval from the South Central – Berkshire Research Ethics Committee on September 23, 2015 (15/SC/0526). ELSA Wave 9 received ethical approval from the South Central – Berkshire Research Ethics Committee on May 10, 2018 (17/SC/0588). This information was retrieved from https://www.elsa-project.ac.uk/ethical-approval.

3.2. Outcome measure: allostatic load

Allostatic load was measured using nine biomarkers, drawing from four organ systems: namely cardiovascular (systolic and diastolic blood pressure), inflammation (C-reactive protein and fibrinogen), metabolic (glycosylated haemoglobin, high-density lipoprotein/total cholesterol ratio, triglycerides, and fasting blood glucose), and body fat deposition (body mass index). To calculate allostatic load following Gruenewald et al. (2012) and Read and Grundy (2014), each of the 9 biomarkers was recoded as 1 if beyond a clinical cut-off point, where a clearly defined cut-off point exists in the literature and the high-risk quartile for the other items. We then derive scores for each of the four organ systems, where each indicator is given equal weight. We also corrected for known relevant diagnoses and medication use. The resulting score ranges from 0 to 4 and is a continuous measure where higher allostatic load scores indicate higher multi-system physiological dysregulation, i.e. worse health. See Supplementary Materials for full details of the cut-offs used.

3.3. Key predictor: subjective social status

Subjective social status (SSS) captures respondents' perceptions of their relative social standing. Both conceptually and empirically, individuals can change their perception at different time points, relative to changing life circumstances. In ELSA, in all waves, respondents were asked to place themselves on one of ten rungs of a ladder following the question: "*Think of this ladder as representing where people stand in our society. At the top of the ladder are the people who are the best off – those who have the most money, most education and best jobs. At the bottom are the people who are the worst off – who have the least money, least education and the worst jobs or no jobs. The higher up you are on this ladder, the closer you are to people at the very top and the lower you are, the closer you are to people at the very bottom. Please mark a cross on the rung on the ladder where you would place yourself.*" Responses to this question were recorded on a scale ranging from five ('worst off') to 100 ('best off') in increments of five. We divide by ten, as social status is more usually measured on a 10-point scale, to give a continuous measure with a value range from 0.5 to 10, with higher values denoting higher SSS. This measure resembles the one introduced by Adler et al. (2000) and is frequently used in current research (Präg, 2020). Cundiff et al. (2013) demonstrated the construct validity of the scale. Gianaros et al. (2007) ask what the ladder question measures and suggest that it may comprise two components: economic circumstances and social status, a point we come back to in the discussion.

3.4. Possible mediators and confounders

We control for relevant factors relating to childhood conditions and current socioeconomic status including income, wealth, occupation, working status, and education; each of these factors is likely to influence both SSS and allostatic load. In addition, allostatic load and subjective social status may be influenced by mediating psychological states. We control for several of these states and have good measures available. For psychological states, we control for the *big five personality* traits: Conscientiousness, Neuroticism, Agreeableness, Openness, and Extraversion. The big five are antecedents of mortality, and further, are stratified by socioeconomic status (Mackenbach, 2019; Chapman et al., 2010), and as such are possible confounders of the SSS-health association. It is widely assumed that personality traits remain constant across the life course, particularly among people over the age of 30 (Terracciano et al., 2010). We follow Lachman and Weaver (1997) to derive the measures from a battery of 23 items: 5 items measure agreeableness, 7 items measure openness, 4 items measure conscientiousness, 5 measure extraversion, and 4 measure neuroticism. These items are worded in the following way: "*Please indicate how well each of the following describes you*?" Examples include *talkative* (extraversion), *calm* (reversed, neuroticism), and *curious* (openness). We z-standardized the scores; see the Supplementary Materials for details. We measure *optimism* as an index of two items drawn from the CASP scale (Hyde et al., 2003): *How often do you feel that life is full of opportunity?* ('not at all' to 'very much') and *How often do you feel that the future looks good?* ('never' to 'often'). Following Steptoe and Wardle (2017), we also consider control as a possible confounder for the SSS-health association. *Perceived control* we measure with a single item, scored from 'strongly disagree' to 'strongly agree': "*At home, I feel I have control over what happens in most situations*". We standardized the variables to have a mean of 0 and a standard deviation of 1. The big 5, optimism and control are not available in each wave, and we thereby rely on a single measure and treat it as time-invariant, though acknowledge this as a limitation (see Discussion).

We also include three indicators of *childhood conditions*, as potential confounders of SSS and health. These include parental occupation, parental education, and childhood adversity. *Parental occupation* at respondents' age 14 is classified into 15 categories running from managerial to factory worker, with additional categories for disabled and long-term unemployed. Highest *parental education* is included as a set of dummies of school-leaving ages, ranging from 'never went to school' to finishing at age 19 or above. *Childhood stress* is a count of adverse experiences from the list: natural disasters, armed combat, divorced parents, difficult living arrangements, life-threatening illness or accident, and severe financial hardship, thus ranging from 0 to 7.

In addition, we control for several sociodemographic factors, namely age, sex, marital status, participant education, participant social class, and household wealth. Further, we include wave dummies to ensure that our results are not subject to wave-specific measurement or distributional fluctuations. Details of measurement are in the Supplementary Materials.

3.5. Analytical strategy

We estimated within–between (also known as 'hybrid' random-effects) panel regression models (Allison, 2009; Van Winkle and Zachary, 2021), with observation years nested within participants. These models combine the advantages of conventional fixed-effects and random-effects panel models, in that they can control for unobserved time-constant heterogeneity (in the same way fixed-effects models can) while also being able to model observed time-constant predictors (as random-effects models can). To achieve this, all time-varying predictors are included twice in the within-between model, firstly as time-constant individual means and secondly as time-varying deviations from those means. A linear within–between random-effects model is

$$y_{it} = \beta_0 + \overline{x_i}\beta^{RE} + (x_{it} - \overline{x_i})\beta^{FE} + u_i + e_{it}$$

where allostatic load y of individual i at time t is a function of time-constant predictors $\overline{x_i}$ and their between-individual coefficients β^{RE}, and time-varying predictors $(x_{it} - \overline{x_i})$ and their within-individual coefficients β^{FE} as well as an individual random intercept u_i and a random error term e_{it}. For our application, we have the following main terms in our model:

$$y_{it} = \beta_0 + \overline{SSS_i}\beta^{RE} + (SSS_{it} - \overline{SSS_i})\beta^{FE} + u_i + e_{it}$$

Our main interest is in the β^{FE} and β^{RE} coefficients, with the former denoting the within-effect of changes in subjective socioeconomic status (SSS) on allostatic load. For this within-effect β^{FE}, each participant essentially serves as their own control group and any time-constant omitted variable bias is removed. The latter β^{RE} is the between-effect, indicating the association between the average SSS of a participant and their average allostatic load. In addition, we add a vector of control variables c_i to investigate potentially confounding variables:

$$y_{it} = \beta_0 + \overline{SSS_i}\beta^{RE} + (SSS_{it} - \overline{SSS_i})\beta^{FE} + c_i\gamma + u_i + e_{it}$$

3.6. Replicability

Data necessary for replicating analyses shown in this study are available from the UK Data Service (Banks et al., 2021); a set of Stata do-files for replicating the analyses are available online at the following weblink: https://doi.org/10.17605/OSF.IO/C756M (Richards et al., 2022).

4. Results

The distributions of within and between SSS can be seen in Fig. 1. Our analytic approach emphasises within-person patterns of association and relies on the presence of variation in the outcome and explanatory variables. Our measure of between SSS has a standard deviation of 1.40. The standard deviation of within SSS is smaller at 0.75 but suggests a substantial amount of variation within individuals. Thus, it appears that SSS is not a fixed characteristic of individuals, but responsive to changing life conditions. Similarly, we find substantial within variation in allostatic load. An additional table of descriptive statistics (Supplementary Materials, Table A4) shows that the average age of the sample increased from 66.9 at Time 1 (wave 2, 2004) to 72.3 at T5 (wave 9, 2018). Given its association with age, it is unsurprising to see that allostatic load increases from 1.56 at T1 to 2.01 at T5.

To address the first research question, we first summarise at the bivariate relationship between SSS and allostatic load in three scatter plots, shown in Fig. 2. Panel A shows a negative association between overall SSS and allostatic load. People with an SSS score of zero would have an allostatic load of just above 2 while those scoring 10 on SSS would have an allostatic load closer to 1, as predicted by the linear regression line (b = −0.08). Panels B and C show SSS broken down into its constituent between and within parts. The between measure is based on the respondent average score over the five waves and shows the negative linear association (b = −0.11). Within SSS, on the other hand, has no association with allostatic load (b = 0.01). We show in the Supplementary Materials (Figure A2) that this holds when outliers are removed.

The multivariate analysis confirms this pattern (Fig. 3). We begin (model 1: M1) by specifying a random effects model of SSS and allostatic load (top panel row of panel A), which confirms as the bivariate association did, an overall negative relationship (b = −0.014, *SE* 0.006). Model 2 (M2) is the first within-between model that shows the constituent within and between components of SSS, this time with controls included for age, sex, marital status, ethnicity, education, social class, household wealth, and household income. Again, this confirms the bivariate pattern that there is no association between within-person SSS and allostatic load (within coefficient = −0.001, *SE* 0.008), but the significance between association is robust to the initial set of socioeconomic and demographic controls (between coefficient −0.036, *SE* 0.010). In models 3 to 7, the time-invariant confounders are added incrementally. Model 3 shows that the between estimate is attenuated slightly when childhood conditions are controlled (−0.030); model 4 shows further attenuation of the between the effect of SSS (−0.023) once the big five personality traits are added to the model. The presence of optimism in the model further attenuates the size of the between

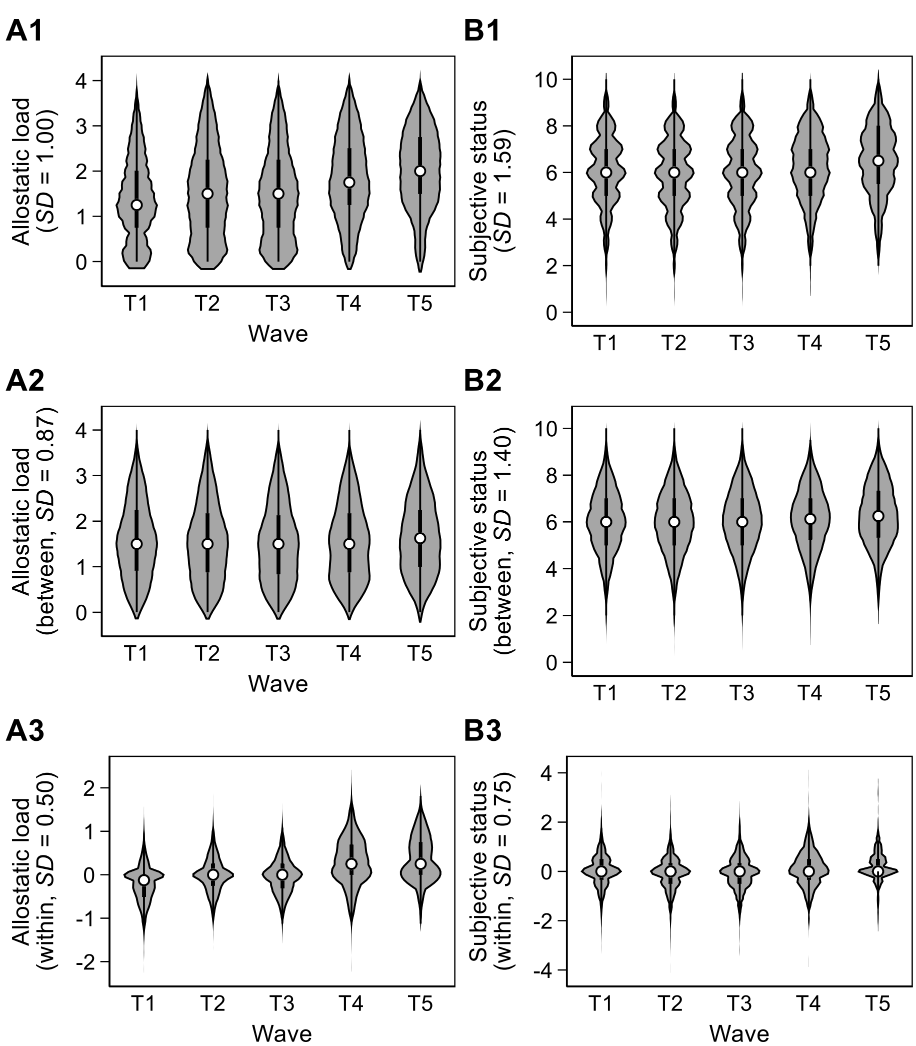

Fig. 1. Median allostatic load increases as study participants get older (Panel A1). A substantial share of allostatic load can be found both between (Panel A2) as well as within (Panel A3) participants over time. Average subjective social status remains largely constant over time (Panel B1), and about two-thirds of variance are found between (Panel B2) and one-third within (Panel B3) participants. Violin plots of allostatic load and subjective status across time points T1-T5. Sample sizes by time point in Table A3 in the Supplementary Materials.

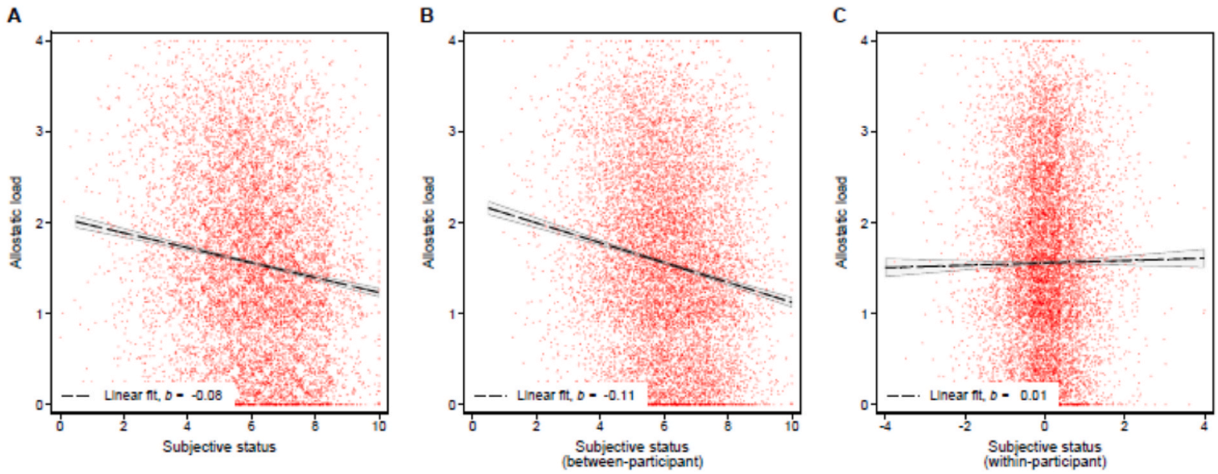

Fig. 2. Panel A: Higher subjective social status is associated with lower allostatic load. Panel B: Higher average subjective status over five waves is associated with lower allostatic load. Panel C: Within-participant subjective social status is not associated with allostatic load. Scatterplot of subjective social status (A), between-participant component (B), and within-participant component (C), and allostatic load, pooled over five time points, N = 10,839 observations, b coefficients from pooled OLS regression, grey areas denote 95% confidence intervals, data points jittered.

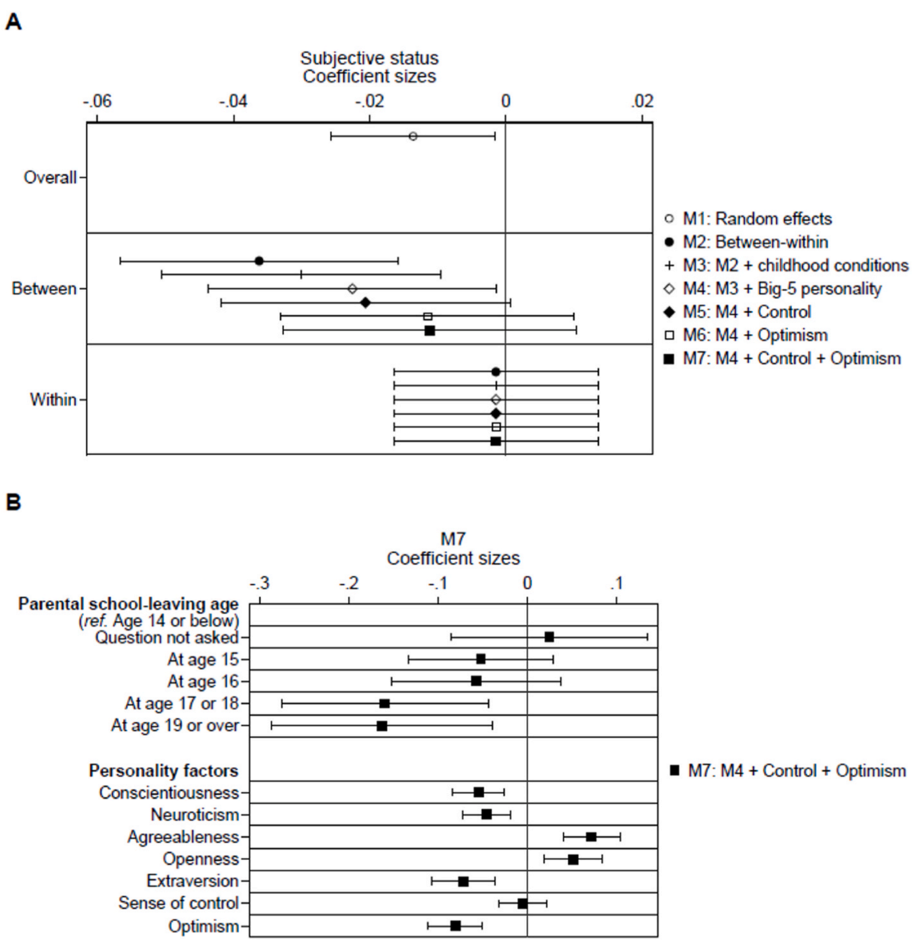

Fig. 3. Panel A: Subjective social status and allostatic load are associated (M1), yet the association only exists when comparing participants, not in the within-participant comparison (M2), and the association between participants is attenuated when accounting for childhood conditions and personality factors (M3-M7). Coefficient of the subjective social status-allostatic load association from seven model specifications M1–M7, N (participants) = 4,505, N (observations) = 10,839. Panel B: Parental education and personality traits are driving both subjective social status and allostatic load. Coefficients for parental education and personality factors from the fully adjusted model M7. Error bars denote 95% confidence intervals. Table A5 in the Supplementary Material shows the full models.

coefficient (model 6, -0.011) Perceived control over one's life, added in model 5 and then model 7, makes little difference to the estimates. In this model specification, the between effect loses statistical significance from model 5. Still, our interpretation here, which also draws on the robustness checks (see next section), is that our controls have attenuated rather than explained away the between effect. Note that the within estimates do not change across models as our added controls only relate to the 'between' part of the model. The tables for the models showing all the coefficients can be found in Supplementary Materials (Table A5).

Panel B of Fig. 3 shows the coefficient estimates for the statistically significant between-level confounders from model 7. These include parental education, the big five personality traits, optimism, all of which are significantly associated with allostatic load, and sense of control, which has no association. Since personality may be correlated with socioeconomic status and health (Chapman et al., 2010), any effects of personality are likely to be sensitive to model specification and we interpret here caution (Westreich and Greenland, 2013). Nonetheless, our models confirm that personality may be an important antecedent of good health (Mackenbach, 2010; Steptoe and Wardle, 2017) The positive effect of conscientiousness and extraversion have been shown elsewhere (e.g. Steptoe and Wardle, 2017), and it has also been noted that neuroticism can have a positive association with health, the "healthy neuroticism" effect (Turiano et al., 2013). Perceived control has no association with allostatic load, as confirmed by the model fit statistics that show the models with parental education, and personality traits (but without perceived control) to be better fitting according to the AIC (shown in Supplementary Materials, Table A5).

4.1. Comparison to self-rated health

Our results stand in contrast to those studies also using ELSA but show a significant association of SSS with health outcomes (e.g. Netuveli and Bartley, 2012; D'Hooge et al., 2018; Demakakos et al., 2018). To rule out the possibility of a false negative due to a lack of within-variation in subjective social status, we re-run our analysis with a different outcome variable, self-rated health, which is also available at all five time points. Running the analysis on the same effective sample as the main analysis, we find a significant 'within' association of higher subjective social status and better self-rated health, even with the full suite of controls. Since the within-participant coefficient of variation for SRH is lower than for AL (see Table A6 in the Supplementary Materials), we interpret this as assurance that our result is not due to a lack of within variation. This result is of interest and may imply that self-rated health taps somatic and vigor-related processes that allostatic load does not (see Coustaury et al., 2022).

4.2. Further robustness checks

As further checks on the robustness of our findings, we re-run the analysis using Multiple Imputation (MI, see Table A15). This analysis intends to assuage concerns that cases with missing values on the covariates are biasing results. Since our MI model also imputes values for those who drop out of the panel and thus provides additional assurance that the results are not driven by selective attrition (for which we also do further analysis, see below). The MI results, based on 10,355 participants with a valid allostatic load measurement, show the same pattern of findings regarding the within-SSS effect which is close to zero and non-significant. Regardless, in this model the between effect remains significant in the presence of the controls for personality traits and childhood conditions. We are therefore cautious in our interpretation of the explanatory power of these controls. Personality and childhood appear to reduce the between effect by around 25% in this model and are therefore likely to be just some of the relevant mediators and confounders.

We run a second robustness check on time points T1-T3 only since these waves had a more comprehensive range of nurse and biomarker measures available. For these three time points, we calculated an alternative version of allostatic load which includes lung function and waist measurement. With this alternative measure, we find the patterns of results to be the same as the main analysis (Table A7).

We also run a suite of checks that restrict the sample in several ways, to rule out the possibility that the results only hold with a specific sample of the data (Tables A8-A10). Since the study by Demakakos et al. (2018) showed a stronger effect of SSS on the younger ELSA participants, we also run our analysis on the subset of those under 64 years old and find our results hold (Table A9). We restrict the sample to those in paid work only since the question wording may have salience for those holding a position in the labour market, and because the importance of subjective social status for health might change after retirement. Here too the results hold (Table A10). Further, we run the models separately for men and women and find that our results hold (Table A8).

We address the biases due to selective dropout by running a joint model (Table A13). This method models within and between effects whilst at the same time modeling attrition status with a survival model, providing valid estimates under missing not at random (MNAR) as conditional on the joint random effects, allostatic load, and the risk of sample dropout are independent. The results of the various model specifications all confirm that the coefficient for the within effect is close to zero and non-significant thus concurring with the main analysis. We also check the results for those who remained in the panel for all waves (Tables A11 and A12). Finally, we re-run our analysis with weights applied (Table A14), and our findings hold.

5. Discussion

Our first aim of this study was to test whether the association between subjective status and allostatic load holds within individuals over time, with a modelling approach that controls for person-level time invariant traits. The 'within' results of our within-between models tell us that a change in SSS is not associated with a change in allostatic load, in our sample of older people in England. In the introduction, we set out the possible explanations for the relationship between SSS and health: psychosocial pathways, measurement error or reverse causality, and third causes. The lack of a 'within' effect provides evidence for the last of these explanations, namely that mediating factors (such as personality) and confounding factors (such as parental education) are likely to be important for understanding the mechanisms linking SSS and health. Our second aim was to find the most likely confounders that explain this 'between'. We have shown that personality traits (the big 5 and optimism) and parental education have statistically significant effects and that the between effect is attenuated, but not explained, when these controls are present. We are not the first to show that the big 5 and optimism have a role in the explanation of how health inequalities come about (Mackenbach, 2010; Kim et al., 2017; Cundiff et al., 2013), but here we suggest that they have a specific role in explaining the known status-health link. It seems likely from our results that parental education plays a confounding role, bringing about higher status and, separately, better health.

5.1. Limitations and future research directions

How can we reconcile our null finding – that SSS is not associated with health once controlling for within-person effects – while previous studies show a significant association? First, since much of the evidence to date has emerged from cross-sectional data, or based on two waves of data in a small number of longitudinal studies, one reason may be methodological. Our data included five time points, spanning fifteen years, allowing for a stronger test of association that accounts for within-person characteristics that may be important for explaining health and status trajectories as well as point-in-time associations. Our comparison to the results for self-rated health shows that our null result is unlikely to result from a lack of within variation. A second point relates to the population in this study. Recent evidence, for example, suggests a causal link between SSS and health among adolescents, based on a robust within-family research design. A future research direction would be to examine the SSS-health link from a life-course perspective, as the nature and foundations of status hierarchies may differ in different age groups. Status itself may matter more during periods of "heightened social awareness" (Rivenbark et al., 2020) such as adolescence while at older ages, as friend and family social networks shrink, and as people leave the labour market, social status may shift in its causes and consequences compared to younger people. Further, it may be that expectations for the future become more important than current socioeconomic concerns (e.g. Andersson, 2015) and this may be inadequately picked up in our study. Similarly, it may be worth investigating cohort differences in the degree to which status matters for health, with early life experiences having particular importance.

Social status may also have a particular role in mediating the effect of stress on health (Muscatell et al., 2016) and this too could be contingent upon age. A third possible consideration relates to the operationalisation of SSS. The question in ELSA is worded in terms of status in terms of education, money, and jobs, but it would also be important to replicate the study with an alternative measure that does not ask respondents to draw on (only) economic aspects of life to determine their social standing. Other well-established measures, for example, emphasise standing in the community (see Ghaed and Gallo, 2007). In a recent examination of the components of status ladder questions and their effect on health, Gianaros et al. (2007) find that a measure of social status based on ladder questions worded in terms of social influence, control, community, and power exerts separate effects to economic standing. These other dimensions of social standing may well have greater salience for health among older people.

As well as these limitations to our study, there are several relevant questions that have been outside our scope but will also make for potentially interesting future research. Patterns of change in allostatic load, for example, could be contingent upon having very high or very low starting levels of SSS. Cross-lagged models (per Nobles et al., 2013; Euteneuer et al., 2021) may also provide an insightful and interesting future direction, as would analysis that can include the effects of early and mid-life status on later-life health outcomes. Other avenues for future research may include gender differences in the perception and implications of status, as well as how status within specific groups, at the local or community level may have more salience for older people. Further, while our use of self-rated health in this study served the primary purpose of a robustness check, it also reveals that the status-health association, and the linking mechanisms, may vary by different measures and conceptualizations of health. The full implications of the differences between subjective and objective outcomes (e.g., Präg et al., 2022; Gaydosh et al., 2018) have yet to be fully understood, including how mental states may influence self-rated health and objective indicators of health differently.

Our findings also have consequences for understanding the nature of SSS that can offer explanations for its associations with health. Others have argued that "researchers cannot fully understand the mechanisms behind these effects without adequately understanding from where individuals derive their senses of status" (Schnittker and McLeod, 2005, p.84). While allostatic load has the benefit that reporting bias is minimised, chronic psychological states and traits still matter, as they may respond to life stressors and influence physiological strain. Our results suggest these relevant psychological states and traits may include personality traits that are likely to be pathways from status to health (Matthews and Gallo, 2011; Steptoe and Wardle, 2017). In addition, we find parental education to be a potentially important source of status, in addition to known sources such as wealth, education, employment, and ethnicity (Lindemann and Saar, 2014). Further, then, there may be implications in our findings for understanding health inequalities. What are the economic and sociological antecedents to optimism and the big five traits? While these are often taken to be dispositional, optimism, for example, is estimated to be just 25% heritable (Plomin et al., 1992), thus leaving considerable variation to be explained by other factors. It is also likely that optimism declines as health declines at older ages. Further, our measure of control showed a non-significant effect and may also benefit from being explored as a time-variant measure and in multiple domains. These may be fruitful directions for future research to explore the social underpinnings of optimism and a sense of control, and their association with status.

6. Conclusions

In the context of a large literature on the consequences of social status on health, we have shown that there is no within-person association between subjective social status and allostatic load among older people in England. These findings contribute to the literature on the psychosocial pathways linking status and health by implying that hidden causes and confounders may be present in cross-sectional analyses. Yet, our finding that allostatic load and self-rated health have different associations with status at the 'within-person' level of analysis shows that the outcome matters when considering the consequences of social status. These different concepts and measurements of health could usefully be further explored to uncover the linking mechanisms between social circumstances and health. Even for allostatic load, our findings do not imply that status hierarchies do not exist or are inconsequential, but rather highlight possible future research directions including which groups in society rely more on social standing for health, which specific conceptualizations of status may be most important, and how social standing stems from or interacts with, other psychological factors such as optimism to exert its influence on health outcomes.

Credit author statement

Lindsay Richards: Conceptualization, writing, reviewing and editing. Asri Maharani: Methodology, analysis, writing. Patrick Präg: Conceptualization, Methodology, analysis, visualization, writing.

Data availability

We provide our code in a file at osf. The link for accessing this is included in the main manuscript under the heading "Replicability".

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2023.115749.

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